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NOTES ON ECONOMICS OF THE MACHINE TOOL INDUSTRY 1/

presented by

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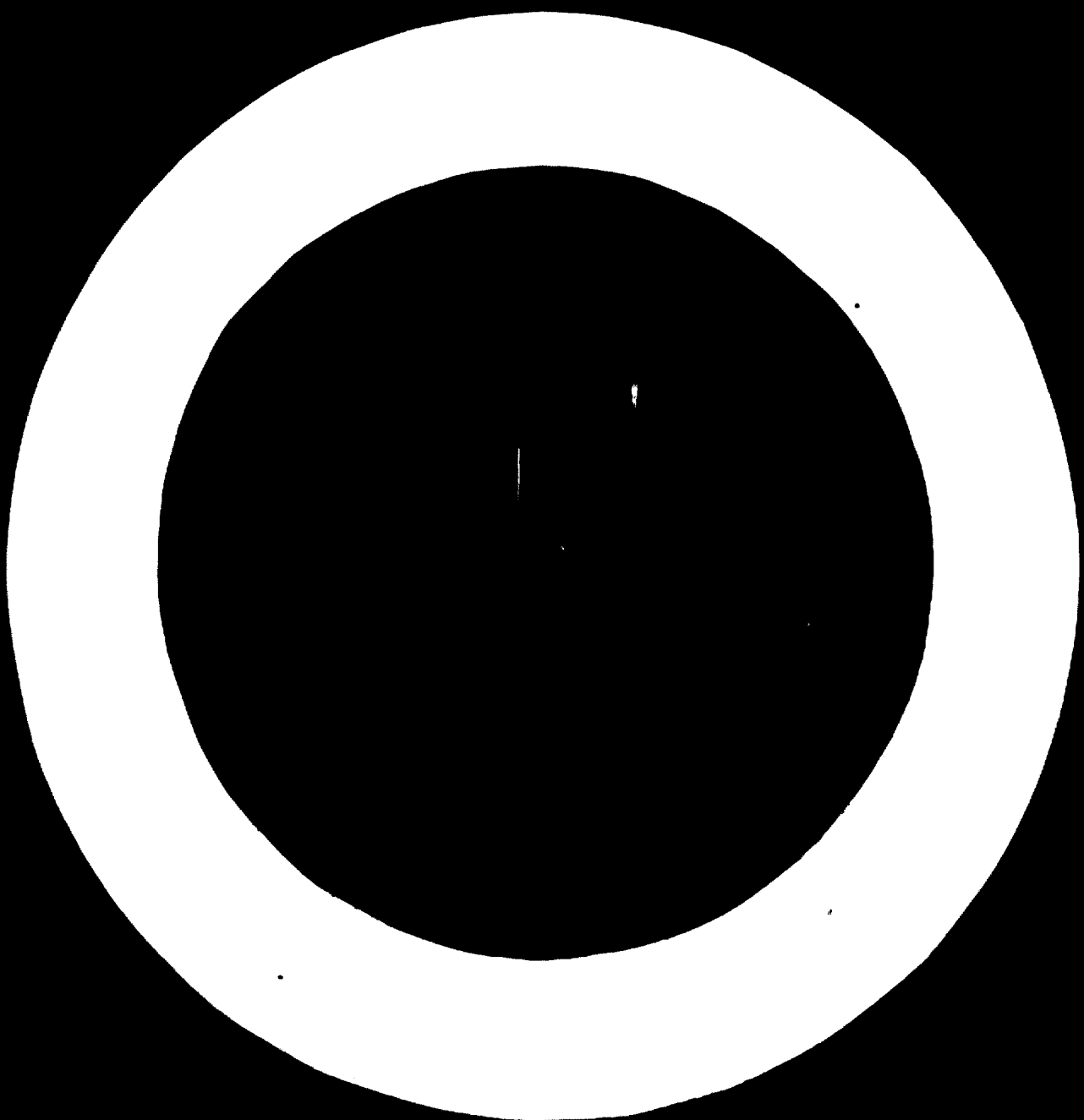

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NOTES ON MACHINE TOOL ECONOMICS

FOREWORD

1. Definition

"A non-portable machine, operated by an external source of power, designed to work as a tool or to form the metal by cutting it, by impact, by pressure or electrical processes, or by a combination of such processes."

We will accept this definition, approved by the European Committee, since this study only concerns the economics of those machine tools (M.T.) used for processing metals, a very high proportion of all machine tools. The remainder are used for wood processing or are included in the "miscellaneous" class (for plastic materials, rubber, etc.) which unfortunately often appear in the statistics produced by the different countries causing serious problems due to lack of homogeneity of such data. (1)

2. The main M.T. groupings

As appears from the definition we have adopted, the metal-processing M.Ts are normally split up into two main groups: Group A for cutting, and Group B for forming.

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(1) In this study the words "machine tools" and the letters M.T. will from now on only refer to tools for processing metal. The proportion of M.Ts to the total output of machine tools of all types (for processing wood, etc. as well as metal) varies from one country to another. In Italy (1970) the output of M.Ts represented about 2/3 of the whole market.

Group A includes machines operating by boring, turning, milling, planing, scraping (and derivates like slotting, shaping etc.);

Group B in the main includes machines operating either by hot or by cold processes such as molding, lamination, extrusion, casting, forging, or drawing).

Classification of the two groups of M.Ts varies from one country to another; as regards the number of types, it will be sufficient to say that in the U.S.S.R. for example, as far back as 1957, it was estimated that about 2000 types of machines existed belonging to group A, and 600 of group B. Today, the total number of types is even higher (further mention of this is made in Chapter III).

