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19010

Distr.
LIMITED

ID/WG.514/1*
29 April 1991

ORIGINAL: ENGLISH

United Nations Industrial Development Organization

Fourth Consultation on the Capital Goods
Industry with Emphasis on Machine Tools

Prague, Czechoslovakia, 16-20 September 1991

REGIONAL STUDY ON THE MACHINE TOOL INDUSTRY IN ASIA: THE CASE OF INDIA**

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*This document was previously issued under the symbol ID/WG.509/1(SPEC.).

**The views expressed in this paper are those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. Mention of firm names and commercial products does not imply the endorsement of the United Nations Industrial Development Organization (UNIDO). This document has not been edited.

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V.91-23912

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C O N T E N T S

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P R E F A C E

This report relates to the Indian experience in setting up of its machine tool industry and reflects its current status, particularly with reference to automation equipment. The diffusion of automation equipment in the engineering industry has also been studied. The problems faced by the industry in switching over to CNC machines and automation equipment have been brought out.

The report refers to the role of the machine tool industry in the economic development of India and economic costs and benefits of setting up this industry. Based on the Indian experience, relevance of automation in developing countries has been discussed.

The report describes the Government policies for engineering and machine tool industry with respect to trade policy, incentive to the local production etc. and the effect it has on the growth of the industry.

The method followed in preparing the report was: extensive discussions with the senior executives concerned with the engineering and machine tool industries and study of published literature on this subject. A recent sample survey conducted

by the Directorate General of Technical Development, Government of India regarding diffusion of the automation equipment in the engineering industry was particularly useful for this study.

EXPLANATORY NOTES

CRORES	Ten million or one hundred lakhs
LAKH	One hundred thousand
RS.	Rupees
DOLLARS ($)	U.S. Dollars
FISCAL YEAR	From April 1 to March 31 (Say 1989-90 is April 1, 1989 to March 31, 1990)

ABBREVIATIONS

AGV	Automated guide vehicles
CAD	Computer aided design
CAM	Computer aided manufacture
CNC MACHINE	Computer numerical control machine
CSO	Central Statistical Organisation, the Government of India
CEI	Confederation of Engineering Industry - India
CMTI	Central Machine Tools Institute, Bangalore, India
CIM	Computer integrated manufacturing
CIF	Cost insurance freight
DGTD	Directorate General of Technical Development, the Government of India
FMC	Flexible manufacturing centre
FMS	Flexible manufacturing system
FOB	Freight on board
GDP	Gross domestic product
GNP	Gross national product

GPM	General purpose machine (conventional)
HMT	Hindustan Machine Tools Limited, Bangalore
IMTMA	Indian Machine Tool Manufacturers Association
ISO	International Standards Organisation
MRTP	Monopolies and Restrictive Trade Practicers Act
MTC	Machine Tool Control (patented by L.M.T. Sweden)
MTTA	Machine Tools Traders Association - U.K.
MVA	Manufacturing value added
NC MACHINE	Numerically controlled machine
NIC	National Industrial Classification of the Government of India
NCMT	NC/CMC machine tools
OGL	Open general licence
R&D	Research & development
SPM	Special purpose machine

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I. INTRODUCTION:

1.1. The Indian Economy and its manufacturing Sector:

1.1.1. Structure of Economy:

When India became independent in 1947, its economy was predominently agricultural. It undertook an extensive programme of economic development in the post-independence period. The Government appointed a Planning Commission in 1950 to prepare a blue print of development, taking an overall view of the needs and resources of the country. The First Five Year Plan (1951-52 to 1955-56) had the objective to initiate a process of all-round balanced development, which would ensure a rising national income and a steady improvement in the living standards over a period of time. Highest priority in this Plan was accorded to agriculture and power projects.

In the Second Five Year Plan (1956-57 to 1960-61), thrust was on rapid industrialisation with particular emphasis on the development of basic and heavy industries. Hence, focus was on increased production of iron and steel, heavy chemicals including fertilisers and thhe development of heavy engineering and machine building industry.

The Third Five Year Plan (1961-62 to 1965-66) aimed at a marked advance towards self-sustaining growth. The emphasis was on the achievement of self-sufficiency in food grains and further expansion of basic industries. This would help meet the requirement of further industrialisation through the country's own resources.

After a gap of two years, the Fourth Five Year Plan was formulated to cover the period 1969-70 to 1973-74. It aimed at accelerating the tempo of overall development to increase the gross domestic product considerably.

The Fifth Plan (1974-75 to 1977-78) was formulated at a time when the economy was facing severe inflationary pressures. Self-reliance was one of the major objectives of this Plan.

After a certain gap, the Sixth Plan (1980-81 to 1984-85) was drawn taking into account the achievements and short-comings of three decades of planning. The emphasis was on strengthening the infrastructure for agriculture and industry so as to create conditions for growth in investments, output and exports.

The Seventh Plan (1985-86 to 1989-90) emphasised on the growth in food grain production, and in increase of productivity. Improvement in

productivity aimed at reducing the cost of capital intensive and resource intensive goods and services. The objective was to expand the scale of the domestic market and improve international competitiveness of the Indian economy.

The approach paper for the Eighth Plan (1990-91 to 1994-95) has been prepared but the Plan has not yet been finalised.

Through successive Plans, gross national product (GNP) at factor cost and current prices has grown from Rs. 89790 million in 1950-51 to Rs. 3488960 million in 1988-89. The index of industrial production has gone up from 18.31 to 181.1 during the same period, with the base of 1980-81 as 100.

Table 1.1 indicates the distribution and growth of gross domestic product at factor cost at 1980-81 prices. Share of primary sectors like agriculture, forestry and fishing etc., which was 56.45 % in 1950-51, has gone down to 34.82 % in 1988-89, though there is appreciable growth in physical terms. It may be noticed that the share of manufacturing and services is growing consistently.

Table 1.1 GROSS DOMESTIC PRODUCT AT FACTOR COST BY INDUSTRY OF ORIGIN

(At 1980-81 prices) (Rs. Crores)

Years	Agriculture, forestry and logging, fishing mining and quarring	Manufacturing, construction, electricity, gas and water supply	Transport, communication and trade	Banking and insurance, real estate and ownership of dwellings and business services	Public administration and other services	Gross domestic product at factor cost(2 to 6)
1	2	3	4	5	6	&
1950-51	24204	6451	4718	3870	3628	42871
1960-61	32793	11790	7945	5185	5191	62904
1970-71	41385	20209	12884	7256	8692	90426
1980-81	48366	29747	20437	10841	12835	122226
1981-82	51280	32000	21684	11354	13282	129600
1982-83	50745	33369	22826	12215	14314	133469
1983-84±	55976	36541	24109	12859	14825	144310
1984-85±	56030	38844	25475	13714	15903	149966
1985-86±	56321	41619	27599	14708	17101	157348
1986-87±	55760	44625	29298	15791	18450	163924
1987-88±	56164	47121	30799	16706	19926	170716
1988-89@	65639	50734	33140	17925	21043	188481

± Provisional

@ Quick Estimates

Source: Central Statistical Organisation

Economic Survey 1989-90

Real economic growth averaged over 5.5 % per year in the eighties as compared to the long term trend growth rate of 3.5 %. Agricultural sector recorded an average annual increase of 5.4 % in the eighties.

India's achievements on the industrial front have been equally impressive. Between 1985-86 and 1988-89, industrial growth averaged 88.5 % per annum. The manufacturing sector, which accounts for nearly 4/5th of the industrial production, performed even better by registering an annual growth rate of 9 %.

1.1.2 Structure of Manufacturing Sector:

The origin of organised industry in India can be traced to the establishment of cotton and jute industry in the last century. The early part of the present century saw the introduction of industries producing steel, sugar, cement, glass , industrial chemicals, soap and some engineering industries connected with Railways, shipping, structurals and armament.

The growth in industries was significant after the planning era commenced in 1951. The focus in the initial period was on the development of heavy industry like machine tools, heavy electrical equipment, machine building and heavy engineering. There was an increase in the output of basic chemicals

such as, nitrogenous fertilisers, caustic soda, soda ash and sulphuric acid. New products introduced in this category were urea, ammonia, phosphates, pencillin, synthetic fibre, industrial explosives, dye-stuffs etc. This early period also saw growth of industries like bicycle, sewing machine, telephone and electrical goods.

In the mid 1960's, the pace of industrial expansion was constrained considerably as a result of external disturbances and two successive droughts. In the seventies also, growth was slow. The rapid rise in prices from 1972 onwards upset investment calculation. Moreover, the industry faced shortage of power. Against annual average growth of 6 % in 1960's, the growth was 4.2 % in 1970's.

Industrial growth picked up significantly in 1980's - it was particularly impressive from 1984-85 onwards as can be seen from the table 1.2.

Annual growth during this period ranged between 7.3 % and 9.1 %. The Seventh Five Year Plan (1985-86 to 1989-90) laid considerable emphgasis on the acceleration of industrial growth by easing infrastructural cosnstraints and the liberalisation of industrial licensing Policy. High growth sectors in this period included electrical machinery and

Table 1.2

Annual Growth Rates in Major Sectors of Industry

Year	Mining	Manufac-turing	Electri-city	All Indus-try
(Weight)	(11.46)	(77.11)	(11.43)	(100.00)
1981-82	17.7	7.9	10.2	9.3
1982-83	12.4	1.4	5.7	3.2
1983-84	11.7	5.7	7.6	6.7
1984-85	8.8	8.0	12.0	8.6
1985-86	4.2	9.7	8.5	8.7
1986-87	6.2	9.3	10.3	9.1
1987-88	3.8	7.9	7.6	7.3
1988-89	7.9	8.9	9.6	8.8

Source: Government of India - Economic Survey 1989-90

appliances, electronics, consumer goods, intermediate goods, paper and paper products, chemicals and metal products.

Besides increase in the volume of output, the manufacturing base of India has widened considerably as seen from the production data of the manufacturing sectors given in Table 1.3. It extends to textiles, chemicals, food products, machinery and machine tools, basic metals, transport equipment, electrical machinery etc.

Value Addition:

Table 1.4 gives the "composition of manufacturing value added' (MVR) from 1980-81 to 1986-87. Data for subsequent years is not available. It may be noticed that the sectors which have shown higher growth in MVR are: chemicals, non-electrical machinery, electrical machinery and transport equipment.

Export:

India is only a marginal exporter on the world scene, accounting for about 0.6 % of the world's total. However, the share of manufactured goods in the total exports is increasing as seen in Table 1.5. In 1970-71, it was 50.3 %, increasing

Table 1.3 Trends in the Performance of Manufacturing Sector.

(Base : 1980-81 = 100)

Code	Industry Group	Weight	Growth Rate (per cent)				
			1985-86 / 1984-85	1986-87 / 1985-86	1987-88 / 1986-87	1988-89 / 1987-88	1989-90 / 1988-89
20-21	Food products	5.33	4.7	6.0	4.4	6.8	-2.8
22	Beverages, Tobacco and products	1.57	0.4	-12.1	-13.8	8.5	14.1
23.	Cotton Textiles	12.31	8.0	1.9	-1.2	-3.5	1.7
25.	Jute, Hemp and Mesta products	2.00	-2.2	4.0	-10.0	12.3	-9.7
26.	Textile products(including wearing apparel other than footwear)	0.82	18.0	-22.8	5.3	46.3	15.2
27.	Wood and Wood products	0.45	3.1	10.3	-34.3	6.[illegible]	-1.0
28.	Paper and Paper products	3.23	12.6	3.9	1.9	3.0	4.9
29.	Leather and Fur products	0.49	21.1	5.0	4.4	-4.4	3.5
30	Rubber,Plastic,Petroleum and Coal products	4.00	3.9	-2.2	3.7	8.5	1.8
31.	Chemicals and Chemical products	12.51	8.1	13.7	14.5	16.1	1.9
32.	Non-Metallic Mineral products	3.00	13.7	1.9	-1.4	16.8	1.1
33.	Basic Metals	9.80	9.0	8.4	6.9	6.9	-2.4
34.	Metal products and parts	2.23	9.2	6.5	4.2	3.0	4.2
35	Machinery and Machine Tools	6.24	2.0	8.9	-1.8	15.2	1.9
36	Electrical Machinery & appliances	5.78	34.8	27.0	31.6	4.6	13.7
37	Transport Equipment	6.39	3.2	6.7	4.8	13.1	5.7
38	Other Manufacturing Industry	0.90	24.3	54.2	15.6	11.1	9.2
	Manufacturing	77.11	9.7	9.3	7.9	8.9	3.6

@ April-November

Source : Government of India - Economic Survey 1989-90.

Note :- For April-November 1988 and 1989, Wholesale Price Index (WPI) base : 1981-82 = 100 has been used instead of WPI base : 1970-71 = 100 used for earlier periods.

Table 1.4 : VALUE ADDED FROM MANUFACTURING-REGISTERED

(Rs.crores)

at 1980-81 prices							NIC code & description
1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	
(9)	(10)	(11)	(12)	(13)	(14)	(15)	(1)
845	1116	1506	1679	1694	1774	1880	20-21 food products
246	261	270	497	420	422	371	22 Beverages, tobacco, etc.
1567	1316	1235	1535	1444	1560	1558	23 cotton textiles
443	535	563	662	698	766	836	24 wool, silk, etc.
324	293	273	203	198	194	202	25 jute textiles
132	165	185	194	231	273	211	26 textile products
71	71	72	91	87	90	99	27 wood, furniture, etc.
526	575	530	610	716	806	386	28 paper & printing etc.
77	94	104	126	147	178	186	29 leather & fur products
614	577	880	930	1074	1116	1089	30 rubber, petroleum, etc.
1854	2203	2281	2808	2919	3155	3587	31 chemicals, etc.
474	508	636	722	913	1038	1058	32 non-metallic products
1556	1735	1601	1736	1733	1889	2048	33 basic metal industries
363	368	372	417	445	486	527	34 metal products
985	1053	1127	1269	1536	1567	1706	35 non-electrical machinery tools & parts
918	843	1212	1276	1607	2166	2751	36 electrical machinery
1007	1140	1283	1401	1547	1596	1701	37 transport equipments
456	548	677	790	645	1125	1454	38 other manufacturing
182	182	219	251	273	322	371	39 repairing services
12640	13633	15026	17197	18627	20523	22523	gross value added including bank charges
359	455	525	568	580	640	764	less: imputed bank charges
12281	13228	14501	16629	18047	19883	21759	gross value added
2231	2352	2422	2582	2737	2889	3065	less: consumption of fixed capital
10050	10876	12079	14047	15310	16994	18694	net value added

Source : CSO

Table 1.5 : India's Exports of Principal Commodities

(Rupees crores)

1970-71		Commodity	1984-85	1985-86	1986-87	1987-88p	1988-89p
487	I.	Agricultural and Allied Products	2,696.5	3,018.3	3,422.0	3,146.9	3,347.3
164	II.	Ores and Minerals	637.6	784.7	717.2	710.1	1,027.1
		Of which					
		Iron ore	459.4	578.8	546.6	542.8	672.5
772	III.	Manufactured Goods	6,210.1	6,374.2	7,808.4	10,076.1	14,631.0
		Of which					
(145)		1. Textile fabric & manufactures (excluding carpets hand made)	1,717.5	1,795.1	2,178.8	3,110.9	3,669.5
(197)		a) Cotton yarn fabric made up	620.4	573.7	637.2	1,063.8	1,131.3
(29)		b)Readymade garments of all textile materials	953.3	1,067.0	1,330.5	1,790.8	2,096.9
(80)		2.Leather & leather manufactures and leather footwear	724.1	769.9	922.4	1,148.2	1,487.7
(73)		3.Handicrafts (including carpets handmade)	1,750.8	1,881.4	2,547.6	3,253.2	5,193.2
		Of which :					
(45)		Gems & jewellery	1,237.1	1,502.7	2,074.3	2,613.5	4,398.1
(29)		4.Chemicals & allied products	482.9	497.5	583.2	822.9	1,531.0
(298)		5.Machinery, transport equipment & metal manufactures including iron & steel.	956.1	954.1	1,132.7	1,432.0	2,359.8
13	IV.	Minerals & Lubricants*	1,822.9	644.7	411.2	633.1	505.0
1535		TOTAL(including others)	11,743.7	10,,894.6	12,452.4	15,719.4	20,280.9

P Provisional

* Relates to petroleum crude and petroleum products only.