As far as concerns the classifications used by the most important statistical institutes in the U.S.A. (1958), the M.Ts in group A were divided into 18 classes, subdivided into 81 sub-classes, while those in group B were divided into 10 classes and subdivided into 36 classes. In the same year, however, in Italy, group A consisted of 20 classes, subdivided into 22 sub-classes, and group B, of 11 classes subdivided into 5 sub-classes. This gives a fair idea of how difficult it is to compare international statistics.

For making a study of this branch of industry and of the economic evolution of the producer country, it is necessary to examine the M.T. Census which is generally taken every 5 years. Though not essential for the purposes of this study, to give an example we will show how a comparison between the data given by the two census figures can provide very important indications.

The census figures for M.Ts in Italy in 1958 and 1967 were as follows:

TABLE 1

Italy: Census of M.Ts for metal processing in 1958 and 1967

	(a) 1958		(b) 1967		% increase of (b) over (a) in:	
	number	weight in tons	number	weight in tons	number	weight
Group A (cutting)	282,149	370,880	368,939	732,564	30.8	97.5
Group B (forming)	80,662	217,622	119,659	492,982	48.3	126.6
Total	362,811	588,410	488,598	1,225,546	34.7	108.3

Source: UCIMU 1970

The table shows the considerable rate of technical and productive evolution our country has undergone, as the increases in number and weight of M.Ts indicated by the census is very appreciable. The analysis should, however, be carried a stage further because it is not so much total quantities (especially in numbers) which provide sound economic data, but rather:

a) the average age of the total number and that of the single classes and sub-classes; it is obvious that a low average age is a key point in deciding the value of the M.Ts censused (in 1958 the average age of M.Ts in Italy, calculated on the number, was 18 years, while in the U.S.A.

it was 14 years). But it is a still better indication to know if the average age is low of the machines used in making articles where technology is advanced (typewriters, computers, etc.);

b) the intrinsic quality of the machines themselves. For example in the U.S.A., between the census of 1953 and that taken in 1958, there was a drop in the total number of machines, but even so their overall productive capacity rose;

c) the weight which, more accurately than the number, represents the increase in productive capacity; for example, this increase is very high in the case of Italy, as shown in Table 1.;

d) the increase in weight and number of the M.Ts in group B (forming machines) which is characteristic of present trends in this field, (see below);

e) finally, the proportion of transfer and numercially controlled machines out of the total; this is extremely important for estimating the technological evolution in M.T. production in the country's economy.

3. Industries using M.Ts

The most important of these is the metalworking industry which takes up about 80-90% of the total output. In turn, this industry creates 13-15% of the gross national product (G.N.P.) in the different industrialized countries, and more than 30% of the output of all manufacturing industries. The largest number of M.Ts possessed by any one country in the western world, this being the U.S.A., was

3,474 million in 1968, of which 2,870 million (about 83%) belonged to the metalworking industry. The other industries absorbed about 10% of the total, and the remainder, not easy to estimate but by no means negligible for all that, was taken up by laboratories, schools, etc. The M.T. industry itself represents a part of the great class of metalworking industries, the latter being at the same time its chief user. But in spite of the key position which M.T. production holds, it only represents a very small part of the turnover of the metalworking industries as a class; for example, this amounts to 3% in the EEC countries, and to less than 1% in the U.S.A. (see below).

It is no easy matter to draw a clear line between the industries using group A or group B. For our purpose it is sufficient to say that the primary metals industry uses mainly forming machines, while others, engineering, electrical or other machinery, etc.) use mostly M.Ts in group A.

With regard to the percentages of the different users out of the total number of M.Ts working, we will once more take U.S. data which, of these users, puts the industries producing non-electrical machinery at the top of the list (31.8%) followed by the primary metals industries (22.9%), then by those making electrical machinery (13.9%) and below again industries making transport equipment (12.7%). Considering the two groups A and B, the same order applies to group A, while for the M.Ts in group B, the first place is held by the primary metals industries, followed by those making electrical machinery, and then by the non-electrical machinery industries.

Apart from their division into groups A and B, M.Ts can be divided into two main categories:

1. the standard, general or many-purpose types (e.g. the slide lathe);
2. the specialized or single-purpose types (e.g. the automatic threading lathe).

Of the latter, a sub-category (2.1) may include those specific and complex machines comprising parts of special machines combined to produce some particular part requiring several processing operations (e.g. transfer lines). As stated above, both groups A and B, and categories 1, 2 and 2.1 may be automated to a greater or lesser degree: plain mechanical, semi-automated or fully automated (1).

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(1) The two tendencies dominating the development of M.T. construction are:

(i) making automated the machines producing on a small or medium scale (numerically controlled machines), and on a large scale (transfer machines);

(ii) the development of forming machines which use new processes such as electro-erosion, chemical erosion, ultra-audible vibrations, plasma jets, lasers, electronic bombardment, etc.

Production of machines of type (i) is particularly well forward in the U.S.A., and of those of type (ii) much has been done in the U.S.A., the U.S.S.R., in Switzerland and in Czechoslovakia.

The appearance of these machines in the market will affect to an ever-increasing extent the processes and operating techniques of the industries using them. For the time being, however, the output of M.Ts of type (i),

Class 1

The following mainly use special and complex machines (automated and semi-automated):
Industries with long production lines (automobiles, household electrical appliances, radios, sewing machines, electric motors, etc.);

Industries using advanced techniques (aeronautical, spatial);

Medium-sized and small industries producing in series and/or standard types (taps, valves, electrical equipment, nuts and screws).

Class 2

Industries producing specialized articles, such as measuring, scientific and medical instruments, electronic instruments, office machinery, mainly use special machines (automated, semi-automated and mechanical).