Source : Reserve Bank of India - Annual Report 1988-89.

to 72.14% in 1988-89. Almost all the manufactured goods have registered growth. In the case of readymade garments the increase is from Rs. 29 crores in 1970-71 to Rs. 2096.9 crores in 1988-89; for handicrafts from Rs. 73 crores to Rs. 5193.2 crores; for gems and jewellery from Rs. 45 crores to Rs. 4398 crores; for machinery & transport equipment from Rs. 198 crores to Rs. 2359.8 crores during the same period.

Liberal policies to encourage capacity expansion for export production and technology up-gradation, apart from other incentives, have facilitated export growth.

Import:

With the emerging needs of the economy, the composition of imports too has been changing. Table 1.6 gives the position of India's imports of principal commodities. From 1984-85 to 1988-89, in the category of bulk imports, petroleum and petroleum products, edible oils and fertilizers have shown no increase in imports. However, there has been increase in the case of iron & steel, metal scrap and non-ferrous metals to meet the growth in requirement of the industry. There has been significant growth in the import of eelectrical machinery and chemicals.

Table 1.6

India's Imports of Principal Commodities

(Rupees crores)

Items	1984-85	1985-86	1986-87	1987-88P	1988-89P
1	2	3	4	5	6
a.Bulk Imports	10,039	10,574	7,790	8,561	10,476
i)Cereals & cereal preparations	242	110	87	33	631
ii)Fertilisers	1,346	1,436	921	486	928
a)Crude	137	163	145	138	135
b)Sulphur & unroasted iron pyrites	202	240	200	176	253
c)Manufactured	1,007	1,053	576	172	493
iii)Edible oils	950	749	634	920	727
iv)Non-ferrous metals	412	542	517	576	786
v)Paper, Paper Board and manufactures thereof (including newsprint)	195	226	217	258	306
vi)Sugar	96	418	224	174	Neg.
vii)Crude Rubber	87	101	107	108	173
viii)Petroleum, Petroleum products & related materials	5,409	4,989	2,811	4,083	4,245
ix)Pulp and waste paper	176	245	244	228	252
x)Metalliferrous ores & metal scrap	185	363	472	422	677
xi)Iron & Steel	941	1,395	1,556	1,273	1,751
b.Pearls, precious & semi precious stones	1,032	1,100	1,489	1,994	2,866
c.Machinery & transport equipment	3,027	4,084	6,279	6,136	6,713
i)Electrical machinery	663	810	1,212	1,115	1,538
ii)Non-electrical machinery	1,995	2,705	4,263	2,889	2,919
iii)Transport equipments	369	569	804	740	766
iv)Project goods @	NA	NA	NA	1,392	1,490
d.Organic & Inorganic chemicals	857	1,089	1,145	1,051	1,[illegible]
e.Others	2,179	2,811	3,393	4,601	5,706
f.Total imports (a+b+c+d+e)	17,134	19,658	20,096	22,343	27,693

P - Provisional

@ These were earlier classified under machinery

Source: Reserve Bank of India-Annual Report - 1988-89

In case of capital goods, the imports fell from 24.7% in 1970-71 to 15.2% in 1980-81, but rose to 28.1 % in 1987-88. The earlier downward trend was due to the increasing use of indigenous plant and machinery, which became available through creation of capacity for manufacturing various types of capital goods.

Since 1982-83, there has been a sharp rise in the import of capital goods to meet the requirement of the transport and electronic industries for which plant and machinery was not available locally. Moreover, this increase is also due to the liberalisation of the import policy to help the user industry in modernising its facilities.

1.2 Structure of Engineering Industry:

1.21. Introduction

National industrial classification Nos. 33, 34, 35, 36 and 37 of the Government of India pertain to the engineering industry. The following industries are included in this category:-

Basic Metals and alloys industries; Metal products and parts, except machinery & equipment; machinery other than electricals; Electrical machinery and; Transport Equipment.

In the weight of 100 for all industry, all manufacturing is 77.11 and the engineering industry, as defined above, has a share of 30.5%.

India has a long history of achievements in the field of engineering. Some of the old monuments bear testimony to such skills in the field of metal working. Coming to more recent times, around two hundred years ago, the foundation of modern engineering activity was laid in Calcutta in the eastern part of India. The production range consisted of steam boats, Steam engines, steam pumping systems, bridges, defence equipment etc. Railways were introduced in India in the middle of 1850's. From 1800's onwards, there was a rapid growth of

engineering and other industries in different parts of the country. The manufacturing range was expanded to include cranes, railway wagons, structurals and a variety of other items. In the following years, the industry maintained further progress, but it was slow.

1.22 Production

Realising the importance of the engineering industry in bringing about economic development, special emphasis has been given to it after independence. The expansion has been both in volume and in variety. Its compound growth in the 1950's was 13.3% and in the 1960's, 7.9% per annum. In the 1970's, however, the growth came down to 4.6% because of high inflation, lower investment and power shortage etc. The output of this industry in value, has increased from Rs. 589 million in 1950-51 to Rs. 572270 million in 1988-89.

The engineering industry has always maintained a higher rate of growth than "all-industry" and "all manufacturing industry" as is clear from the following table, which gives the position from 1950-51 to 1980-81. The position in the last five years is given in Table 1.7, from which similar trends can be observed, except for the year 1988-89 when there was a drop in the case of the engineering industry.

Table 1.7 : Index of Industrial Production : CSO

Revised Series : 1980-81 = 100

	Industry/Sector	Weight	1980-81	1984-85	1985-86	1986-87	1987-88	1988-89
1.	All Industry	100.00	100.0	130.7	142.1 8.7	155.1 9.1	166.4 7.3	181.0 8.8
2.	All Manufacturing	77.11	100.0	124.8	136.9 9.7	149.9 9.3	161.7 7.9	175.8 8.8
3.	Engineering Industry	30.5	100.0	124.2	139.3 12.1	157.7 13.2	177.1 12.3	191.7 8.2
	a) Basic Metals	9.8	100.0	107.3	117.0 9.0	126.8 8.4	135.6 6.9	145.0 6.9
	b) Metal Products	2.29	100.0	105.0	114.7 9.2	124.5 8.5	129.6 4.1	133.5 3.0
	c) Machinery other than Electricals	6.24	100.0	127.6	130.2 2.0	141.8 8.9	139.2 -1.8	159.7 14.7
	d) Electrical Machinery	5.78	100.0	148.8	200.6 34.8	254.7 27.0	335.2 31.6	351.0 4.7
	e) Transport Equipment	6.39	100.0	131.6	135.8 3.2	144.9 6.7	151.9 4.8	171.3 12.8
	Mining	11.46	100.0	160.8	167.5 4.2	177.9 6.2	184.6 3.8	198.9 7.7
	Electricity	11.43	100.0	140.4	152.4 8.5	168.1 10.3	181.0 7.7	198.0 9.4

Source CSO

The index of the engineering industry has gone up from 100 in 1980-81 to 191.7 in 1988-89. The growth was particularly high in electrical machinery followed by transport equipment and machinery other than electricals.

Production growth rates (%)

Period	All Industry	Engineering Industry
1950-51 to 1960-61	7.1	13.3
1960-61 to 1970-71	6. 3	7.9
1970-71 to 1980-81	4.2	4.6

Table 1.8 gives the value of output, employment, invested capital, value added, exports and imports from 1974-75 onwards. The engineering industry has registered an impressive growth. The value of output has gone up from Rs. 78866 million in 1974-75 to an estimated value of Rs. 572268 million in 1988-89. As per current indications, it is expected to keep up the tempo of growth till the turn of the century.

Value added

The value added in this industry has gone up from Rs. 2123 million in 1974-75 to Rs. 117924

Table 1.8

ENGINEERINGINDUSTRY : SELECT CHARACTERISTICS PROJECTED [Rs. Million]

Years	Employment [Mln. No.]	Value of Output	Invested Capital	Value Added	Engineering goods Exports	Engineering goods Imports
1974-75	1.72	78866	71824	21231	3491	13169
1975-76	1.85	93271	80874	23897	4082	13459
1976-77	1.77	105259	86359	26423	5517	14309
1977-78	1.87	112680	90022	27174	6240	17172
1978-79	1.92	134678	107324	31898	7169	21712
1979-80	2.14	167170	130886	37432	7367	28129
1980-81	2.15	201024	148600	43901	8742	34839
1981-82	2.18	243534	173942	54542	10469	40398
1982-83	2.27	280062	199790	62065	10113	45552
1983-84	2.29	286482	218333	69551	10000	52042
1984-85	2.37	333588	244458	75990	11500	49205
1985-86	2.25	374319	266217	81727	10950	68854
1986-87	2.31	431215	299760	92352	11500	94422
1987-88	2.36	496760	337530	104357	13550	90240
1988-89	2.42	572268	380059	117924	23217	102582
Compound Growth Rate(%) (Based on Actuals)	2.5 (11 yrs.)	15.2 (11 yrs.)	12.6 (11 yrs.)	13.8 (11 yrs.)	14.5 (14 yrs)	15.9 (14 yrs.)

Source: 1) Annual Survey of Industries,CSO; 2) EEPC; 3)Ministry of Commerce Annual Report; 4) Economic Survey, Ministry of Commerce Report 1989-90; 5) CEI.

million in 1988-89. As seen in Table 1.4, the engineering industries which have recorded appreciable growth in value-added during the period of 1980-81 and 1986-87 are: non-electrical machinery, electrical machinery and transport equipment.

1.24 Import

The import of engineering goods has gone up from Rs. 13169 million in 1974-75 to Rs. 103582 million in 1988-89. As seen in Table 1.6, the growth in imports, between 1984-85 and 1988-89 has been high in electrical and non-electrical machinery.

1.25 Export

The exports of engineering goods have risen sharply, from merely Rs. 30 million in 1950-51 to Rs. 22580 million in 1988-89. The share of export of engineering goods in total exports was only 0.5% in 1950-51; it has gone up to 11.1% in 1988-89. However, engineering exports, as a percentage of engineering production, have dropped from 4.3% in 1980-81 to 2.9% in 1985-86. The sectoral analysis of exports in 1988-89 shows that electronics and software account for 29.6% of engineering exports, followed by consumer durables (26.6%) and capital goods (26.3%). The share of export of capital goods has fallen over the years from 40.3% in 1971-72 to 26.3% in 1988-89.

The engineering industry, by and large, still continues to cater to domestic demand. The increase in its production has not resulted in the increase of exports as a percentage of production. The capital goods industry needs modernisation to compete effectively with international firms in India and abroad.

1.3 Industrial Policy concerning Engineering Industry:

1.31 Introduction:

At the time of independence in 1947, the industrial sector in India was weak. It was felt that the State had to play a key role in accelerating the pace of industrial development. The policies then were so formulated as to ensure that industrial development conformed to national plan priorities. Self reliance was one of the major goals. This strategy served well in the initial period.

At a later stage, it was felt that, in the interest of accelerating industrial growth, lowering costs, increasing productivity, technological upgradation and increasing exports, the policy should be liberalised. Hence, a number of measures were taken in the 1980's to ease controls, which are described later.

1.32 Policy

Industries are governed by the Industries Development and Regulation Act, 1951. Under this, the industries listed in the First Schedule to the Act are required to be licensed by the Government. Industrial development has been based on the Industrial Policy Resolution of 1956. The core industries were developed in the public sector and other areas were open to private sector and joint sector. The system of industrial licensing exists for setting up new ventures and the expansion of existing ones. Through this system, it is ensured that capacity is created in different industry groups in a manner that lopsided development is prevented. At the same time, this system ensures effective deployment of available financial resources. One of the further events of relevance in the policy area is the Monopolies and Restrictive Trade Practices (MRTP) Act, 1969. It seeks to prevent the emergence of monopolies and to keep a control on restrictive trade practices. Covered under this Act, are enterprises with an investment of Rs. 100 crores and above, and those having above 25% of market share. They are required to seek permission under this Act if they want to put up new enterprises or expand existing ones.

The Foreign Exchange Regulation Act (FERA), 1973, applies to companies having foreign equity of over 40%. Such companies have to seek permission from the Reserve Bank of India for establishing any new venture and for substantial expansion of their existing activities.

The Backward Area Scheme of 1971, seeks to give special concessions to industries if they are set up in certain specified backward areas. To ensure dispersal of industries and to prevent their concentration around larger cities and towns, there is a locational policy.

The expansion of small scale sector is considered as one of the solutions to tackle the problem of unemployment in the country. To encourage its growth, there is a reservation of 836 items which can only be manufactured in the small scale sector.

The other aspects which are examined by the Government while according industrial approval are as follows :-

(i) Capacity:- Whether in the proposed items of manufacture, enough capacity already exists and if there is a justification to set up new capacity.

(ii) Financial Structure:- Whether the foreign investment is as per guidelines. Generally, it is permitted upto the level of 40% of the equity. In special cases, higher proportion is permitted for high technology and export oriented industries.

(iii) Technology Imports:- Whether the technology proposed for import is "state of art" and payments for it are reasonable and whether it is indigenously available.

(iv) Capital Goods:- In case they are sought to be imported, it is checked whether they are indigenously available.

(v) Import of components & materials:- Their import is allowed after taking into account the essentiality of the requirement and its indigenous availability. The imports may be reduced gradually as the project progresses.

The controls mentioned above were introduced to ensure co-ordinated development, keeping in mind the availability of resources. The import controls, sought to protect nascent industries from competition from well established

firms abroad. Among other reasons, sanctioning of foreign investments and foreign technical collaborations was carried out to emphasise the scope for indigenous initiatives. In fact, the important elements of the industrial policy were self-reliance and import substitution. It was, however, realised in the early 1980's that a change in the policy was required. The strategy of self-reliance and sheltered market, insulated the industry from competition, both internal and external. It resulted in high costs, low productivity, continuance with obsolete technology, inadequate quality and unsuitability of products for export.

Starting from the early 1980's, measures listed below were taken as a result of the policy. of liberalisation.

(i) Broad banding of product-mix in several industries to provide operational freedom

(ii) Regularisation of built-in installed capacities in a number of industries to allow production increase without significant additional capital investment.

(iii) Liberalisation of import of know-how for up-gradation of existing technology.

(iv) Fixation of minimum economic size in several industries for the promotion of cost efficiencies.

(v) Delicensing of certain categories of industries with a view of attracting investment and growth.

(vi) Introduction in 1985, of a three year import export policy to impart a sense of stability in the respect of import of capital goods, intermediates and raw materials.

(vii) Increase in asset limits for MRTP companies, exempting a number of industries from this Act and delicensing some specified industries for MRTP and FERA companies, if they are set up in backward areas. These increases were introduced to increase the involvement of MRTP and FERA companies in industrial development in priority areas.

To encourage export of engineering goods, the following incentives are given to the industry

(i) Cash compensatory support to refund the un-rebated taxes etc.

(ii) Advance licence/blanket licences are available for duty free import raw materials, components, spares and consumables.

(iii) Duty draw back scheme to refund the import/ excise duty in lieu of advance licence.

(iv) International Price Reimbursement Scheme is available for the different categories of steel and aluminium to reimburse difference of international and domestic price.

(v) Replenishment licence is granted upto 20% on the FOB value of export for meeting import requirement.

(vi) Additional licences are also issued to Export Houses and Trading Houses to facilitate import of raw materials, components etc. to use as inputs.

(vii) Preshipment/postshipment credit facilities.

1.33 R & D

During the last five years, around 900 collaborations per year have been approved by the Government of India. Out of them, 71% are in the engineering sector. India has relied extensively on imported technology for achieving industrial growth. However, it is well known that no country can maintain a continuous economic growth based only on imported technology.

India has a satisfactory record of technology absorption for production, but it has lagged behind in absorbing basic engineering & design skills. Its R&D base is weak, in spite of having one of the largest reservoirs of scientific manpower. Realising the importance of R&D in industry, the following incentives are available to the Indian industry:-

(i) All expenditure incurred on R&D, including that on capital equipment, is tax deductible.