Class 3

Industries constructing durable goods of an individual nature (ships, chemical and metallurgical plants, M.Ts, big electric motors, etc.) mainly use special and many-purpose machines (semi-automated and mechanical).

Class 4

Repair workshops, school labs. etc. use many-purpose types.

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(1) cont.
the most revolutionary from this aspect, is only a very small part of world production (between 3.8% and 5% in 1967). Only recently (1969) in the U.S.A. has it reached the level of 18.6% of the total output ($293.9 million out of a total of $1,597 million). Average prices of M.Ts in the USA in that year were: numerically controlled machines $84,161 each, and machine tools $4,605 each.

CHAPTER I

The M.T. industry in the economic structure of a country

Having examined the external features of a branch of industry, this must now be seen within the economic structure of the producer country. Since M.Ts form part of the metalworking industry which, in turn, is a category of the manufacturing industry, the main branch of any economy, we will consider the interrelation between the different subdivisions and the economy as a whole.

It is a well-known fact that the proportions of primary production, manufacturing and services making up the various items of the national income, are directly related to the level of industrial development of each single country. It is also well known that in the industrialized countries, the proportion of services is very close, and sometimes exceeds (e.g. U.S.A.) the amount of manufacturing activity. In the highly developed countries, manufacturing however represents a percentage varying between 40% and 50% of the gross national product (G.N.P.) at cost factor (e.g. Italy in 1970: 40.2%).

1. Proportion of the G.N.I. represented by the manufacturing industry

The manufacturing industries represent on an average 65-70% (still in terms of gross product at factor cost), or about 28-30% in terms of G.N.I. (and a slightly higher percentage of the G.N.P. which does not include items of the country's income coming in from abroad).

2. Proportion of manufacturing and of the G.N.I. represented by M.Ts

In turn, the metalworking industries represent, on an av-

erage, 30% of the gross product of the manufacturing industry as a whole (31% in the EEC countries in 1968, and slightly higher percentages in the U.S.A., Japan, Switzerland, U.K. and Sweden in the same year); while it represents about 13% of the different G.N.Ps.

It may be recalled that, although the historical development of the metalworking industry differed in the various countries which are now industrialized, its structure is very similar today between one European country and another, while there are differences between this structure and that prevailing in the U.S.A. There, in fact, not only was output per employee in 1968 three times higher than the average in the EEC countries, but the ratio between investments and turnover was 2½ times lower. In the American metalworking industry we find a higher yield from investments and greater output due to the more concentrated structure characteristic of the industry there, its greater homogeneity and the enormous demand which the country provides.

While, as we shall see, the output from the machine tool industry is only a very small proportion of that from the class to which it belongs, purchases made of M.Ts represent a large part of the investments which the metalworking industry makes.

Table 2 shows that the average proportion is about 30%.

Table 2

Proportion held by M.Ts in the investments made by the metal-working industry as a whole. Average for the years 1964-1966

Country	Total investments made by this class in million $	Purchases of M.Ts in million $	Percentage of M.T.investments out of total
German Federal Republic	1,540	459	30
France	620	220	35
Italy	330	107	32
Belgium	140	36	26
Netherlands	210	28	13
EEC total	2,840	850	30
U.S.A.	4,600	1,237	27
U.K.	950	75	35

Source: SOBEMAP page 41

3. The proportion of manufacturing as a whole represented by the M.T. industry

We will now examine further interrelations between M.Ts, the class of industry to which they belong, manufacturing as a whole and the G.N.P.

First of all, in the highly developed countries, the proportion of M.T. production in the G.N.P. is so low that, allowing further for the relative unreliability of statistical data, in a study of this kind it is impossible to

establish any real correlation between the stages of development of a country and the growth of its M.T.industry. The following list shows the proportion of the G.N.P. represented by M.T. production in 1969, going from the top downwards:

Switzerland	1.05
German Federal Rep.	0.64
Japan	0.50
U.K.	0.45
Italy	0.44
U.S.A.	0.37
France	0.21
Belgium	0.14
Netherlands	0.06

The average of these figures stands at 0.42%. It is interesting to note that the divergence existing between two highly industrialized countries, like the U.S.A. and Switzerland, is in an inverse ratio to the size of their two markets.

Neither does there appear to be any significant connection between the G.N.P. and up-take of M.Ts per inhabitant, apart from one of a general and obvious kind (see point (4) of this chapter dealing with the relationship to be seen between G.N.P., consumption of steel and installation of M.Ts per inhabitant.)

All we will do is mention how this consumption varies from $5 per inhabitant in the EEC countries (excluding the German Federal Republic) to $5-10 per inhabitant in the U.S.A., the U.K. and the German Federal Republic, climbing to a maximum of $10-15 per inhabitant in Switzerland.

There does however exist a significant relationship between a drop in the G.N.P. per inhabitant and a reduction

in purchases of M.Ts per inhabitant (or at least this happened during the economic recessions of 1958 in Belgium, in the Netherlands and in Switzerland, and during 1957-58 in the U.S.A.).

On the other hand, from any point of view, the interrelation between M.Ts and the class of industry to which they belong are very close indeed. We have already said that the metalworking industry absorbs between 80% and 90% of the total M.Ts built. But the converse is also true, i.e. that about 80% to 90% of the in-puts of this sector come from establishments belonging to the same class. This is also clear from the most recent statistics we have available, relating to the materials used in the American M.T. industry, given in Table 3.

Table 3

Metalworking industry materials used in the United States M.T. industry in 1967

(out of a total production of $2826.1 million, with an added value of $1819.3 million, the cost of materials was $1053.6 million of which $914.5 million(including utilities) came from metalworking establishments as stated below):

	million $
Mill shapes (carbon steel,stainless steel etc.)	107.8
Rough and semi-finished castings (iron,steel, alluminium, copper)	132.9
Iron and steel forgings	13.5
Electric motors and generators	42.5
Ball and roller bearings	20.4
All other materials (component parts)	461.4
No breakdown given (miscell.apparatus, containers, etc.)	136.0
Total	914.5

Source: Economic Handbook 1970/71

If a graph is made of the up-take of M.Ts and the output from metalworking establishments in the most important countries, the result is a straight line with an average slope of 45°, and this being a measurement of elasticity, it causes the increase in the abscissa (production) to correspond to an equivalent increase in the co-ordinate (consumption). If anything, it is just the U.S.A. to make an exception, even though slight, and for them, the slope assumes an asymptotical trend, i.e. consumption increases at a lower rate than production. This may be explained by the fact that, in the most highly developed countries, there is a greater utilization of labour and services besides the larger industrial concentrations, and a more economic use of investments.

Once in fact a certain degree of mechanization has been reached, measured in terms of M.T per employee, the users absorb output through the increase in productive capacity of the machines themselves. This is, for that matter, a general phenomenon in the metalworking industries of all countries where the number of M.Ts per employee, in the large establishments, is nearly always lower than that in the small ones.

A final and interesting ratio exists in deliveries of M.Ts to its own class of industry. Table 4 below is taken from the survey made by SOBEMAP, and though limited to the ten-year period 1955-65, it not only confirms the quantitative evolution of this ratio, but also the possibility of applying it to the main Western producer countries.

Table 4

The M.T. industry and the metalworking industry in some countries in the period 1955-65

	1955	1960	1965
A. Deliveries by the M.T. industries (in mil. $)			
EEC	459	826	1,232
U.S.A.	961	778	1,458
U.K.	211	266	395
Switzerland	81	107	156
B. Deliveries by the metalworking industry (in mil. $)			
EEC	18,118	28,669	44,718
U.S.A.	84,450	104,720	151,840
U.K.	11,377	14,684	19,675
Switzerland	1,020	1,464	2,346
Percentages of A to B			
ECC	2.5	2.9	2.8
U.S.A.	1.1	0.7	1.0
U.K.	1.9	1.8	2.0
Switzerland	7.9	7.3	6.7
Source: SOBEMAP			

It will be seen that the ratio between deliveries of M.Ts and those from the metalworking industry is not only constant, but also the percentage is low in all countries; the one exception to this, from the quantitative standpoint, is Switzerland which possesses a great many establishments engaged on high prevision work, making durable goods of a very high technological level, interacting especially with the M.T. industry.

4. Ratio of M.T. production to the national economy

There is no need to emphasise the importance of the development of M.T. production in relation to the primary metals industry and, through it, to the country's economy.

Steel is the most important product of this industry, and the quantity used is a sound indication of any country's economic expansion. From the time it appeared, its production has continued to make steady progress in all the industrialized countries. At present, average annual world consumption per inhabitant stands at about 145 kgs. With an average of this level, those countries with highly-developed economies clearly use a very great deal of it, while others in the process of taking-off economically speaking, remain a long way below the world average. It may be useful to correlate the data on steel consumption to the M.Ts installed and to the G.N.P per inhabitant. This data is given in Table 5, and it will be noted that, generally speaking, a high rate of steel consumption and a high G.N.P. are found where there are the greatest numbers of M.Ts installed per inhabitant and vice versa. Even so, this ratio is not rigorously base and, in our view, not really significant; the table in fact shows that there are many exceptions both as regards consumption of steel, and level of the G.N.P. in relation to the quantity of M.Ts installed, this in both directions, at a macroscopic level; the question should therefore be given further study. The relationship between M.T. production and the economic structure of each single country remains a matter of great importance and needs careful study using suitable and diversified parameters.

Table 5

Steel, M.Ts and the Gross National Product in a number of countries

Country	Consumption of steel per inhabitant Kg/inhab. 1967	M.Ts installed per inhabitant	G.N.P/inhab in $ at market price 1966
1.U.S.A.	577	1/53 (1966)	3,840
2.German Federal Republic	641	1/22 (1970) •	2,010
3.France	400	1/97 (1960)	2,060
4.Canada	340	1/107 (1968)	2,670
5.U.K.	435	1/48 (1966)	1,920
6.Italy	306	1/107 (1967)	1,180
7.U.S.S.R.••	433	no data	no data
8.Japan	620	1/110 (1967)	970
9.India	14	1/1,340 (1968)	no data
Source: Calculations by UCIMU			

• On the basis of the data supplied by the V.D.W., the total number of M.Ts in use in Germany in 1970 was 1,300 million, of which about 1/3 were of the forming type.

•• In 1958 the MTs in use in the U.S.A. were 2,117 million and in 1957 the U.S.S.R. had 1,840 million operating. Today both countries should have about the same number even though the composition will be different.

5. Final remarks

We have seen that, in value, the percentage of the entire production of the metalworking industry represented by M.Ts is very small. Similarly the contribution of M.Ts

to the G.N.P. is everywhere less than 1% (with the exception of Switzerland where it is just above: 1.05%).

These percentages do not however represent the importance such machines have in the different national economies. All machinery, including the M.Ts themselves, required machine tools to make them; nearly all manufacturing industries use M.Ts, or metal in the form of durable goods in the production of which M.Ts had a part; in the metalworking industry, investments in M.Ts are one of the basic items, while the interrelation between this branch and the metalworking class of industry is so close, one geared to the other as it were, that it is impossible to imagine one operating without the other; so considering all this, it is clear what an important role M.Ts play in the structure of an industrialized country.