(ii) The equipment for R&D can be imported on Open General Licence.

(iii) If production facilities are set up using indigenously developed technology, higher rates of depreciation are allowed.

(iv) Financial institutions grant soft loans for funding Venture Capital required for commercialising R&D projects.

(v) Units set up on the basis of indigenous technology are granted exemption from industrial licensing.

3.34 Training Institutes

The Indian industry is served by a wide variety of institutions. Universities impart education in the fields of engineering, management, commerce, science and technology, and social sciences for the upper crust of management. For the middle level, there are polytechnics which impart education for diploma courses in various disciplines. For the operatives, there are industrial training institutes which provide education and training for various trades. In addition, there are a number of training centres which provide practical training in various trades.

There are institutes of management which impart post-graduate management training and conduct in-service training programmes.

Many large industries have their own training centres where training is given to their employees at the time of induction and later, through in-service refresher courses. Apprentices, taken under the Apprenticeship Act of the Government of India, are also trained in the industry. They are given practical training, as well as, theoretical instructions.

As explained above, sufficient institutional support exists for industry in India.

2. Machine Tool Manufacturing Sector:

2.1 Machine Tool Sector

2.1.1 Introduction:

A metal working machine tool is "a power-driven machine, not portable by hand while in operation, which works metal by cutting, forming, physico-chemical processing or a combination of these techniques". (MMTA - 1983:2).

Generally, machine tools are of two types, metal cutting (or metal removing) and metal forming. Metal cutting machine tools are those that shape or surface work metal by removing metal either in the form of chips, dust, swarg etc. or by spark erossion, ultrasonic, electrolytic and other chipless methods. Metal forming machine tools include machines for punching, shearing, bending, forming, processing, forging and other special purpose machines.

The Indian Machine Tool Manufacturers Association (IMTMA) classifies machine tools as A,B, & C as follows :-

Group A - Metal cutting and metal forming machine tools.

Group B - Welding, die casting and plastic machinery; CNC, hydraulic and pneumatic equipment; machine tool attachments and accessories etc.

Group C - Small tools and cutting tools, testing and measuring equipment etc.

The current study relates to Group A and B machines.

In the development process in a country based on industrial growth, machine tools play an important role. They are required to produce capital goods for industries such as textile, chemicals, cement, sugar, steel, automobiles, consumer durables etc. In fact, almost all the products and services available in the present day world would require the use of machine tools at some stage. With the fast development of new products and services, there is a pressure on the machine tool industry to adapt and develop machine tools to satisfy the changing requirement of the users. In fact, the industrial progress and modernisation of industry is dependent on innovation capability of the machine tool industry.

2.1.2 Development of machine tool production and trade.

The evolution of Indian machine tool industry:

The earliest record of machine tools made in India dates back to 1890, when it is known that some factory and workshop owners in the Punjab State, in the northern part of India, produced machine tools, such as cone pulley, lathes, and drilling machines, mainly for the manufacture of component parts for chaff-cutters, cane crushers, oil expellers and similar simple machines. During the first World War, some engineering companies took up the manufacture of machine tools such as grinders, milling and drilling machines and shell turning lathes. After 1930, some more companies, with better organised production, came up in the eastern and western parts of the country. Later, during the Second World War, a few companies in western India started the production of machine tools to meet the requirement of Indian Ordnance Factories.

After independence in 1947, it was decided by the Government of India to strengthen the machine tool industry of India, as a part of the strategy to achieve industrial growth. One of the earliest

actions in this regard was the setting up of a public sector undertaking, Hindustan Machine Tools Ltd. (HMT), in 1953. It had collaboration with M/s. Oerlikon Machine Tool Works, Buehrle and Company, Zurich, Switzerland. Other machine tool companies, then in operation, also upgraded their technology and diversified their product range.

In the 1950's, the machine tool industry started the production of general purpose machine tools like centre lathes, radial drilling machines, milling and grinding machines etc. with technical assistance from foreign collaborators. As machine building capability of the industry increased, more sophisticated machine tools such as copying lathes, single and multi-spindle automats, gear cutting machines and special purpose machines were built under license. The 1960's was a decade of rapid growth for this industry when horizontal and vertical boring machines, broaching machines, mechanical/hydraulic processes were taken up for production to meet the growing needs of the modern engineering industries. Progress continued in 1970's and 1980's with further diversification of the machine tool range including introduction of CNC machine tools.

Production and Trade:

Though the machine tool sector is important for the growth of the economy, by itself its size is not generally large in proportion to the size of the economy in a country. So is the case with India. As per "American Machinist" of February 1990, India ranks 22nd by volume in the list of machine tool producers in the world in 1989 as shown in the Table 2.1. Table 2.2 and figure 1 indicate the growth of machine tool production, consumption and trade from 1974 to 1989. Prior to this period, position was as follows:-

Year	Production Rs./ Million	Import Rs./ Million	Export Rs./ Million	Consumption Rs./ Million	Share of Production in consumption per cent
1955	6.8	52.9		59.7	11
1960	58.6	209.4		268.0	22
1965	254.8	349.4	1.4	602.7	42
1970	372.3	183.0	27.9	527.4	71
1980	1859.5	1048.6	169.5	2738.6	68

World machine-tool production and trade (millions of US dollars)

Country	1989 (estimated) Production Total	Cutting	Forming	Trade Export	Import
1. Japan	9,816.9	8,041.9	1,775.0	3,765.4	481.1
2. FRG(West Germany)	6,859.7	4,624.6	2,235.1	4,331.9	1,399.6
3. Soviet Union*	c5,000.0	c4,200.0	c800.0	c380.0	c2000.0
4. United States	3,270.0	2,375.0	895.0	945.0	2,445.0
5. Italy	3,067.3	2,217.8	849.5	1,537.3	845.2
6. Switzerland	1,797.6	1,440.6	357.0	1,589.8	440.3
7. United Kingdom	1,597.4	1,251.4	346.0	627.7	837.7
8. GDR(East Germany)*	1,445.3	1,165.0	280.3	1,269.8	299.5
9. France	1,081.4	830.7	250.8	470.2	1,097.1
10.Taiwan	1,016.4	788.6	227.8	667.8	374.2
11.PRChina*	823.6	614.0	209.6	190.0	530.0
12.Spain	795.1	603.5	191.6	325.0	349.4
13.South Korea	760.6	97.7	162.9	76.0	760.0
14.Rumania*	708.8	618.9	89.9	187.7	115.5
15.Yugoslavia	602.1	401.2	200.9	405.0	153.7
16.Brazil	458.0	354.0	104.0	24.0	c35.0
17.Czechoslovakia*	u450.0	u400.0	u50.0	219.3	170.2
18.Sweden	403.4	147.4	256.0	225.0	310.3
19.Canada	383.0	242.5	140.5	193.4	676.9
20.Poland*	c320.0	c265.0	c55.0	c120.0	c250.0
21.Austria	302.5	260.1	42.3	363.0	529.3
22.India	c262.8	152.8	c110.0	c35.0	c145.0
23.Belgium	194.4	27.0	167.4	372.0	411.8
24.Bulgaria*	c175.0	c160.0	c15.0	138.7	93.4
25.Hungary*	124.0	101.5	22.5	96.0	60.2
26.Denmark	72.5	51.3	21.2	61.6	99.2
27.Netherlands	66.5	33.5	33.0	156.6	251.4
28.Singapore	47.9	43.2	4.7	35.8	49.7
29.Finland	c41.0	c6.0	c35.0	c40.0	c110.0
30.Argentina	38.5	30.1	8.4	30.5	33.0
31.Mexico	20.9	13.5	7.4	10.2	203.2
32.Portugal	c17.5	c7.0	c10.5	c10.0	c35.0
33.Australia	15.8	11.1	4.7	7.9	83.8
34.Hong Kong	u12.2	u6.1	u6.1	0.3	8.6
35.South Africa	9.5	5.3	4.2	0.2	66.8
TOTAL	**42,057.6**	**32,088.3**	**9,969.3**	**18,908.1**	**15,742.1**

Source: AMERICAN MACHINIST

Notes: Whenever possible, data includes machine tools only; it does not include parts and attachments.

c = circa. Rough estimate from fragmentary data.

u = unrevised

* = country with controlled currency whose official rate may not represent real value. See discussion below.

Controlled currencies have been converted as follows: Soviet Union, Bulgaria, Poland and China at 70% of official rate; GDR at 65% of the FRG rate. Hungary, Czechoslovakia and China report foreign trade in dollars.

Some countries with high inflation rates (e.g.Argentina,Brazil,Czechoslovakia) report pdtn. in dollars.

Free-mark currencies have been converted at current rates for the period covered. A complete list of the actual exchange rates used is available on request to the editorial office. For 1988, the rate is that reported as the average daily market rate by the International Monetary Fund. For 1989, the IMF rate is used for three quarters, and bank-transfer rates for the final quarter.

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INDIAN MACHINE TOOL INDUSTRY AT A GLANCE

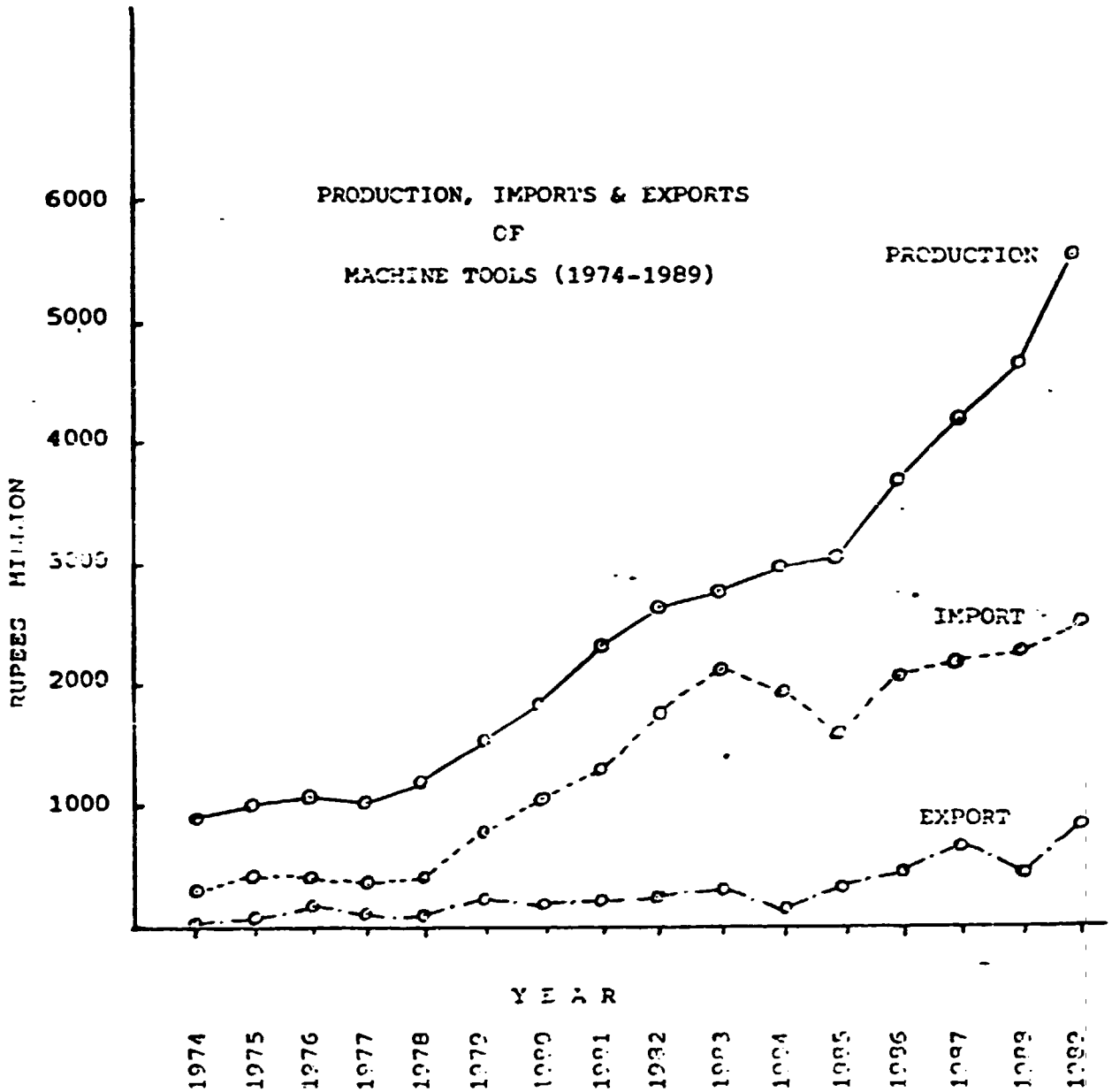
TABLE 2.2

YEAR	PRODUCTION RS/MILLION	GROWTH IN PRODUCTION %	IMPORT RS/MILLION	EXPORT RS/MILLION	CONSUMPTION RS/MILLION	SHARE OF PRODUCTION IN CONSUMPTION %	EXPORT AS PERCENTAGE OF PRODUCTION
1974	884.40	42	294.60	71.20	1107.80	80	8.05
1975	1040.30	18	440.50	81.80	1399.00	74	7.86
1976	1168.50	12	444.90	169.20	1444.20	81	14.48
1977	1095.70	-6	357.20	136.60	1316.30	83	12.46
1978	1210.50	10	400.00	105.90	1504.60	80	8.74
1979	1558.20	29	787.70	182.30	2163.60	72	11.69
1980	1859.50	19	1048.60	169.50	2738.60	68	9.11
1981	2342.10	26	1297.30	187.70	3451.70	68	8.01
1982	2665.10	14	1766.40	197.20	4234.30	63	7.39
1983	2752.00	3	2113.70	241.60	4624.10	60	8.77
1984	2990.70	9	1952.90	175.80	4767.80	63	5.87
1985	3031.60	1	1550.60	296.50	4285.70	71	9.78
1986	3716.70	22	2062.80	463.00	5316.50	70	12.45
1987	4172.70	12	2183.20	699.00	5656.90	74	16.75
1988	4631.60	11	* 2250.00	459.70	6421.90	72	9.92
1989	5552.90	19	* 2500.00	797.00	7255.90	77	14.35

* ESTIMATED

SOURCE INTMA
PRODUCTION-GROUP A & B MACHINES

Figure 1


PRODUCTION, IMPORTS & EXPORTS
OF
MACHINE TOOLS (1974-1989)
PRODUCTION
IMPORT
EXPORT
6000
5000
4000
3000
2000
1000
RUPEES MILLION
YEAR
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989

From these stastistics, it can be observed that the 1960's and 1970's were a period of dynamic growth for the machine tool industry in India. The indigenous production grew from 11% of the consumption in 1955 to around 80% in the mid 1970's. However, the tempo could not be maintained in the following years. The liberalisation of imports and the inability of the machine tool industry to cater to the changing requirement of the users brought own their share in consumption to 60% in 1983. In absolute terms, however, the growth was maintained. The share of indigenous production in consumption started going up again from 1983 onwards; by 1989 it had reached 77%. This was achieved because of the introduction of CNC machines and other equipment required by the users. Export, which has contributed to the growth in production, has been dealt with in detail later in the report.

2.1.3 No. of firms (local, foreign) employment:

There are about 160 machine tool units in the organised sector and about 300 in the small scale sector. However, ten firms in the organised sector accounted for over 70% of the production in 1989. This industry employs an estimated number of 60,000 persons. Foreign firms have not played an important role in the machine tool production of

the country by way of investment in equity. Only 6 or 7 companies have foreign equity varying from 14% to 40%, but the market share of these companies is not yet significant. However, the Indian industry has a large number of foreign technical collaborations.

A recent development of significance is the manufacture of machine tools by the users of machine tools for internal use. Though evidence of such production is there since long, in the small scale and in the organised sector, this activity has increased in the last two decades. A variety of reasons led to the development of this sector. For instance, a large manufacturer of commercial vehicles started making machine tools to meet its requirement of special purpose machines for replacement of old machines and later for expansion of facilities. A fuel injection equipment manufacturer started this activity, as an import substitution effort, to make high precision machines to their collaborator's designs. Such machines having special applications were not available locally. Many other firms also started this activity for a variety of reasons; important among them are as follows :-

(i) Long deliveries quoted by machine tool manufacturers in India and abroad;

(ii) Special quality requirement

(iii) Need for dedicated machines with special design features and small requirement, hence not of interest to the indigenous and foreign manufacturers;

(iv) High prices quoted by indigenous and foreign machine tool manufacturers;

(v) Many features of standard machines remain unutilised, hence low cost machines could be produced without these features to meet their specific requirement.

For the machine tool industry, in some cases, it has resulted in the loss of opportunity to expand its operations. For the users, establishment of machine building capability has given many spin-off benefits. They can make minor alterations on the existing machines to improve their productivity and quality. It gives them encouragement to innovate and improve upon the existing production process since implementation can be fast through in-house manufacture of machines. At the time of routine overhauling of the machines, some modern features could be added to increase their capabili

2.1.4 Means of access to technology:

Growth of the Indian machine tools industry is by and large, based on imported technology. During the period of 1976 to 1988, one hundred and sixty eight foreign collaborations have been approved by the Government of India. One project of significance, executed on turnkey basis in 1953-55, was Hindustan Machine Tools Ltd., with the technical assistance of a Swiss company, which also had 10% equity stake in the company. This project marked the beginning of precision machine tool manufacture in the country.

During the Second World War, manufacture of a few machine tools was introduced through collaborations with firms in U.K., primarily to meet the requirement of the Ordnance Factories. Later, in the 1950's and 1960's, a number of types of machine tools were added to broaden the base of the industry to meet the requirements of the rapidly expanding machine tool user sector. The user sector was also, by and large, using imported technology and its production processes were based on machines available abroad. Hence, machines of indigenous design, whenever available, also did not find ready acceptance. Moreover, the development of machine tool user sector during this period was so rapid

that machine tools produced through indigenous R&D effort, could not have met their technological and delivery requirement. Hence, the machine tool industry, by and large, depended on imported technology for its growth to meet the demand of the user industry. Simultaneously, during this period they also commenced indigenous development of conventional machine tools. Indigenously designed lathes, milling machines, grinding machines etc. found acceptance with users. In-house R&D was also directed to making improvements upon the imported designs and designing new machines to meet the special requirements of the users. Reverse engineering concept was also adopted in many cases. Joint effort along with machine tool companies abroad was also attempted during this period to design machines to meet the requirement of machine tool users in India and abroad. The objective was to share the R&D costs and to use the marketing strengths of the companies in their respective countries. This effort, however, met with limited success and was not pursued vigorously.

To provide institutional back up to the R&D efforts of the industry and to bring in the designs of current technology, Central Machine Tool Institute was set up in Bangalore in 1962 with the technical and financial assistance of the Government

of Czechoslovakia. In the area of metal forming, Central Metal Forming Institute was set up at Hyderabad in 1980.

Prototype Development and Training Centres have been set up at Delhi, Calcutta, Rajkot, and other places to develop simple designs of machine tools for production by the small scale sector. These centres also train personnel and produce prototypes.

In the 1970's, machine tool R&D became qualitatively different from the past because of the introduction of electronics. At this stage, both foreign collaborations and indigenous development went hand in hand. A few types of centre lathes, milling machines, machining centres and electro discharge machines were developed indigenously. For CNC machine tools, involving high technology, reliance was placed on technical collaborations with foreign firms.

Dependence on foreign technology still exists in introducing changes in machine tool building concepts concerning materials of construction, sliding surfaces, drives, in process gauging, controls and software, accessories and attachments etc. New cost effective methods of

building machines have to be evolved by the Indian machine tool industry to remain competitive in the domestic and international market. Technology generation for this purpose is far from satisfactory.

2.1.5 Organisation of Production:

In industrially advanced countries, there is a high degree of sub-contracting by machine tool units. When machine tool production started in India, feeding industry to this sector was not well developed. Hence, factories set up in the early period were highly vertically integrated. They produced their own castings, they had to have well-equipped tool rooms to meet their requirement of jigs, fixtures and special tools. Even parts involving simple operations and low technology were manufactured in-house.

For economic manufacture, a machine tool unit should prefer to produce only such components which have a technical need for special high-cost plant and machinery, and highly skilled staff. Over the years, the feeder industry has developed and so has the small scale and ancillary sector. A new machine tool unit today requires much less of vertical integration than what was required three decades ago.

The first ancillary estate of significance in the machine tool sector came up in Bangalore in 1957-59. Almost all the major machine tool manufacturers are now supported by ancillary units. They also source their supplies from the small scale sector and others who have developed items required in the construction of machine tools. Some of the items available from such sources are castings, forgings, machine tool accessories, sheet metal parts, jigs and fixtures, cutting tools, gauges, machined parts, electrical and electronic assemblies and sub-assemblies.

2.1.6 Product mix, local integration, cost structure and competitiveness:

Product mix and local integration:

By and large, machine tools in India have been primarily manufactured to meet the demand of the local market and effort has been directed towards substitution of imports. Even when products having export potential were introduced, domestic demand was kept in view. Hence, the growth of machine tool industry in India has a close relationship with the development of machine tool using industries. The major machine tool using industries in India are: Automobile, auto ancillary

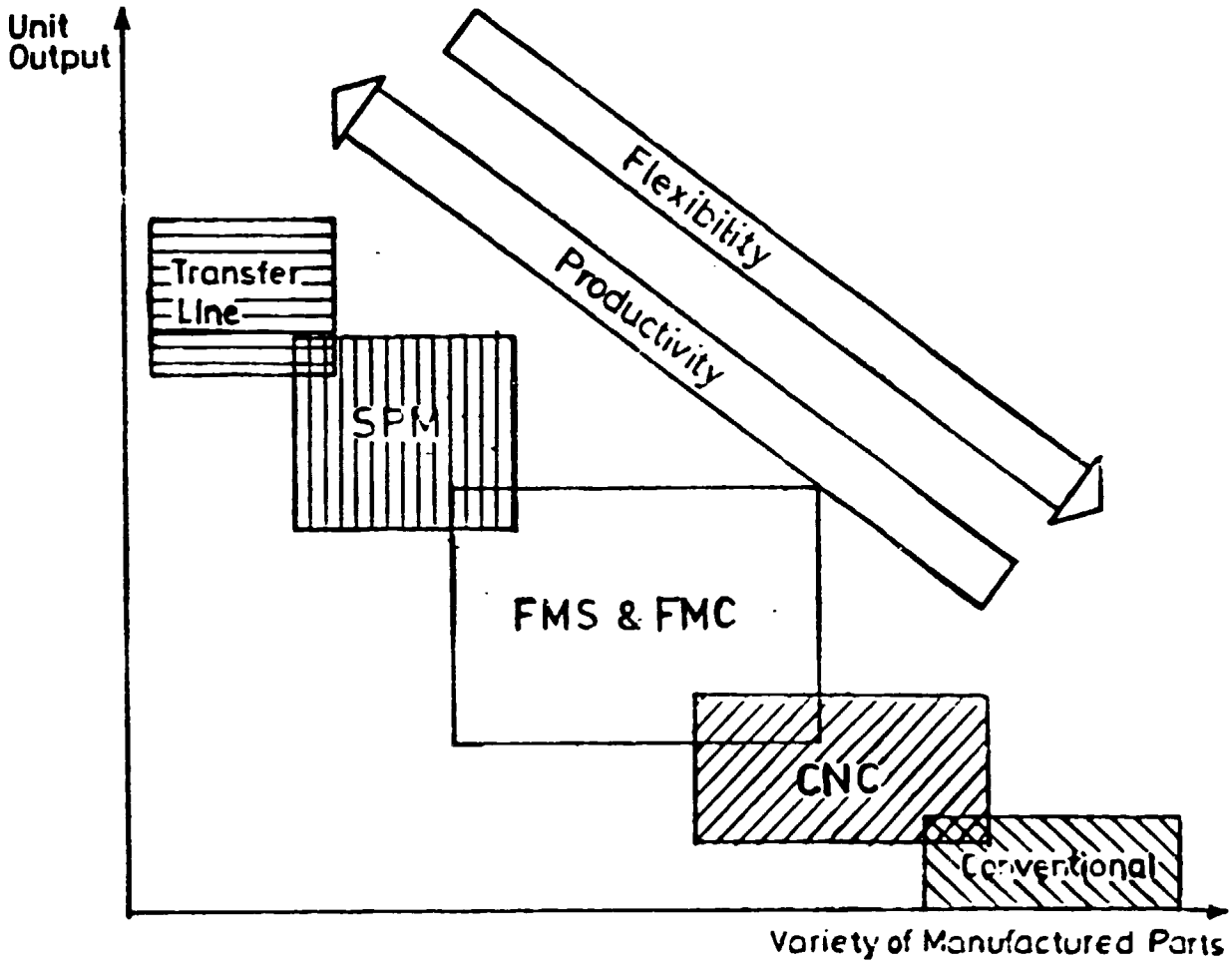
and other transport equipment, industrial machinery, railways, defence, power equipment and industrial intermediates.

Economies of scale, to some extent, were available only in automobile industry, auto ancillaries, watches, electrical & electronic parts, electric fans, electric motors, bearings and some of the house-hold appliances like refrigerators to mention a few. Hence, the bulk of development was directed towards conventional, general purpose machine tools. Figure No. 2 shows the use of machine tool types under various conditions. As it can be seen, CNC machines, FMC and FMS are required when high degree of flexibility is desired whereas special purpose machines are suitable for large volume production.

As the product range of user industry increased, transfer lines, special purpose machines, N.C. machines were added to the product range of the country. Though a beginning has been made, flexible manufacturing systems and manufacturing cells have still to find wide usage. The enclosed list (Annexure-I) of machine tools produced in 1989, gives an idea about the vast range of machine tools which are produced in India.

Figure 2

Trade-off Between Scale Economies and Flexibility of Production in Machine Tools



SPM = Special Purpose Machines
FMS = Flexible Machine Systems
FMC = Flexible Machine Centers
CNC = Computer Numerically Controlled Machines

There is a high degree of local integration in this industry. It is a policy of the Government that in case of foreign collaborations, there should be a progressive increase in the indigenous content through a phased manufacturing programme. This programme is approved by the Government in consultation with entrepreneurs. To start with, higher import content is permitted which progressively goes down as components are developed indigenously. Through this instrument, it is sought to ensure technology transfer and absorption, save foreign exchange and increase local industrial activity. As a criticism of this policy, it has been stated that it results in higher cost of machine tools, since the producer does not have access to the purchase of components at the lowest price available in the world.

Local integration has reached a high level in the case of conventional machine tools, the average import content being below 5%. However, in the case of stand-alone CNC machines, it ranges between 20% to 30% of the cost of the machine.

Cost structure:

Considering international competition, cost of Indian machine tools is high. The cost would depend on many factors, one of which is cost added at the works of the machine tool manufacturer. Various

elements of cost are materials, wages, machining, plant utilisation, inventory costs and other inputs.

Material Cost:

This element constitutes 50 - 60% of the manufacturing cost in production of most of the conventional machine tools in India. They include the cost of raw materials, bought-out items and sub-contracted parts. Main raw materials used are cast iron, steel and forgings. Cost of these materials in India is higher than that of both developed and developing countries engaged in the manufacture of machine tools. Lack of ready availability of these materials poses another problem. Long delivery time and uncertainty of supplies, tend to develop a tendency on the part of the manufacturers to hold large inventories, adding further to the cost.

The cost of bought-out standard parts like bearings, fasteners and electrical parts like motors, switches and relays is also higher than other countries.

Sub-contracted parts and components form a low percentage of the cost of machine tools in India. This situation is, however, changing with the development of feeder, small scale and ancillary industry. Machine tool industry has understood the benefits of sub-contracting. Hence, cost efficiency of this portion is on the increase.

Wage Cost:

Wage rates in India are lower than other major machine tool producing countries. But this advantage is partially lost because of low per - worker productivity. The industry is now conscious of this fact and a number of steps are being taken to increase productivity. They include education, greater involvement of employees in working of the factories, change in management systems, reorganisation of work place, productivity incentives etc.

Machining Cost:

Among others, machining cost depends on the technology level of the plant and equipment, tooling and the process used for machining. In contrast to international competitors, the Indian industry is largely using outdated plant and machinery. It does not permit the use of latest cutting tools and measuring systems and hence machining costs are high. The industry is conscious of this fact and modernisation of the factories has started by way of installation of CNC machines and modern measuring systems. However, the pace of modernisation needs to be stepped up to increase international competitiveness of the industry.

Plant Utilisation:

Plant utilisation of Indian factories is rather low because of a variety of reasons. They are: large product variety, power interruptions, high rejections, poor maintenance of machines, inadequate systems support, work attitudes of employees etc. Low plant utilisation has adverse effects on cost of the machines.

Inventory Cost:

Indian machine tool factories generally hold high inventory in the form of raw materials, components, work-in-progress and finished goods. It can vary from 6 to 12 months of the annual production volume. This results in high cost of carrying inventories. However, concepts like "just in time" manufacturing are being vigorously pursued to reach international levels.

Other inputs:

Cost of capital in India is higher than other major machine tool producing countries . Further, high customs duty and other levies make plant and equipment more expensive.

Competitiveness:

Because of the protection given to the Indian Machine Tool Industry, it has not been subjected to severe international competition in the domestic market. However, a few conventional machines were allowed to be imported, under the easier route of Open General Licence, of course, by payment of customs duty. This change did not result in an increase in the level of such imports. It could be assumed that considering price, quality and aftersales service, Indian users did not prefer to import conventional machines.

The position is, however, different in the case of machines like CNC, involving comparatively much higher import content than conventional machines. Like-to-like comparison reveals that, in spite of protection given by way of customs duty, in many cases, the price of indigenous machines is higher. The reasons are; low volumes of production, high customs duty on imported components, higher input costs in the case of indigenous content and the lack of standardisation because of different sources of technology.

However, competitiveness of indigenous CNC machines like lathes, turning centres and machining centres is improving because of increase in volumes

of production, experience gained in production and in providing presale and aftersales service.

In 1986, the Bureau of Industrial Costs and Prices (BICP), New Delhi, carried out an exercise to compare domestic prices of indigenous machine tools with C.I.F. prices of imported ones. The result is listed below:-

Item	Domestic price (including duties)	C.I.F. Price of imported machine	Difference (2-3) as Percentage of c.i.f. cost (3)
	Rs.lakhs	Rs. lakhs	
(1)	(2)	(3)	(4)
Radial Drill	2.408	1.293	86.23
Surface Grinder	4.658	2.462	89.20
CNC Lathe	15.638	6.591	137.26
Heavy Duty Centre Lathe	22.37	6.48	245.22

The high price of domestic machine tools has been traced to the following:-

- difference in basic raw material and component cost;

- import duty and excise on basic raw-materials and components;
- excise duty and sales tax on finished products, and
- difference in conversion cost.

2.1.7 Market (local and export):

Domestic Market:

Demand of machine tools, being derived demand, depends on the growth of machine tool using industries. Major machine tool using industries in India are: Automobile, Auto Ancillary Industry and other Transport Equipment, Industrial Machinery and Industrial Intermediates, Defence, Railway and Power Equipment. These industries have grown consistantly and are expected to grow further during the Eighth Five Year Plan period beginning 1990.

As can be seen from Table 2.2 on page 47, the consumption of machine tools has been growing steadily from Rs. 1107 million in 1974 to Rs. 7255 million in 1989. The share of domestic production in the total consumption was 23% in 1961; it rose to 83% in 1977. This rising trend changed from 1978 onwards. The consumption of machine tools grew at a higher rate than the domestic production. The share of domestic production in consumption started

declining and it reached 60% in 1983. From 1984 onwards, the share of domestic production has been rising again and it has reached 77% in 1989.

In the 1960's and 1970's, a large variety of machine tools were added to the domestic product range to meet the requirement of the user industry as indicated earlier. However, in this period, internal competition was weak and the user industry was not so demanding since their own products enjoyed protection, as did the machine tool industry. Hence, efforts at modernisation of products and processes did not receive due attention.