When it is said that the M.T is the machine of machines, the idea is to use a slogan to sum up its character as a key durable product The fact that in every industrialized country such a small part of the G.N.P. is represented by M.Ts, makes it of even more interest for countries whose economic take-off is about to start. As in fact we shall see, a branch of industry of such vital importance as this, requires neither very large investments nor a high degree of industrial concentration: generally it requires only a fairly low productive capacity, but what is important is the question of its coexistance alongside an adequate metalworking industry and in addition, the technological level required by the productive processes operated by M.Ts, these being directly related to the degree of specialization. More will be said about this in the next chapter.

CHAPTER II

Production, Sales and World Trade in machine tools

1. Production and absorption

There is an appreciable difference between the concentration of M.Ts in different countries throughout the world, and the levels of evolution in these countries. Out of a world production figure of $7,840 million in 1970, Europe and North America accounted for $6,554 million, or 83%. On the other hand these same countries account for an "absorption" (production - exports + imports) of only $5,583 million, or 81%. The production surplus in North America is, however, very small; only $66 million out of the $1,500 million produced (about 4%); it is thus Western Europe (EEC plus EFTA), with its total surplus of production over absorption of $995 million, which holds the position of chief supplier to the world market. Details of this appear in Table 6.

Table 6

Production and consumption of K.Ts in 1970 (in million $)

Producer country	Production	Absorption (produc.- exports + imports)	Variations more or less than production level
E.E.C.	2,248	1,650	+ 598
of this total:			
Italy	(471)	(390)	(+ 91)
German Fed. Rep.	(1,435)	(860)	(+ 575)
France	(291)	(330)	(- 39)
EFTA	832	384	- 448
of this total:			
U.K.	(475)	(410)	(+ 65)
[illegible]	1,974	1,973	- 1
of this total:			
U.S.S.R.	(1,185)	(1,278)	(- 93)
German Dem. Rep.	(275)	(195)	(+ 80)
Czechoslovakia	(245)	(196)	(+ 49)
Other European countries	--	143	-
Total for Europe	5,054	4,140	+ 914
North America	1,500	1,434	+ 66
of this total:			
U.S.A.	(1,460)	(1,290)	(+ 170)
Canada	(40)	(143)	(- 103)
Asia	1,196	1,253	- 57
of this total:			
Japan	(1,106)	(1,160)	(- 54)
Latin America	60	—	
Africa	30	—	
Oil producers	—	1,023	
Total	**7,840**	**7,840**	

2. Trade in machine tools

See Table 7 for trade among the main M.T. producer countries and areas (U.S.A., Western Europe, U.S.S.R. other countries) related to their evolution in the last decade.

Table 7

Comparison of statistics of production and exports of M.Ts throughout the world in 1960 and 1970 (in thousand millions of Italian lire and in millions of dollars)

Production				Area	Exports			
1960		1970			% of respective outputs		% of world outputs	
Lit. 000 mil.	$ mil.	Lit. 000 mil.	$ mil.		1960	1970	1960	1970
792.5	1,268	1,981.2	3,170	European Committee *	41.5	44.0	16.3	17.7
486.0	777	912.5	1,460	U.S.A.	28.0	21.2	6.8	3.9
371.5	594	740.6	1,184	U.S.S.R.	5.0	9.0	0.9	1.3
365.0	584	1,265.7	2,025	Other countries **	31.0	37.3	5.7	9.8
2,0150	3.223	4,900.0	7,839	WORLD Total	29.7	32.7	29.7	32.7

* The twelve member countries of the European Committee are: Austria, Belgium, Denmark, France, German Federal Republic, U.K., Holland, Portugal, Spain, Sweden and Switzerland.

** In the "other countries" grouping, Japan is by far the largest producer. In 1960 her output was only 46,000 million lire (74 million $), but in 1970 it had risen to L.6,866,000 million ($1,198 million). The German Democratic Republic and Czechoslovakia follow with L.1,718,000 million ($275 million) and L.1,531,000 million ($245 million) respectively in 1970, and below them comes the Chinese People's Republic with only L.313,000 million ($50 million) in the same year.

Source: UCIMU 1970.

Export and import figures for each country in 1970 are in Table 8

Table 8

Imports and exports of M.Ts throughout the world in 1970

in millions of $

Country	Imports	Exports
EEC	537	1,131
Socialist countries	539	478
U.S.A.	140	310
U.K.	130	194
Canada	119	-
India	40	-
Australia	36	-
Sweden	62	-
Yugoslavia	8	
Spain	66	
Japan	153	
Other countries	264	250
Switzerland	-	195
Trade within EEC •	-	-417
Trade within Socialist countries •	-	- 47
Total	2,094	2,094

• Exports also include internal trade between EEC countries which, in 1970, amounted to $417 million. In this connection see Table 9. Similar trade exchanges took place between the Socialist countries and these have been estimated by their differences.

Source: UCIMU calculations 1970.

As mentioned in the note to Table 8, trade between the EEC countries in 1970 reached $417 million, and this is shown in Table 9.

Table 9

Trade in machine tools between EEC countries in 1970 (in millions $)

Country	Production	Trade with other EEC countries	Availability	Absorption
German Federal Rep.	1,435	187	+ 1,248	840
Italy	471	85	+ 386	390
France	291	72	+ 119	330
Belgium	33	39	- 6	50
Holland	18	34	- 16	40
Total	2,248	417	+ 1,731	1,650

Source: UCIMU calculations 1970.

An analysis of Tables 7, 8 and 9 gives the following results.