The decline of domestic share in consumption occurred as a result of the change in machine tool requirement of the users, consequent to the change in market pattern of their own goods and also as a result of the policy of liberalisation followed by the Government. Internal and to some extent, external competition, developed the need for machines of latest technology, having CNC controls, high precision, limited automation in handling of work pieces and tools, in-process gauging etc. During this period, the Indian engineering industry also started looking abroad for a market and needed machines which would produce goods of the required quality, at costs with which they could compete abroad.

The Indian machine tool industry was aware of the change in technology of machine tools taking place abroad, through their participation in international exhibitions and symposia in India and abroad. They had planned to introduce "state of art" products but the same were not available when suddenly, the market for them developed. After a few years of drop in the share of domestic production in consumption, it picked up again from 1984 onwards. This is because of favourable response of Indian machine tool industry to the changed need of the user industry. There was a gradual increase in the domestic production of CNC machines and they found acceptance with the Indian user.

India has a large replacement market for machine tools. As per census of machine tools 1986, age-wise position of machine tools installed was as follows:-

Age	Metal cutting machines (Percentage)	Metal forming machines (Percentage)
0-10 years	22.5	23
11-20 years	35.7	39
More than 20 years.	41.8	38
	100	100

It can be seen that 77.5% of metal cutting machines and 77% of metal forming machines are more than 10 years old.

Considering the growth trends of machine tool using industries and replacement demand, domestic market will continue to grow for some more years.

Exorts:

Import substitution has been the main aim of the Indian machine tool industry. Projects were not set up with the global market in view, as was done by many other machine tool producing industries in the west, as well as, by the newly industrialised countries. During the period 1967-70, there was a recession in the domestic machine tool market and the demand dropped sharply. It is during this period that, for the first time, a need was felt to develop markets abroad to offset the effect the domestic recession. Export efforts were, however, confined to achieve this limited objective. The opportunities available in the global market were not utilised to develop a strong export base in India as was done by Japan, Korea, Taiwan and a few other countries. India had an adequate machine tool base to expand from; it had knowledge of machine tool building technology and trained manpower to be a world player. The industry was de-licensed by the Government and a number of incentives were offered

for export. The industry is making effort, however, to increase its exports. Though slow, growth in exports has been registered. From the Table 2.2, it is seen that export in 1974 was merely Rs. 71.2 million representing 8.05% of the domestic production. It rose to Rs. 979 million in 1989 representing 14.35% of production.

India's exports are predominantly composed of conventional machine tools, markets for which have been vacated by traditional machine tool exporters like FRG, USA, UK and Japan. South Korea, Taiwan and China , however, have entered the same market and offer stiff competition to the Indian machine tool industry by offering machines at lower prices. They have also captured the market for low-cost CNC machine tools. India has started exporting CNC machine tools in a small way. From 1986 to 1989, cummulative export is Rs. 211 million

In the earlier period, exports were primarily directed to USA, West Europe and Australia. From around 1980 onwards, there was a shift towards the eastern block countries. Bilateral trade with these countries and stiff competition in the western countries has resulted in a change in this pattern.

There is a clear need for the Indian machine tool industry to diversify its markets for a continued growth of export. In 1989, significant exports were registered in the following products:-

Products	Export Rs./Millions
Lathes	115.7
Automats	97.1
Milling machines	88.9
Presses	56.0
Grinding machines	31.1
Gear cutting machines	29.2
Plastic working machines	259.0

The products were exported to 56 countries. However, a major portion of the export was directed to the following countries:-

COUNTRY	VALUE Rs./Millions
USSR	430
BULGARIA	78
ALGERIA	54
IRAQ	50
MALAYSIA	28
POLAND	20
USA	20
W. GERMANY	13
KENYA	13
AUSTRALIA	8

2.2 Production of Industrial automation equipment:

Domestic use of industrial automation equipment started in the early 80's and production also started gaining momentum during this period. The position is described in following pages.

2.21 Local production of CNC machine tools, robots, CAD/CAM and trends:

CNC machine tools (NCMT)

Technological development in machine tools have primarily aimed at increasing productivity, efficiency and accuracy of manufacture. The most important development in achieving these aims has been the infusion of electronics in machine tool manufacture. Starting from stand-alone CNC machines, there has been an increasing application of electronics through integration of computers and robots into the manufacturing process. A variety of functions, which were hitherto carried out manually, are performed automatically with the help of electronic controls. N.C. system was introduced in 1950 by Prof. John T. Parson of USA. The first N.C. machine was built in USA in 1953 and once again the first machining centre was developed in USA in 1959. Machining Centres would combine functions like milling, drilling, boring etc. Automation and flexibility provided by CNC machines have

totally changed machining systems.

Because of high costs of the NCMT's and the unreliability of the numerical control unit, the technology was not widely in use until the early 1970's when N.C. units began to be based on mini-computers. A still more significant change in the technology was the introduction of mirco-computers, a process which began in 1975. The use of micro-electronics was associated with an increase in reliability, simplification in programming, and the automation of other tasks, in addition to setting of the machine, controlling tool movements, selection of tools and transporting of work piece.

The Indian machine tool industry was conscious of the shift in trends in the world towards the production of CNC machines. HMT Ltd., hence, started developing NC/CNC machine tools in 1970 through its own R&D efforts and put up a milling machine, with an indigenously developed N.C. system, in the Asia 72 exhibition in India. The user industry, however, did not show much interest in NC machines in the 1970's. It was only in the 1980's that the demand for CNC machines picked up. Domestic production started growing from 1985 onwards. Table 2.3 and figure 3 give CNC production in various years from 1985 onwards. It can be seen that from the production of 65 Nos. valued at Rs. 128 million in 1985, the production has gone up in 1989 to 457 Nos. valued at

Table 2.3

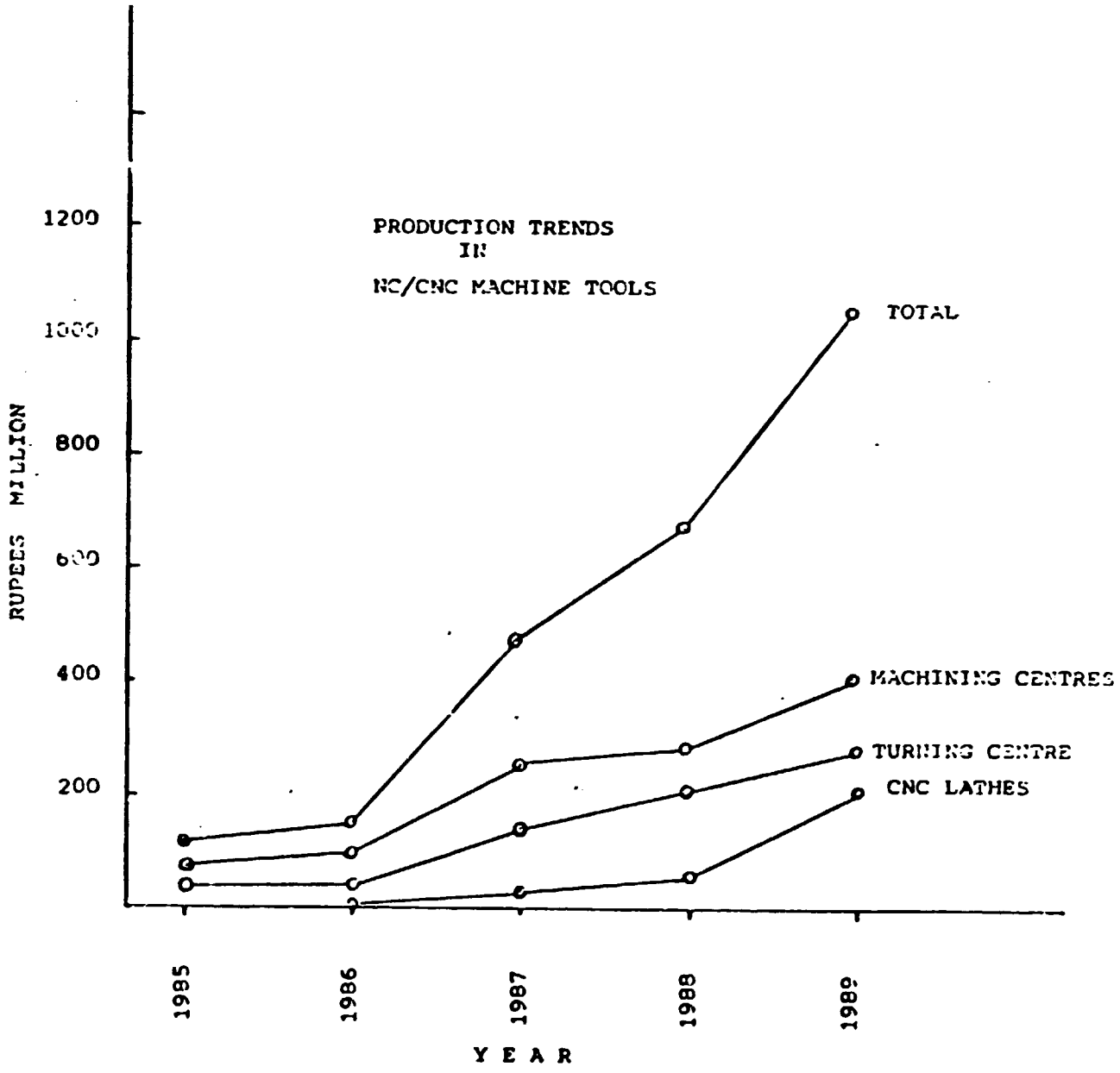
PRODUCTION OF NC/CNC MACHINE TOOLS 1985 - 1989

(Value in Rs.Million)

Description of Machines	1985		1986		1987		1988		1989	
	No.	Value	No.	Value	No.	Value	No.	Value	No.	Value
CNC Lathes/Machines	-	-	4	1.75	24	24.59	21	47.81	95	201.83
CNC Chucker	-	-	-		8	14.23	8	9.04	6	7.71
CNC Turning Centres	28	38.90	23	45.07	57	147.70	95	200.91	170	282.63
CNC Grinding Machines	1	2.80	-	-	1	2.04	6	25.72	6	19.47
CNC Milling Machines	-	-	6	3.52	4	3.62	8	9.27	17	25.24
CNC Drilling Machine	-	-	2	1.05	2	1.20	2	1.06	10	10.81
CNC Boring Machine	-	-	-	-	3	8.78	1	4.75	4	14.41
CNC Wire-cut EDMs	-	-	-	-	9	9.12	30	39.43	35	49.19
CNC SPMs	8	5.36	3	6.00	7	14.39	10	26.18	6	15.56
Machining Centres	28	81.50	50	115.64	85	253.17	71	274.30	96	408.51
CNC Pipe Bending Machine	-	-	-	-	-	-	-	-	6	1.82
CNC Gear Cutting Machine	-	-	-	-	-	-	1	3.00	-	-
CNC Turning & Boring Machines	-	-	-	-	-	-	1	4.50	2	10.60
Milling & Boring Centres	-	-	-	-	-	-	26	23.32	3	2.56
CNC Presses	-	-	-	-	-	-	-	-	1	2.70
CNC Shearing Machine	-	-	-	-	-	-	2	2.70	-	-
Total	65	128.56	88	175.03	200	478.84	282	671.99	457	1053.04
Total Production Group A	12042	2109.0	11092	2240.0	10345	2400.0	8526	2752.0	7911	3393.0
Group A + B	-	3434.6	-	3716.7	-	4172.7	-	4631.9	-	5552.9
% of CNC Production to Group A Machines		6.09		7.81		19.95		24.41		31.03
% of CNC Production to Group A & B Machines		3.74		4.7		11.47		14.50		18.96

Source - IMTMA

Figure 3


PRODUCTION TRENDS
IN
NC/CNC MACHINE TOOLS
RUPEES MILLION
1200
1000
800
600
400
200
TOTAL
MACHINING CENTRES
TURNING CENTRE
CNC LATHES
1985
1986
1987
1988
1989
YEAR

Rs. 1053 million. The share of CNC machines in the total production of group "A" machines was 6.09% and in group A&B 3.74% in 1985. It has gone upto 31.03% in group A and 18.96% in group A&B in 1989.

Over 25 firms are engaged in the manufacture of CNC machines. They produce a wide range of machine tools such as:

> CNC lathes, turning centres, machining centres, milling machines, grinders, electro-discharge machines, boring machines and special purpose machines.

Advantages of using CNC machines have been understood by machine tool users and their consumption, therefore, is expected to grow steadily. The domestic production of CNC machines is also expected to go up in order to meet this increased demand. The Ten Year Perspective Plan for machine tools formulated in November, 1983, projects the production of CNC machine tools as 25% of the total machine tools produced by 1993. A sub-group for machine tool industry, set up by the Ministry of Industry, Government of India, has projected targets of production for Group A and B machine tools as follows:-

Year	Total Production		CNC Machines Production	
	Rs.Millions	Growth Rate percent	Rs. Millions	Percentage of NC/CNC to total Production.
1990-91	6000	14	1200	20
1991-92	6900	15	1400	20
1992-93	8300	20	2000	24
1993-94	10000	20	2500	25
1994-95	12000	22	3600	30

From this table, it may be observed that the projected rate of growth of CNC machines is higher than that of the total machine tool industry.

Considering that 457 machines have been produced in 1989, against 65 Nos. in 1985, it is expected that these projections will come true. There will also be an increase in the variety of machine tools using CNC controls. However, though the manufacture of flexible manufacturing cells has started in India, its usage still is limited. The demand for flexible manufacturing systems has still not developed though, the capability for building such machines exists. In the area of CNC machines too, domestic manufacturers are looking primarily to local demand; entry into the export market is slow. If they step up the rate of growth of export, India could develop a strong indigenous base for the production of CNC machines, which in turn, would also encourage local industry to use more of such

machines. Increased production volumes would also bring down the prices.

Robots.

According to ISO definition, an industrial Robot is an "Automatically controlled, reprogramable, multi-purpose manipulative machine with several degrees of freedom, which may be either fixed in a place or mobile, for use in industrial automation applications". Robot is an important equipment for industrial automation and is widely used along with CNC machines. It is used for material handling, tool handling, assembly, inspection, welding etc. It can take up some of the functions which are normally done manually. It is especially useful for carrying out hazardous tasks. It is an important device to increase productivity.

Manual operation is most economical where the volume of production is low. Robots are cost effective where medium level quantities are involved and rigid automation is more suited to large scale production with special purpose machines. The use of Robots has increased tremendously in Japan and western countries. In Japan alone, the number of industrial Robots has increased from 15000 in 1981 to an estimated 327,000 in 1990. In India, its use is still very limited. A survey carried out in 1989 by the Allahabad University revealed that just over one hundred robots were in use in India. Their use in industry is in the areas of

welding, painting and some other hazardous jobs. It may take a long time before any considerable level of its application is found in the Indian industry. Manual operations are still more economical than the use of this expensive equipment.

At present, three companies in India have taken up production of robotic systems. Production levels are, however, quite low.

CAD/CAM

Computer aided design (CAD) system, is a system which incorporates one or more computers for carrying out some of the calculations and actions involved in product design and analysis. With the help of this system, an engineer can create, visualise and test his design. Modifications can be made until the design suits his requirement. It improves drawing office productivity by its automated drafting. It also eliminates the need to manufacture models.

A computer aided manufacturing (CAM) system, is a system which incorporates one or more computers for carrying out some of the tasks involved in organising, scheduling and control of the operations concerning the manufacture of a product. Where machining is required, it will involve CNC machine tools and the means for providing a part program for them.

CAD/CAM system is a system, in which computers are used to carry out some of the tasks involved in designing and manufacturing a product. In particular, computers are often used to produce part programmes for CNC machines in the system directly from design data. Therefore, CAD and CAM systems are combined into CAD/CAM systems.

These design and production processes make use of computers, printers, graphic terminals and dedicated software to carry 2 or 3 D designing and computer aided manufacturing.

Application of CAD systems in India is increasing at a fast pace in the industry in general and in the engineering industry in particular. Though the use of CAM systems has commenced, it is not yet so wide.

Many firms in India have started supplying such systems. It is estimated that their production in 1989-90 was Rs. 65 crores consisting of 1259 Nos. of systems. However, three companies accounted for the supply of 82% in No. and 90% in value. Systems available are, low cost P.C. based and CAD/CAM work stations. The production is expected to grow to Rs. 100 crores in 1990-91 and then on to Rs. 500 crores in 1994-95. The Indian industry is collaborating with a number of firms from abroad for technology inputs. However, considerable hardware and software capability has already been acquired by the Indian firms.