- the M.T. market is becoming more and more internationalized. In 1955, world trade represented 19% of world production; in 1960 it rose to 29%, reaching 32.7 in 1970. In the last 15 years the average annual rate of trade expansion was 2.4%.
- the main producer countries are the EEC (headed by the German Federal Republic), the Socialist countries (in

particular Czechoslovakia and the German Democratic Republic), the U.S.A., Switzerland and the U.K.

- The countries with the most favourable trade balances are: the EEC (particularly the German Federal Republic and Italy, the U.S.A. and Switzerland).

- The four main producer countries (U.S.A., German Federal Republic, the U.S.S.R. and Japan) alone produced 68% of the total value (in 1970).

- Total exports from EEC countries to others outside it are nearly three times as much as those from the U.S.A.

- Imports by EEC countries from others outside it are high and amount to about 33% of the total absorption inside the EEC.

CHAPTER III

Structure and economic features of the machine tool industry

Before looking at the main structural features of M.T. production, it is as well to remember that:

a) the statistical data provided by public and private institutes on this point is not fully reliable; amongst other things it does not include output by small workshops (extremely numerous) and by establishments who make M.Ts for their own use;

b) comparisons between different sets of data are often invalidated by the non-homogeneous groupings of which statistics are composed.

A. Some Structural Features

1. Employees and other factors

The most recent data available about the structural features of the chief producer countries are given in Table 10.

Table 10 (1)

Structure of the machine tool industry in some producer countries (number of establishments and number of employees)

N° of employees	(2)	German Fed.Rep. 1966	France 1966	Italy 1969	Belgium 1966	Holland 1966	E.E.C. 1966	U.K. 1966	U.S.A 1963
1 - 50	A	182	137	225	16	10	579	213	934
	B	3,326	2,683	7,630	271	300	11,180	3,129	10,264
51 -100 (3)	A	79	36	121	6	9	212	58	96
	B	5,750	2,576	10,121	392	590	15,408	4,059	6,455
101 -250 (3)	A	84	20	48	5	1	137	39	67
	B	13,455	2,686	8,204	757	140	21,238	5,293	10,620
251 - 500	A	61	16	11	3	2	89	43	31
	B	20,801	4,720	3,246	1,083	770	29,674	13,951	11,249
501 -1000	A	35	7	1	2	-	44	19	22
	B	26,162	4,391	907	1,013	-	31,566	13,761	15,583
Over 1000	A	15	3	-	-	-	18	12	17
	B	22,274	4,864	-	-	-	27,138	30,192	28,965
Total	A	456	219	414	32	22	1,079	384	1,167
	B	91,768	21,920	30,108	3,516	1,800	136,204	70,385	83,136
More recent data on B		120,000 (1969)	-	32,000 (1970)	-	-	-	-	114,400 (1968)

(1) Data from SOBEMAP, UCIMU report 1970 and Bureau of Census 1970/71

(2) A = number of establishments
B = number of employees

(3) 101 to 200, and 201 to 500 for France and the U.K.

As, with the exceptions of Italy and the U.S.A., most of the data available for the countries included in Table 10 concerns 1966, it is interesting to examine that relating to the Italian M.T. production in the three-year period 1966-1969, to gain an idea, even though indirect, of the evolutionary trends of structural alterations taking place in Europe. These appear in Table 11.

Table 11

Comparison between the structures of the machine tool industry in Italy in 1966 and 1969

N° of employees per factory	(1)	1966	1969	% variations
1 to 50	A	234	225	- 2.5
	B	4,600	7,630	+ 65
51 to 100	A	82	121	+ 47
	B	6,100	10,121	+ 66
101 to 250	A	27	48	+ 77
	B	4,200	8,204	+ 49
251 to 500	A	7	11	+ 57
	B	2,300	3,246	+ 41
500 to 1000	A	-	1	-
	B	-	907	-
Total	A	350	414	+ 18.2
	B	17,200	30,108	+ 77.0

(1) Cf. Note 2 to Table 10.

Source: CENSIS

Table 10 shows amongst other things that in 1966 the average number of employees were:

110 in the EEC countries
90 in the U.S.A.
140 in the U.K.

As far as concerns the EEC countries, the average indicated ranges from 49 employees in Italy, to 90 in the Netherlands and to 200 in the German Federal Republic. Only France (100) and Belgium (110) have an average the same or near to that of the EEC. Table 11 shows that in 1969 Italy's average number rose to 71, with an annual rate of expansion of 25.5% (higher than that of other European countries such as the German Federal Republic which, in the same period, had an annual rate of expansion of 12.5%).

In the countries with a market economy, the most typical structural feature of M.T. production is the predominance of small establishments. Out of the total considered in Table 10 (3,772), 62% (2,296) belong to the smaller group with from 1 to 50 employees, and 14% (520) to the group with between 51 and 100 employees. Furthermore, in the EEC countries only 5.7% of the establishments belong to the big groups (over 500 employees), and in the U.S.A. too their percentage is only 3.3% (the only exception relative to this is the U.K. which has 8% of the large M.T. establishments).

It is true that the data in Table 10 nearly all relate to 1966 (and even to 1963 in the case of the U.S.A.), but this structural feature seems to be confirmed by more recent information, and in particular by the changes which have taken place in the subsequent three years in Italy, where the number of small establishments (1 to 50 employees) has dropped from 55% to 54%, while the number of establish-

ments in the second grouping (from 51 to 100) has risen from 23.4% to 29.2%. Even so, the total percentage of the two groups of smaller establishments remains very high: 76% in 1966 and 83.2 in 1969.

For that matter the degree of concentration in the M.T. industry does not appear likely to rise, at least in the countries with a market economy; there in fact, as a well known authority on the subject states, the industry seems to be based "mainly on medium and small sized productive units, each of which covers only a small part of the output as a whole though here and there producing a considerable quota of a particular type of machine chosen as a specialization".

It must in fact be borne in mind that M.Ts are used for widely differing types of work, and production of them must necessarily be differentiated.

As stated before, the two big categories of M.Ts are: the many-purpose machines produced for the market and thus for stock as well, and the machines made for special purposes usually only built to order. Only where many-purpose machines are built might, in theory at any rate, specialization be combined with concentration. However, here too, the great degree of product differentiation, and the fact that in any case M.Ts are always the result of a confluence of parts and factors derived from technologically

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Note: Sufficient data is not available wherewith to make a structural analysis of M.T. production in the countries with a socialist economy. It is however known that there is a much higher rate of concentration in those countries. For example, in the U.S.S.R., which has nearly the same number of M.Ts in use as there are in the U.S.A., there are not more than a hundred establishments producing them, nearly all with over 1000 employees, while in the U.S.A. there are 1245 establishments (1969).

defined fields of production, both tend to hinder concentration.

The technology applied to the whole field of M.T. production develops in line with the pressure exercised by the requirements of the user establishments, which are much bigger and more highly concentrated than those making M.Ts. This does not favour standardization of products, which would lead to scale economies and, for other reasons, assist the processes of concentration. On the other hand, vertical integration upstream is practically non-existent, seeing that the consumption of raw and auxiliary materials by this field does not justify the installation of metallurgical complexes, and not even of foundries, to supply the requirements of one single M.T. maker. Finally, only very rarely does a maker produce common types of machines only; this in order to avoid tying up capital in stocks during the periodic economic crises he must prepare himself to face by differentiating his products as much as he can. In most cases, even highly specialized establishments build special machines to order, or at least, special versions of the ordinary types.

As regards the special and/or complex machines, which in themselves make a process of high concentration contradictory, it may be recalled that the users too make them especially the bigger ones (e.g. Fiat in Italy) who do not always stop at using their own products themselves, but sometimes sell them as well. In some countries a fair percentage of the overall output is produced by such establishments, who strictly speaking, do not belong to the M.T. industry, and often such machines are not even included in the official statistics.

2. Productivity

a) Productivity per employee

There are many and varied reasons why indications on productivity in M.T. building are not easy to supply. Some of these are: the difficulty of comparing statistics (as mentioned above, these often include non-homogeneous data); that of knowing exactly how many people are employed (both because the numbers vary and because data on the subject is not fully reliable); finally, because of the structure of the industry which includes very many tiny establishments alongside others medium or large sized (so that data on productivity turns out to be merely averages of situations and running costs greatly different one from another). Again, there are also an enormous number of small workshops of which statistics take no account at all, or only cover an unknown number of them.

With all this in mind, and using the rather modest amount of data available, Table 12 gives some indications or productivity (turnover divided by the number of employees) expressed in averages for some producer countries.

Table 12

M.T.Industry: examples of productivity (turnover divided by number of employees

Country	$ per employee	Equivalent in millions of lire	Tons per employee
U.S.A. (1968)	25,222	16.5	no data
Italy (1970)	14,720	9.2	5.7
German F.R. (1970)	12,930	8.0	no data
U.K. (1966)	5,920	3.7	3.8
France (1969)	12,480	7.8	3.8

Sources: UCIMU and the Economic Handbook 1970/71.

This table (to be read with paragraph 4 of this chapter) should lead us to the following observations:

defined fields of production, both tend to hinder concentration.

The technology applied to the whole field of M.T. production develops in line with the pressure exercised by the requirements of the user establishments, which are much bigger and more highly concentrated than those making M.Ts. This does not favour standardization of products, which would lead to scale economies and, for other reasons, assist the processes of concentration. On the other hand, vertical integration upstream is practically non-existent, seeing that the consumption of raw and auxiliary materials by this field does not justify the installation of metallurgical complexes, and not even of foundries, to supply the requirements of one single M.T. maker. Finally, only very rarely does a maker produce common types of machines only; this in order to avoid tying up capital in stocks during the periodic economic crises he must prepare himself to face by differentiating his products as much as he can. In most cases, even highly specialized establishments build special machines to order, or at least, special versions of the ordinary types.

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Sources: UCIMU and the Economic Handbook 1970/71.

This table (to be read with paragraph 4 of this chapter) should lead us to the following observations:

(i) productivity in the U.S.A. is still appreciably higher than that in the chief European producer countries;

(ii) productivity levels in France, Italy and the German Federal Republic are high in terms of value. As regards Italy, the high weight per employee should be noted. As mentioned, this is a very useful indication for estimating the quality of the output.

(iii) even if related to 1966 only, productivity in the U.K. expressed in value, seems very much behind the others.

b) Productivity of fixed capital

Everywhere the productivity of the capital invested in the M.T. industry seems high, similar to that of labour. Taking Italy as an example, in the last ten years there has been an increase of over 50% in output per machine. This is mainly due to new tools, to electronic control devices and to programming the work in cycles. The example of Italy well illustrates the overall productivity of the M.T. industry if a comparison is made with the average data of production indices in general against that specifically relation to manufacturing output, and against that of M.T. industries recorded in the three-year period 1967-1969.

Table 13

Averages of industrial production: general index, and indices for some branches and sub-classes (1966 = 100)

Category	1967	1968	1969
General index of Italian production	108.3	115.1	119.0
Index of manufacturing industries	110.5	115.2	118.8
Index of M.T. industry	160.7	170.0	231.8

Source: elaboration of Istat data by CENSIS

Before ending these short notes on productivity, we think

it advisable to emphasise that, though naturally of importance, it must be remembered that, quality prevailing over price in the M.T. branch of industry, so also the lesser amount of labour incorporated in the M.T. is socially less important than the reduction of labour incorporated in the product the M.T. makes. In other words the increase in productivity in the M.T. industry is less important than the rise in productivity in the metalworking industry and in the entire economic system. Once more, the parameter for measuring the evolution of this branch of industry must be sought rather in the qualitative values (technological evolution, flexibility etc.) than in the quantitative ones. The two aspects may of course be combined to the advantage of both.