2.22 Access to technology and technology updating.

Considering the complexity of technology and the importance of CNC machines vis-a-vis user industries, the Government of India has followed a liberal policy towards import of technology. Some of the major foreign collaborations approved are given in Annexure-II. It may be observed that technology has been obtained from a number of well-known sources in Western Europe and Japan. Simultaneously, indigenous development was also taken up.

As mentioned earlier, the development of N.C. machines was taken up in India wayback in 1970 by HMT Ltd. Subsequently, other machine tool companies also entered the field. Through sustained R&D effort, they have developed a large number of models of CNC lathes, vertical and horizontal machining centres, special purpose machining centres, flexible manufacturing cell, cylindrical grinding machines, horizontal boring machines, electro discharge machines etc. These manufacturers have met with varying degrees of commercial success in the domestic and export market. It must be said, however, that R&D work is mostly confined to machine development; very little research work is done by any firm. They have not yet reached stage of developing machines of advanced desig enter the international market earlier than their

competitors. An advantage of indigenous R&D capability has been that the updation of existing designs has been made possible through local effort. This may eventually reduce the need for repetitive import of technology.

The Central Machine Tool Institute (CMTI), Bangalore is well-equipped with R&D facilities. It can take up development of CNC machines for projects sponsored by the industry. But it has not received such orders from the machine tool industry. However, the machine tool user industry is utilising its facilities for the design and development of prototypes for their requirement of special machines. Through a UNIDO assisted CNC Centre, the technology of CNC machine tool development and its applications is being promoted by CMTI. The Institute provides independent testing and evaluation services for new products developed by machine tool industries in India.

With the availability of imported technology and R&D back up to the Indian machine tool industry, it can take a leap forward to compete effectively in both, national and international markets. It will have to respond fast to the rapidly changing technology in this field to gain an adequate market share.

2.23 Local Integration:

Apart from structural elements, other important items used in the construction of CNC machine tools are: CNC system, drive system, ball screws, bearings and measuring devices.

CNC systems represent the brain behind today's highly productive machine tools. They provide a wide range of capabilities. As more machines are integrated into manufacturing systems, CNC provides a link between the machine tool and the central computer. The development of software is an important activity in operating the system.

There is still a high dependence on the import of CNC systems. At present, through HMT's collaboration with Siemens of West Germany, about 40% of the requirement is being met locally. Some other collaborations for CNC systems with Indian parties are, with Anilam and General Electric of USA. Electronica is in the market with an indigenously designed system. Fanuc are in the process of establishing manufacture in India, jointly with two Indian firms. Only HMT has effectively entered the market of new machines. The others have, by and large produced systems for retrofit purposes. With the steady increase expected in the demand for systems, there is ample scope for increasing production and bringing in more sophisticated versions.

However, technology is changing fast and India will have to put together all its resources to produce systems of the "state of art" technology.

In the area of Drive systems, D.C. and A.C. Drives are used. At present, A.C. drives and controllers are imported, whereas, D.C. drives and controllers are available locally, though the entire demand is not met. Efforts are being made to produce A.C. drives and controllers in India.

Ball screws are being manufactured by two machine tool companies but, at present, they can only meet their own requirement, partially or fully. One more company has taken up the manufacture of this item recently to cater to the needs of the machine tool industry.

Bearings and measuring devices are still largely imported. In the case of bearings, however, efforts are being made by some companies to take up the manufacture to meet the local demand.

The import content of various types of CNC machines is reducing progressively. At present, it varies from 20 - 30% of the cost of the machines. As against this, the import content for conventional machines is just around 5%.

2.24 Market - local and export:

Local Market

Considering the advantages of the use of CNC machines, industries which may install them in larger numbers in India are as follows:-

> Aerospace, Defence, Railways, Heavy and Light Electrical Industries, Communication and electronic equipment, Industrial Machinery, Machine Tools Earth Moving, Construction Equipment, Automobile and auto ancilliaries.

All these industries are expected to grow steadily. In the new projects and expansions, there is an increasing use of CNC machines. In the case of replacements, purchases are not generally made on like to like basis. CNC machines find a place in replacement plans of most of the industries in the organised sector. As mentioned earlier, over 77% of machine tools installed in 1985 were over ten years old. Hence, the replacement market is quite large.

In the face of rising labour costs and considering higher productivity, accuracy and flexibility CNC machines offer, there is an ample economic justification for installing them in new projects and as a replacement for old conventional machines. Local market for indigenous manufacturers is expected to grow from Rs. 1000 million in 1989 to around Rs. 3000 million in 1995. Out of the targetted

production Rs. 3600 millllion in 1995, machines worth Rs. 600 million may be exported. Local manufacturers are diversifying their range of CNC production and may offer stiff competition to imported machines. Their share in domestic consumption of CNC machines is expected to go up.

Export Market:

As mentioned earlier, the Indian machine tool industry primarily tends to cater to the domestic market: export for it, is a peripheral activity. In the case of CNC machines, as in the case of conventional machines, their concentration has been on the domestic market. Of course, it is more difficult to operate in the international market place for CNC machines as compared to conventional machines, of which Indian manufacturers have little experience. Factors normally important in the sale of machine tools are: price, quality and reliability, delivery, pre and after-sales service facilities and the reputation of the manufacturer. To gain even a reasonable edge over competitors in this field, calls for tremendous effort and investment - both at the plant level and at the market place. There is little evidence of a move in this direction by the Indian machine tool industry. Through initiative, by way of joint production and marketing, HMT Ltd. succeeded in exporting a few machines in the early 1970's even when the domestic

market for these machines had not fully developed. They did not, however, continue their efforts in this direction and failed to export consistantly. Coming to recent times, from 1986 onwards, export of CNC machines has started. The following table gives the position of the same:-

Year	Total Export in Rs./Millions	Export of CNC machines in Rs./ Millions	Percentage share of CNC machines in total export
1986	463.00	42.9	9.26
1987	699.00	90.3	12.91
1988	459.70	25.9	5.63
1989	797.00	52.1	6.53

It may be observed that the export of CNC machines has varied between 5.63% and 12.91% of the total machine tool exports in the last four years. The industry has still not developed a foothold abroad. It faces competition from countries like Japan, Korea, Taiwan, China, Spain and Italy. The Indian CNC machines are not price competitive and in some cases, lack features offered by other manufacturers.

2.3 Industrial Policy with regard to machine tools and its impact.

As explained earlier, the Government encouraged growth of th.s industry right since the First Five Year Plan. It was felt that for the healthy growth

of the engineering industry, machine tool production should be encouraged. From the point of view of Government policies, there was hardly any restriction with regard to the setting up of this industry or the import of technology for the same.

In the initial period, physical and tariff protection was given to this industry. At a later stage, when it was observed that diversification of this industry would be in the interest of its further growth and better capacity utilisation, broad-banding was permitted. This gave flexibility to the industry to attune their production programme to the market demand. They were also permitted increase in capacity to the level of the highest production achieved by them during any of the previous five years plus 1/3rd thereof. The facility of modernisation and technology upgradation has also been granted to the units operating in this field. In such cases, an increase in capacity upto 49% is allowed. In short, there was no problem for this industry to produce more as per the market requirement.

To give further encouragement to this industry, it was delicensed in 1985. This provision also applied to MRTP and FERA companies if they put up such units in backward areas.

Import of machine tools are allowed under two Provisions:-

(a) Open General Licence; and

(b) Import Licence

Import of one hundred sixty five items of machine tools are allowed under Open General Licence. Import of other machine tools are allowed against a specific import licence where indigenous availability is checked. The Customs duty on various items of machine tools varies from 35% to 115%. The higher rate of duty is applicable to conventional machine tools, however, lower rates of duty are applicable under various conditions like requirement for technology upgradation etc. The duty on import of components is 55.25%. The excise duty on machine tools which was 15.75% has been reduced to 10.5% recently. However, excise duty on NC/CNC machines is only 5.25%. This is to encourage their use by the industry.

Import liberalisation has been done through the expansion of the OGL list from time to time and permitting import comparatively liberally in other cases, considering the type of use they were to be put to.

Import liberalisation in the early 1980's affected the indigenous machine tool producers initially as explained earlier. Their share in the consumption of machine tools went down, but subsequently, the industry responded to the challenge of the market and upgraded their technology of the products and the process of production of machine tools. Their share in consuumption has been growing since 1984.

3. DIFFUSION OF INDUSTRIAL AUTOMATION EQUIPMENT WITH ENGINEERING INDUSTRIES.

Introduction

Until CNC Machines and related equipment appeared on the scene, automation meant mechanisation of production processes. It required large investments and had hardly any flexibility. Such investments could only be justified in the case of large scale production. If a new product or product varient had to be produced, almost the entire line had to be rebuilt.

Now with a combination of CNC Machines, computers, material and tool handling systems etc., both material processing systems and information processing systems can be integrated. In the former system, raw material is processed to finished goods through a series of operations; the latter system receives information regarding status in the material processing system and transmits back orders and control information concerning individual machine operations, as well as, material flow between work stations. With this computerised manufacturing technology, it has become possible to automate small batch production. Major equipment associated with industrial automation is:- Stand-alone CNC machines, Flexible manufacturing cells, Flexible manufacturing system, computer aided design/computer aided manufacturing and industrial robots.

3.1 Analysis of Diffusion of Industrial Automation Equipment.

The Indian engineering industry has been very slow in the introduction of automation equipment. There are a variety of reasons for this like; insufficient market pressure for modernisation, because of the lack of internal and external competition for engineering goods; high cost of automation equipment; lack of back-up facilities to make its optimum use; problem of utilising surplus labour as a result of installation of such highly productive machines and; the cost of labour for certain applications.

To make effective use of such machines, an enterprise has to change the system of management. For example, the flexibility provided by the equipment makes it possible to introduce the concept of "just in time" manufacturing, but it also calls for a number of other related actions. The management has to introduce suitable systems concerning: quality control of input materials, inventory and purchasing, transportation of materials within the shop, tool setting and scheduling. Not many firms are willing to take up this challenge. However, internal and external competition and opportunities for export are encouraging many enterprises to plan for this change. The benefits they visualise are: better quality, higher productivity and lower throughput time.

As per the census of machine tools, 1986, No. of CN/CNC machines installed in India were 1182. In addition to the manufacturing units in large, medium and small scale sector, such machines have been installed by R&D organisations, educational institutions, tool rooms and training centres.

Table No 3.1 indicates that out of 981 machines installed in the medium and large scale sector, 860 were of foreign origin. Turning machines and machining centres accounted for 56% of the machines installed.

Table No. 3.2 shows that only 67 machines were installed in the small scale sector, out of which, 62 were imported. In this case, milling machines and boring machines accounted for 70% of the machines installed.

Table Nos. 3.3 to 3.6 indicate the sector-wise position of the machines installed. Three sectors mentioned below accounted for 832 machines out of 1182 Nos. that is over 70% of the machines installed.

Sector	No. of machines.
Electrical machinery & equipment	206
Transportation (Railway, Auto Sectors etc.)	226
Machinery & Parts (expect electrical)	400

NC Machines installed at the beginning of 1986 in India by medium and large scale units.

Table No. 3.1

Sl.No.	Name of the NC Machines	Quantity installed in Nos.		
		Indigenous	Imported	Total
1.	N.C. Electro discharge Machine	0	53	53
2.	N.C. Flame cutting machine	0	3	3
3.	N.C. Turning machine	79	266	345
4.	N.C. Milling machine	1	103	104
5.	N.C. Drilling machine	0	28	28
6	N.C. Boring machine	9	114	123
7.	N.C. Grinders	0	42	42
8.	Horizontal Machining Centre	12	130	142
9.	Vertical machining centre	11	52	63
10.	N.C. Bending machine	9	25	34
11.	N.C. Punching/Sheering machine	0	25	25
12.	Others	0	18	18
	Total	121	860	981

Table No. 3.2

N.C. Machines installed at the beginning of 1986 in India by small scale sector

Sr. No.	Name of the N.C. Machines	Quantity installed in Nos.		
		Indigenous	Imported	Total
1.	N.C. Electro Discharge machine	0	3	3
2.	N.C. Flame cutting machine	-	-	-
3.	N.C. Turning machine	3	5	8
4.	N.C. Milling machines	0	27	27
5.	N.C. Drilling machine	-	-	-
6.	N.C. Boring machine	-	20	20
7.	N.C. Grinders	-	-	-
8.	Horizontal machining centre	2	-	2
9.	Vertical machining centre	-	5	5
10.	N.C. Bending machine	-	-	-
11.	N.C. Punching/Shearing machine	-	2	2
12.	Others	-	-	-
	Total	5	62	67

Source: Machine Tool Census 1986

Table 3.3

NC Machines installed at the beginning of 1986 by machinery and parts, Except eletrical equipment manufacturers

Sr. No.	Name of the NC Machine	Quantity in Nos.																		
		Construction, mining and materials handling equipments			Steam engine, turbine, boiler, I.C Engine			Industrial machinery			Pumps & Compressor bearing & gear boxes			Machine Tool Jigs, fixture Tools, etc.			Total Machinery and parts		
		Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total
1.	NC Electro discharge M/c.	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	0	4	4
2.	NC flame cutting M/c.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	1
3.	NC Turning M/c.	-	6	6	4	28	32	6	45	51	3	13	16	12	9	21	29	115	144
4.	NC Milling M/c.	-	-	-	-	1	1	-	13	13	-	3	3	-	7	7	-	25	25
5.	NC Drilling M/c.	-	2	2	-	5	5	-	2	2	-	-	-	-	-	-	-	12	12
6.	NC Boring M/c.	2	4	6	-	3	3	-	6	6	-	9	9	3	12	15	5	37	42
7.	NC Grinders	-	-	-	-	-	-	-	4	4	-	14	14	-	1	1	-	19	19
8.	Horizontal Machining centre	-	2	2	10	16	26	-	18	18	1	7	8	-	24	24	12	84	96
9.	Vertical machining centre	-	-	-	1	-	1	-	13	13	1	1	2	1	6	7	5	22	27
10.	NC Banding M/c.	-	4	4	-	3	3	-	-	-	-	-	-	-	1	1	-	8	8
11.	NC Punching/ Shearing M/c.	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	0	7	7
12.	Others	-	4	4	-	1	1	-	4	4	-	1	1	-	2	2	0	13	13
	Grand Total	2	22	24	15	57	72	6	107	113	5	49	54	16	64	80	51	349	400

Source : Machine Tools Census 1986

Table 3.4

NC machines installed at the beinning of 1986 in India by Transportation Sector
(Railway Rolling Stock, four-wheelers, two/three wheelers, automobile ancillary, etc.)

Sr. No.	Name of the N.C.	Quantity installed in numbers															
		Rly. rolling stock			Four-wheelers			Two/three wheelers			Automotive ancillary			Total for TPT. Sec.		
		Ind.	Imp.	Total	Ind.	Imp	Total	Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total
1.	NC Electro Discharge M/c.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.	NC Plane cutting machine	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
3.	NC Turning M/c.	3	32	35	1	5	6	-	4	4	3	10	13	10	75	85
4.	NC Milling M/c.	-	2	2	-	-	-	-	1	1	-	6	6	0	30	30
5.	NC Drilling M/c.	-	-	-	-	-	-	-	-	-	-	3	3	0	5	5
6.	NC Boring M/c.	-	1	1	-	4	4	-	21	21	-	4	4	0	46	46
7.	NC Grinders	-	-	-	-	4	4	-	-	-	-	9	9	0	14	14
8.	Horizontal machining centre	-	1	1	-	1	1	-	3	3	-	3	3	0	23	23
9.	Vertical machining Centre	-	-	-	1	-	1	-	1	1	-	-	-	1	12	13
10.	NC Banding M/c.	-	-	-	1	-	1	3	-	3	-	-	-	4	4	8
11.	NC Punching/ Shearing machine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12.	Others	-	-	-	-	1	1	-	-	-	-	-	-	-	1	1
	Grand Total	3	36	39	3	14	17	3	30	33	3	35	38	15	211	226

Source : Machine Tool Census 1986

Table 3.5

NC Machines installed at the beginning of 1986 in India by Electrical machines & equipments (Power generators, motors, transformers, electrical appliance, communication and electronic equipments)

Sr. No.	Name of the N.C. Machine	Quantity installed in numbers											
		Electrical equipment, generator, transformer motors			Communication and Electronic equipment			Electrical appliances			Total electrical machines and equipment		
		Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total
01.	NC Electro discharge machine	-	14	14	-	13	13	-	2	2	-	29	29
02.	NC Flame cutting M/c.	-	-	-	-	-	-	-	-	-	-	-	-
03.	NC Turning M/c.	13	18	31	-	5	5	4	-	4	17	23	40
04.	NC Milling machine	1	3	4	-	33	33	-	-	-	1	36	37
05.	NC Drilling M/c.	-	1	1	-	10	10	-	-	-	-	11	11
06.	NC Boring machine	-	4	4	-	15	15	4	4	8	4	23	27
07.	NC Grinders	-	3	3	-	-	-	-	-	-	-	3	3
08.	Horizontal machining Centre	-	15	15	-	4	4	-	2	2	-	21	21
09.	Vertical machining Centre	1	-	1	-	13	13	-	-	-	1	13	14
10.	NC Banding machine	-	-	-	-	5	5	-	-	-	-	5	5
11.	NC Punching/shearing machines	-	5	5	-	11	11	-	2	2	-	18	18
12.	Others		1	1	-	-	-	-	-	-	-	1	1
	Grand Total	15	64	79	-	109	109	8	10	18	23	183	206

Source : Machine Tools Census 1986

Table 3.6

NC Machines installed at the beginning of 1986 by basic metal, metal products, Educational, training & R & D Organisations.

Sr.	Name of the NC machine	Quality installed in Nos.								
		Basic metal industry			Metal products except machinery & Transport equipment			Educational, training and Research & Development Organisations		
		Ind.	Imp.	Total	Ind.	Imp.	Total	Ind.	Imp.	Total
01.	NC Electro discharge M/c.	-	12	12	-	6	6	-	3	3
02.	NC flame cutting M/c.	-	-	-	-	-	-	-	2	2
03.	NC Turning Machine	7	12	19	16	31	47	4	29	33
04.	NC Milling machine	-	4	4	-	8	8	3	17	20
05.	NC Drilling machine	-	-	-	-	-	-	-	3	3
06.	NC Boring machine	-	-	-	-	4	4	-	6	6
07.	NC Grinders	-	-	-	-	6	6	-	9	9
08.	Horizontal machining centre	-	2	2	-	-	-	-	15	15
09.	Vertical machining centre	2	-	2	2	4	6	2	1	3
10.	NC Banding machine	2	2	4	3	6	9	1	0	1
11.	NC Punching/Shearing M/c.	-	-	-	-	-	-	-	2	2
12.	Others.	-	-	-	-	3	3	-	1	1
	Grand Total	11	32	43	21	68	89	10	88	98

Source : Machine Tools Census 1986

From 1986 onwards, well documented data is not available regarding machines installed subsequently. However, a recent sample survey carried out by the Directorate General of Technical Development (DGTD), Government of India, indicates trends in recent purchases of the automation equipment by the different industry groups in India. A questionnaire was sent to the likely major users of the automation equipment. They were asked information regarding their purchases from 1980 to 1989, yearwise, for conventional machines, SPM's, NC/CNC machines, FMC, FMS and CAD/CAM equipment. Twenty five units, which are major manufacturers of automobiles, auto ancilliaries, machine tools, power generation sector (electric motors, generators, switch gear), industrial machinery (compressors, chemical machinery, dairy equipment) and consumer durables responded. The summary of their purchases is given in table 3.7. It may be noticed that the investment in NC/CNC machines started, in an appreciable way, only from 1984 onwards and increased substantially from 1987 onwards. The use of CAD/CAM systems, started in 1987 and it has still not reached any sizeable level.

Apart from the sample survey, this subject was discussed with a few representatives of the major machine tool users. The sector-wise findings are as follows:-

Table: 3.7

Details of investments made by units in Machine Tools (Units surveyed)

In Rs. Million

Item	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
GPM	332.0	407.6	420.1	428.2	671.1	478.2	527.8	608.6	495.9	726.5
SPM	101.0	115.5	36.9	53.8	85.0	227.8	406.8	236.6	390.5	339.5
NC/CNC	6.5	106.6	76.2	111.5	322.9	226.8	323.0	468.0	375.8	663.1
CAD/CAM	-	-	-	-	0.2	0.5	1.6	5.2	6.5	100.4
FMC/FMS	-	-	-	-	-	-	-	-	-	-
Total	439.5	629.7	533.2	593.5	1079.2	933.3	1259.2	1318.4	1268.7	1829.8
Percentage of CNC/NC CAD/CAM FMC/FMS over total investment	1.47	16.92	14.29	18.78	29.93	24.35	25.77	35.89	30.13	41.72

Number of firms, who responded to DGTD survey in each sector:

1.	Automobiles	8
2.	Automobile Ancillaries	2
3.	Power Generation	5
4.	Machine Tools	3
5.	Industrial Machinery	4
6.	Others	3
	Total:	25

Source: DGTD - Sample Survey 1990

Automobile Sector:

Wherever large volumes are involved, the firms have gone for line production system for the major components. Such lines have high productivity special purpose machines. Even GPM's used for intermediate/final operations are dedicated machines, specially tooled up for carrying the designated operations. The CNC machines such as machining centre, wire cut EDM, CNC jig boring machine, CNC milling machines, etc. have been introduced in the tool rooms and for production purposes. Also in use are CNC coil winding machines and CNC automatic buffing machines. Some of the firms have introduced main-frame computers for computer aided design, tool engineering and the development of individual components. These firms have also introduced computer aided manufacturing for the tooling and are in the process of introducing the same for the mass production of components. They have also introduced robotics for the multi-spot welding SPM. Even in the GPMs, the firms have provided for auto gauging. Some of the machines have also been equiped with auto loaders. They have also retrofitted DROS and CNC systems on the existing machines. The painting operations have been automated through the use of electrostatic bell applicators and automatic colour changing system. Large scale conveyors for material handing operations have also been introduced.

One of the major manufacturers of automobiles, has installed DEC-ELEXSI computer system for computer aided design of auto parts, machine tool elements and press tools / . . dies using IDEAS and Euclid CAD/CAM packages. Euclid has the facility for preparation of part program tapes for use on CNC machines. This company is planning to introduce integrated CAD/CAM system for press tools and die manufacture . For this purpose, they propose to install 5 Axis CNC die-sinking machine, model making and digitising machines and co-ordinate measuring inspection machines shortly.

In the sample survey of DGTD, 8 firms responded. Their investment in CNC machines started from 1983 onwards. Cummulative investment of these firms in 1983 was 3% of their total machine tool purchases; it rose to over 38% in 1987 and dropped to 24% in 1989.

One of the tractor manufacturers who has introduced automatic head changer for machining of a component has reported following advantages:-

One head changer replaced six conventional machines; 38% saving in the cost per piece for the same operations; 61% reduction in conveyor space; 50% reduction in power consumption; 65% reduction in the number of operators and 66% reduction in number of supervisors.

One of the auto ancillary units has introduced high precision honing machines, CNC super finishing machines and creep feed grinding machines. Another automobile component manufacturer, has introduced CNC chucker and turning machines. In addition to using SPM and dedicated machine tools, many machine tools have been fitted with program logic controllers to enhance the performance by controlling the process sequence and thus achieving repeatability and better quality parts. Low cost automation has been extensively used in feeding, clamping/de-clamping of parts, both in manufacturing and assembly areas. A number of fully automatic assembly machines have been introduced for sub-assembly of parts to eliminate labour intensive operations and to improve productivity and quality. Similarly, in the revitting machine, hoppers or bowl feeders have been introduced for automatic revitting operation. One firm has introduced the concept of modular cells. Kanban system has been introduced in all the modules. These cellular manufacturing systems have been resorted to in all manufacturing and assembly areas of the factory. It has resulted in multi-fold benefits besides increased productivity and quality. Two major auto ancillary units responded to DGTD sample survey. They started investing in CNC machines in 1985, when they constituted 10.65% of their total machine tool purchases. In subsequent years, this ratio has varied between 26 to 47%.

Machine tools:

A leading machine tool manufacturer has planned a continuous changeover from the conventional manufacturing system to flexible manufacturing system, which is more suited to their product range, with its characteristic features of a large number of varients of small batch quantities. The thrust has been on installing machining centre, SPM and CNC machines as replacement and for balancing of the capacity. Retrofitting of CNC system to the existing machines has also been resorted to. The firm proposes to changerover progressively to computer integrated manufacturing (C.I.M.). The retrofitting of auto gauging unit to the cylindrical grinding machine for dynamic measurement of parts, has resulted in the following benefits:-

Parts confirmity is very high; rejection is negligible; and in-process control is easier.

The other manufacturers in the machine tool sector have introduced retrofitting of of NC/CNC systems and DROS, which have resulted in considerable improvement in the quality and efficiency of their products.

This manufacturer has also introduced CAD centre with the following facility:

3 P.C. based work stations, one A-1 size plotter and one A-3 size printer.

The software for these machines is the latest auto CAD release 10, which is versatile for preparation of mechanical drawings.

Three machine tool firms have responded to the DGTD suyvey. They are progressively switching over to the use of CNC machines and CAD/CAM systems. In fact, replacements are being planned mostly by such machines.

Power generation equipment.

One of the D.G. set manufacturers has set up a sophisticated system, where the stater and rotor assembly of the alternators are manufactured with the help of automated CNC equipment. The emphasis has been placed on process quality engineering to avoid rejections. Each generator is tested completely on a CNC performance testing device.

Another major manufacturer of power generation equipment has gone in for retrofitting of a CNC system on the existing equipment. The retrofitted machines have increased productivity by 40 - 50% and have helped in better repeatibility and dimensional controls, as well as, machining of such critical components, which was not possible earlier on conventional machines.

One more electrical equipment manufacturer has reported that they have started installing CNC machines from 1986 onward and they have contributed

towards an increase in productivity of the order of 4:1, as compared to conventional machines. These machines have also helped them to achieve a zero defect level in manufacturing precision components. In addition, they have been able to reduce through-put time considerably and consequently, the inventory. For winding operation also, this firm has introduced a special purpose machine for torodial winding. Introduction of this machine has given them a productivity advantage of 5:1. They have also installed a CAD facility for design work. Five firms responded to the DGTD sample survey. Their cummulative investment in CNC machines was 3.8% of the total machine tools purchased in 1980, 28% in 1985 and since then it has varied between from 38% to 44%.

Industrial machinery:

As a result of the introduction of CNC machines in their manufacturing facility, one manufacturer has reported the following advantages:

> Increased production efficiency, better quality output, reduced inventory cost, reduced lead time and improved worker motivation.

A manufacturer of compressors has reported that with the introduction of CNC machines, they initially faced technological problems, but they were solved with the help of Indian machine tool producers. The benefits they have reported are increase in

productivity, and consistancy in quality of production. The firm has also introduced a CAD/CAM system in their unit.

One of the rolling bearing manufacturers have introduced SPM/NC/CNC/MTC machines in their following sections:- grinding; assembly and tool room.

The machines have auto-gauging system and have helped them in maintaining close tolerances. The grinding machines have micro processor controlled system, for controlling the grinding cycle sequentially and this system also helps in fault tracking. All the machines are inter-connected with chutes, belt conveyors, slat conveyors, specially designed plastic linked conveyors, elevators, etc.

The automation has resulted in the following advantages for them:- reduced maintenance/down time; better and consistant quality; reduced scrap and reduced re-work, resulting in increase in productivity.

The sample survey of DGTD reveals that in this sector also, there is an increasing use of CNC machines, as well as, CAD/CAM systems. They started installing CNC machines from 1981 onwards.

3.1.1 The reasons for purchasing NCMT, problems raised and utilisation of CNC machine tool compared to conventional.

The analysis given in 3.1.1, is based on the sample survey and the discussions held with the major machine tool manufacturers, those involved with auto and auto ancillary sector and intermediate engineering goods. The reasons, which have emerged in favour of purchase of NCMT, problems faced in doing so, and general observations are listed below.

New factories are being predominantly planned, based on the use of CNC machines. However, the use of FMS is not yet envisaged mainly because of the high cost of such equipment in India. Though the advantages of its use are clearly understood by the entrepreneurs, the cost per piece produced does not justify its use. To manufacture an FMS line in India, equipment like the automated guided vehicles (AGV) and a number of electronic components have to be imported. High customs duty on them contributes considerably to increase in its cost. One FMS line with AGV and, automatic loading and unloading, is in operation in India. Some manufacturers have installed machining cells with pallet changers and tool head changers, but full use of their flexibility is being made only in a few cases. Eight or more flexible turning certres are in operation in the country.

In case of the older units, expansions are being planned based on CNC machines. Main advantages anticipated are: better quality, reduction in work in progress, decrease in through-put time, flexibility, high increase in turn-over with only marginal addition to man-power and reduction in lead time to introduce new products.

In case of replacement of the old machines with new ones, the situation is slightly different. CNC machines would normally replace 3 to 5 conventional machines. An effective use of the labour rendered surplus has to be simultaneously planned by the unit, because of the difficulties involved in separations. In cases, where the business of the unit can be expanded, and the surplus labour can be usefully employed for this purpose, the replacement is done with CNC machines. Otherwise, the old machines may be reconditioned or replaced on like to like machines.

In certain cases, where intricate profiles have to be generated, as in the industries like aircraft and power generation equipment, CNC machines become a technical necessity. These industries in India, were one of the earliest users of CNC machines.

In the case of machine tool industry in India, most of the manufacturers have a large variety of machines in their range and volumes are generally suitable for small batch manufacture. In addition, for

building special purpose machines, small quantity of components, in a large variety, have to be produced. The components of machine tools have to be manufactured to close tolerances and a number of operations have to be carried out on them. Considering this requirement, the machine tool industry is aware of the advantages of the use of CNC machines, FMC and FMS. It is progressively switching over to stand-alone CNC machines e.g. replacing centre lathes and copying lathes with CNC lathes and turning centres; boring and milling machines with machining centres and planning machines with CNC plano-millers, to give a few examples. They are, however, slow in introducing FMC and FMS because of high initial investment, risks involved with this change-over and, in some cases, higher cost per piece produced as compared to the current process.

An important aspect, which will help in the increased use of CNC machines, is that the user industry is no longer afraid of using such machines. They are confident of providing infrastructure required for their use and in organising trained manpower to operate the system. The skill saving through CNC machine is not a major consideration with the Indian buyer. For conventional machine, there is a need to have an operator who can obtain the required accuracy through his skill; in case of CNC machine, though similar skill is not required, an educated operator is needed who can interact with the machine computer and understand

various functions of the system. Hence, operator with manual skill is replaced by the one with superior education and training. There is no saving in cost on this account.

Change from manufacture based on conventional machines to CNC machines, affects the working of almost all the disciplines in a factory. To start with, the purchase decision for the equipment has to be made carefully, since comparatively larger investment is involved in CNC machines. There are initial fears about the reliability of the equipment, since one is dependent on fewer CNC machines instead of a large number of conventional machines. In case of breakdown of a conventional machine, the job can be transferred to some other conventional machine; such an alternative is not easily available in case of CNC machines, since at times, there may be only one machine of a kind available in the factory.

There is a serious concern about repair and maintenance of CNC machines. Problems have been faced by the users in procuring spare parts, particularly for CNC control system, since electronic parts are mostly imported.

Training of the management personnel and workers was another area of concern, but now adequate back up of institutions and industry supplying the machines is available.

Continuous availability and the quality of power is a major problem for full utilisation of CNC machines. Use of voltage regulators and captive production of power has been reported by the industry.

Inadequate quality of castings, forgings and other input materials has been a problem which is being tackled by the industry.

Costs on the related facilities, like dust free areas, air-conditioning, inspection equipments etc. tend to push up requirement of capital.

For efficient use of high cost equipment, systems relating to production planning, material management and quality assurance had to be redesigned. This called for arranging involvement of the entire organisation to make the use of NCMT's a success.

The organisations contacted had not kept any record of the utilisation of CNC machine vis-a-vis conventional machine. It was, however, clear that they aim at achieving higher utilisation of CNC machines. They run them round the clock, in many cases, to get adequate return on high capital employed. In some cases, there is a tendency to keep the conventional machines on the shop floor, though CNC machines have been installed to replace them. The managements, however, realise that this is not a healthy practice and proves a deterrent to spreading the culture of use of automation equipment.

3.2 The Market Trends for Industrial Automation Equipment:

As explained earlier, the Indian machine tool users have become aware of the advantages of introducing automation in their factories. The extent of automation will depend on the economic justification in each case. However, the trends indicate that stand-alone CNC machines will be increasingly used by the industry in new factories, as well as, for replacement. The use of FMC is becoming popular, but during the next five years growth of its use will be slow. FMS has not so far been found to be a good proposal for investment, but it is expected that its use may start if its prices come down. The use of Robots has started, though in a small way. It is expected to grow, particularly, in the field of welding and in hazardous tasks.

It can be observed from the analysis at 3.1.1 above that the use of NCMT is growing at a fast rate. It is reasonable to assume that similar trend will continue because the machine tool user industries are expected to have sustained growth as per draft projections of 8th Five Year Plan beginning 1990-91.

There is an increasing awareness of advantages of CAD among the user industry. A number of companies in the field of Auto industry, machine tools industrial machinery, electrical machinery, structurals and R&D institutions have started its use. In some cases,

computer aided manufacturing (CAM) has also commenced. The status of use of CAD/CAM has been discussed earlier at 2.2. Out of 25 firms in our sample survey, 12 have reported the use of CAD. Their application is bound to grow at a fast rate in the years to come.

4. CONCLUSION:

4.1 The economic costs and benefits of an entry into the machine tool industry for a developing country

The Indian Experience

Economic Benefits: As stated earlier, at the time of independence in 1947, India was essentially an agrarian economy. However, the country with its vast natural and human resources was also ideally suited for industries. The problems of poverty and unemployment, among others, needed to be tackled. It was felt that rapid industrialisation was essential for the development of agriculture and other sectors of economy, as well as, to raise per capita income. India had, however, limited resources for investment. The investment strategy then formulated, laid emphasis on heavy industries producing basic machines and basic metals. The purpose of this strategy was to achieve self-sustained growth.

It is under this policy framework that the development of engineering and machine tool industry was taken up. India had natural resources like coal and iron ore, and steel was being produced at competitive prices. The other required resources were also available for promoting the growth of engineering industries. India took up engineering

industry as a growth area, since it is labour intensive. Moreover, with the availability of low cost labour, it could effectively compete in India and abroad. Through this strategy, the value of output of the engineering industry has gone up from Rs. 58.90 crores in 1950-51 to Rs. 57227 crores in 1988-89. Engineering exports have gone up from Rs. 3 crores in 1950-51 to Rs. 2258 crores in 1988-89. In the same period, employment in this sector has gone up from 0.14 million nos. to 2.42 million nos.

For the growth of the engineering industry, easy availability of machine tools is essential. Being "mother machines", they are an important part of the capital goods installed in an engineering establishment. The conditions for setting up a machine tool industry were favourable, considering the availability of low cost labour, material and an expanding market. Initially, the production of technology conventional machines was taken up with the help of imported technology. The engineering industry in India made full use of these locally manufactured machine tools, considering that the share of indigenous machine tools in consumption increased from 11% in 1955 to 83% in 1977. Hence, the Indian machine tool industry has played a vital role in the growth of the engineering industry.

It might as well be argued that the engineering industry could also have grown with the help of imported machine tools. Perhaps so, but the spin off benefits of having a machine tool industry cannot be ignored. Along with a machine tool, a large number of accessories and cutting tools are used. They can be manufactured by small scale industries, which are employment oriented. Along with the growth of the machine tool industry, this sector of industry has also grown. So much so that, at times, the basic machines are imported and they are tooled up and engineered in India. The benefits have not been limited only to the generation of employment, there has also been a large scale generation of skilled manpower. This manpower forms a new class of technocrat entrepreneures who, with the help of state promotion agencies and the banking institutions, have set up small to medium scale enterprises, thereby increasing the industrial activity. The machine tool industry in India has thus helped in spreading the industrial culture. Another advantage of significance has been the capability developed for manufacture of spare parts, thus reducing maintenance costs of the economy which has scarce capital resources. Indigenous capability in machine tool production has also helped in keeping a check on the prices of imported machines.

India had a good reason for producing conventional machine tools, even in the general economic sense. They were produced at competitive prices and were also exported. Hence, it was not necessary to depend on the imported conventional machine tools for growth of the engineering industry. However, in the initial period, it is difficult to justify

local manufacture of the machines of high technology like CNC machines, high precision grinders, jig borers etc. They require high skills, the volumes involved are low and the components and materials for these machines may not be locally available. The considerations which favour the production of such machines at a subsequent stage are: self-reliance for strategic industries in the country and expectation that some of these machines may find wider usage in the country with the passage of time and justify economic manufacture. An early start in building such machines generates skills to use imported machines effectively and increase the confidence of the industry in the use of high-tech machines.

Economic Costs: To analyse economic costs to the country of entry into the machine tool industry, it is necessary to trace its growth. This industry was given a heavy protection through tariffs, as well as physical controls. In the initial period it was justified since, in its nascent stage, it could not have withstood the competition from imports. The protection was, however, continued even when the industry matured. It resulted in the availability of a captive domestic market to the industry thereby increasing the prices of the products. Moreover, inadequate attention was paid to quality and there was no incentive to modernise the products and the processes of manufacture Eventually, exports were also

affected on the considerations of prices, product quality and product features.

The cost to the economy was not limited to the machine tool industry alone. The domestic engineering industry was given machines of inadequate quality, at high prices. Hence, in turn, their production suffered in respect of cost and quality. Protection to the Indian machine tool industry also resulted in the delayed introduction of high technology machines in the user sector. Consequently, not only did they produce high cost products, their exports also suffered.

The liberalised import introduced in 1980's reversed this trend. After the initial shock, resulting in higher imports of machine tools, particularly CNC, the industry is finding its feet again and its share in the domestic consumption is going up and so are the exports.

Analysis: Through this experience, it is felt that a developing country should promote machine tool industry to spread industrialisation and create employment opportunities. However, protection should be given to the industry for a limited period. A base for production of high technology machines should be established for utilising

opportunities in the domestic and global markets. At the same time, the import of high technology machines should also be permitted to the users to keep their production facilities uptodate.

4.2 Relevance of industrial automation in engineering industries for developing countries:

The implications of the use of various stages of automation in industry have been discussed earlier. The Indian experience shows that the use of stand-alone CNC machines in the engineering industry is growing at a very fast pace and same is the trend in the use of computer-aided-design equipment. There is, however, slow growth of the next higher stage of automation i.e. the use of FMC, FMS, Robots and computer aided manufacturing, primarily because of the lack of economic justification. Stand-alone CNC machines are also being increasingly used by the small scale sector to meet cost, quality and technical requirements of the factories which give work to them. Export oriented industries and those facing stiff internal and external competition are also using such machines.

At the national level, however, automation is seen as labour displacing and not whole heartedly supported in the face of large scale unemployment.

The use of the extent of automation in developing countries will depend on their strategies for economic growth and the problems they face. It will also depend on the extent of self-reliance they desired for strategic reasons. For certain industries like defence, space, air-craft, power generation etc., it is a technical necessity to engineer and machine the components. If the economic development is planned through exports and global operations, automation will be a necessity. The industry will have to compete with goods produced in automated plants at the international market place. If unemployment is a problem for the country, there is a risk of aggravation of the same, unless there is a large scale growth in production and consequent generation of opportunities for employment in service industries. The strategies, in such cases, would involve introducing technologies which would create employment opportunities in the long run.

To summerise, it is apparent that a developing country cannot ignore the trends in the world towards a gradual increase in automation in engineering industry. The extent and the pace of growth may vary from country to country.

Annexure-I

SUMMARY OF MACHINE TOOL PRODUCTION DATA 1989

Qty. in Nos. Value in Rs. Million

S/N	PRODUCT	TOTAL QTY.	TOTAL VALUE
	GROUP - A		
1.	AUTOMATICS	559	152.54
2.	CAPSTAN AND TURRET LATHES	156	29.77
3.	CENTRE LATHES	2149	281.54
4.	COPYING LATHES	21	19.77
5.	OTHER LATHES	18	145.70
6.	BORING MACHINES	190	163.59
7.	BROACHING MACHINES	14	5.54
8.	DRILLING MACHINES	641	82.87
9.	TAPPING & THREADING MACHINES	45	10.20
10.	MILLING MACHINES	1263	228.78
11.	PLANING MACHINES	8	30.25
12.	SHAPING MACHINES	57	5.10
13.	SLOTTING MACHINES	1	0.38
14.	GEAR CUTTING MACHINES	62	61.51
15.	GRINDING MACHINES	996	234.35
16.	LAPPING/HONING & POLISHING MACHINES	22	6.02
17.	SAWING & CUT OFF MACHINES	116	4.64
18.	BENDING/STRAIGHTENING MACHINES	48	46.58
19.	FOLDING MACHINES	29	0.78
20.	PRESS BRAKES	25	15.27

S/N	PRODUCT	TOTAL	
		QTY.	VALUE
21.	PRESSES	357	312.84
22.	PUNCHING SHEARING CROPING MACHINES	34	20.99
23.	NIBBLING MACHINES	17	1.66
24.	FORGING MACHINES	18	51.44
25.	SPARK EROSION MACHINES	87	29.05
26.	CNC LATHES / TURNING MACHINES	95	201.83
27.	CNC CHUCKER	6	7.71
28.	CNC MILLING MACHINES	17	25.24
29.	CNC TURNING CENTRES	170	282.63
30.	CNC DRILLING MACHINES	10	10.81
31.	CNC GRINDING MACHINES	6	19.47
32.	CNC BORING MACHINES	4	14.41
33.	CNC PRESS	1	2.70
34	CNC BORING AND TURNING MACHINES	2	10.60
35.	CNC WIRE CUT EDMS	35	49.19
36.	CNC SPMS	6	15.56
37.	PIPE BENDING CNC	6	1.82
38.	CNC BORING & MILLING CENTRE	3	2.56
39.	CNC VERTICAL MACHINING CENTRE	44	124.07
40.	CNC HORIZONTAL MACHINING CENTRE	52	284.43

S/N	PRODUCT	TOTAL	
		QTY.	VALUE
41.	ROBOTS	4	1.16
42.	SPECIAL PURPOSE MACHINES	414	389.35
43.	WIRE WORKING MACHINES	50	5.59
44.	MACHINE TOOLS (NES)	53	2.19
	TOTAL - GROUP A	7911	3392.48
	GROUP - B		
45.	WELDING & GAS CUTTING MACHINES	3336	166.39
46.	PLASTIC INJECTION MOULDING M/C	712	534.32
47.	DIE CASTING MACHINE	11	25.53
48.	TESTING MACHINES	550	46.04
49.	WOOD WORKING M/C	43	4.50
50.	HYDRAULIC EQUIPMENT	132559	366.46
51.	PORTABLE ELECTRIC TOOLS	49049	110.73
52.	PORTABLE PNEUMATIC TOOLS	12565	43.79
53.	MACHINE TOOL ACCESSORIES/ ATTACHMENT	119438	837.49
54.	CNC SYSTEMS	30	7.70
55.	CNC EQUIPMENT	5	3.73
56.	DIGITAL READOUT SYSTEM	707	13.70
	TOTAL - GROUP B	319005	2160.44
	TOTAL GROUP A & B	326916	5552.92

SOURCE: IMTMA

Annexure-II

Foreign collaboration approved for manufacture of NC/CNC machine tools

Sl. No.	Name of the Indian Company	Name of foreign collaborator	Item of manufacture
1.	Walchandnagar Industries Ltd., Pune.	Hitachi Seiki, Japan	Machining Centres
2.	Central India Machy. Mfs. Co. Ltd., Birlanagar	Yamazaki, Japan	Machining Centres
3.	HMT Ltd., Hyderabad	K.T.M. Ltd., U.K.	Machining centres including Heads Changers Mch. centres and FMS
4.	Praga Tools Ltd., Secunderabad	Mitusbishi, Japan	Machg. Centres
		Sachman, Italy	CNC Bed Type Milling mch.
		Keiyo Seiki, Japan	CNC lathe
5.	The Mysore Kirloskar Ltd., Harihar	Balding Engg Ltd. (Beaver Works) U.K.	Machining Centres including Pallet Transfer system and Ball Screws
		Bendix Automotion Co. (Werner Swassey Div.) USA	CNC Lathes
		Maccanica Mova, Italy	NC/CNC Internal Grinders
6.	Bharat Fritz Pvt. Ltd., Bangalore	Fritiz Werner West Germany	Machining Centres
		Technoimpex, Hungary	CNC Universal and Slant Bed Lathes

Sl. No.	Name of the Indian Company	Name of foreign collaborator	Item of manufacture
7.	Lakshmi Machine Works, Coimbatore	Mori Seiki Co. Ltd., Japan	Machining Centres and CNC Lathes
8.	Alfred Herbet (I) Ltd., Bangalore	Mitsui Seiki, Japan	Machining Centres
9.	TELCO Ltd., Pune	Nigata Engg. Co., Japan	Machining Centres including monitoring systems
		Nachi Fuji Kashi, Japan	NC SPM's
10.	XLO (India) Ltd. Bombay	Nigata Engg. Co. Japan	Machining Centres including Rotary Type Automatic Pallet Changer
		Esercizio, Italy	CNC Lathe
11.	Toolcraft, Bangalore	Storebro Bruks, Sweden	CNC Lathes
12.	PMT Machine Tool Automatic Pvt. Ltd., Pune	Traub GmbH, W.G.	CNC Turning Centres including CNC systems
13.	Beco Engg. Co. Ltd. Ballabhgarh	Soraluce, Spain	CNC Horizontal Boring Machine Spindle dia 130 mm
14.	Batliboi & Co. Ltd., Udhna	Klopp Werke, W.G.	NC/CNC Knee and Bed Type Milling Mch.
15.	Machine & Machines Tools Pvt.Ltd.,Hyderabad	Stama Machinen Fabrik, W.G.	Drilling Centres
16.	Emag (I) Ltd., Bangalore	Emag, W.G.	CNC Machines
17.	CAD Machines Ltd.	Montan Werke W.Germany	CNC tool & Cutter Grinder
18.	Premier Automobiles Ltd.	Dorries Scharmann W.Germany	CNC Vertical Turning Centre
		Pfauter & Co., W.Germany	CNC Gear Hobbing Machine

Sl. No.	Name of the Indian Company	Name of foreign collaborator	Item of manufacture
19.	Ashok Mfg. Co.	Rhodes Pierce U.K.	CNC Turret Punch Press
20.	Sieflex Automation & Robotics Co.	American Cimflex U.S.A.	Industrial Robots
21.	HEC Ltd.	SKODA Czechoslovakia	CNC Horizontal Boring M/c.
22.	Batliboi & Co.	CINCINNATI MILACRON U.S.A.	CNC Lathes
23.	HEC Ltd.	O-M Ltd, Japan	CNC Vertical Turning Centre
		OSAKA KIKKI, Japan	Machining Centre
24.	Kirloskar Electric Co.	REIS, W.G.	Industrial Robots
		ANILAM, U.S.A	CNC System
25.	Rallis (I) Ltd. Bombay	International Trade Development Centre, Ltd. Japan	CNC Drilling Centre
		TAIYO Seiki Co. Japan	CNC Lathes
26.	Numeric Engg. Ltd.	CSEPOL Technoimpex Hungury	Machining Centre CNC Lathe
			Laser Machining Centre
27.	Soma Finance & Leasing Co., Calcutta	A. Monforts, W.Germany	CNC Lathes
28.	Lakshmi Electric Controls Systems Ltd., Coimbatore	OSAI A-B, Italy	CNC Systems

SOURCE: D.G.T.D.