B. Other features peculiar to this industry

1. Dimensional minima and optimum dimensions

The slight importance which dimensions have in this industry is underlined by the fact that nearly all the countries making M.Ts are active in international trade, and that in each one, exports and imports form a sizeable part of the market, quite apart from their productive and structural capacities.

As we have noted, the average size, expressed in terms of employees of M.T establishments in the various countries, lies between 60 and 100, i.e. slightly higher than the average level of all the manufacturing establishments. Apart from a few exceptions, however, there is a lack of large concentrations since, only here and there, do we find anything in the way of large-scale production (to this structural feature the Socialist countries provide an exception). Thus, there are not even any dimensional minima in view of the existence of an enormous number of small

workshops making M.Ts for themselves and/or accepting work from larger establishments. On the other hand, it may be asserted that the optimum dimensions, varying according to the different technologies used and to the range of final products, must at present be considered those of the small or medium sized establishment: this also on account of the financial, economic and technical implications mentioned above.

An exception to this rule seems to be found in the establishments mainly engaged on M.Ts with advanced technologies, such as the transfer and numerically controlled machines. Here there seems to be an ever clearer tendency to greater size, towards standardizing and extending production. In view of the high rate of investment so needed, it is evident that:

a) only large financial concentrations can successfully undertake this work;

b) the establishments themselves feel the influence of the electronic industry, to which they are closely linked, from the point of view of size and of their structural features generally.

2. <u>Productive differentiation</u>

a) As stated earlier, the relatively small dimensional limits, characteristic of the structure of this industry, are partly imposed by the very wide diversification of the final products. This is one of the most notable aspects characterising this industry and is, at the same time, one of the best means it has of defending itself from the effects of trade cycles, and for operating an

an effective policy for the penetration of foreign markets. There is in fact a close relationship between the pulverization of productive units, down to the level of the small workshop, and foreign business in M.Ts, when it is realised that Italy, with the productive structure we have examined above, has in the last three years managed to export about 50% of her total output and equivalent to about 40% of what she has herself absorbed. Naturally, in view of the very wide range of products, the cost of which greatly varies in the composition of the factors, each country concentrates on one type of product. For example, on those with a high content of labour and home-made know-how (as happens in the case of the common types of universal machines), or on special and/or complex machinery working a very high speed and precision, the factor cost of which is characterised by large investments and a great deal of research, as well as by home and imported know-how.

On the whole it may be said that the countries with their economic take-off in progress, concentrate mainly on the first type of machine, while the highly developed industrial countries are specializing more and more in the production of special and/or complex types. The U.S.A. has of course for years concentrated on building transfer and numerically controlled machines involving very advanced technologies and very big investments.

At the beginning of this study we gave some data on the number of final products the M.T. industry makes. We can now add that, according to the latest catalogue issued by the Fachgemeinschaft Werkzeugmaschinen, on the German market there are 368 types of M.Ts differing in functions and structures, while for each type there is a whole range

of sizes, powers and different possibilities of drive and automation, realizing, in fact, a great multitude of variants. To these types must be added all the special machines the user wants made for his own particular requirements.

The following list gives some classes of machines, taken from the above catalogue:

70 different types of machines for:
abrasion work
pressing and producing sheet metal

50 different types of machines for:
milling cutting, boring and milling, etc.

30 different types of machines for:
lathes, threading machines, shearers, hammers, forging machines, others for making wires, screws, bolts, etc.

20 different types of machines for:
punching and boring etc., gear cutting;

10 different types of machines for:
planing, filing, slotting;
automatic lathes, turret lathes.

The degree of specialization achieved by the industry may be estimated taking the German Federal Republic again, being the largest European producer country. Among the 425 establishments listed in the above catalogue:
200 produce only one class of machine,
120 produce two classes of machine,
70 produce three or four classes of machine, and
35 produce from five to eight classes of machine.

b) On a world scale the productive subdivision of the main single types of machine is not known. A rough idea may however by gained from the percentages given in Table 14, on the basis of which an estimate has recently been made (1970) of world production by weight according to the main types of machines.

Table 14

World production of machine tools in percentages of weight

M.T.	%
Automatic lathes	2
Semi-automatic lathes	3
Other lathes	19
Planers, filers, slotters	2
Punchers, tapping machines	8
Boring machines	10
Milling machines	8.
Gear cutting machines	0.5
Grinding and other abrasive machines	13
Presses, hammers, shears	30
Others	4.5

Source: FAST conference in 1970.

3. Employment

Employment trends in the M.T. industry vary from one country to another; especially in latter years, however, a general tendency may be noted, this being stagnation of the number employed or at least only a very slow rise. Particularly between 1966 and 1970 the number of employees in the chief European countries remained almost the same (example: German Federal Republic: 1966, 112,500 employees and in 1969, 120,000; in France, 22,000 and 22,800 respectively, and in the U.K., 43,600 and 39,090 respectively).

Similarly in the U.S.A., the rate of growth has been negligible (1965, 96,344 employees and 111,400 in 1968).

For that matter, even over the longer period, the increase in employees in the two biggest world producer countries remained low (U.S.A. 1960: 81,200 employees; German Federal Republic 1960: 103,000 employees).

Indeed, alongside the considerable rise in product discussed above, there is another factor putting a brake on an increase in employment in the M.T. industry. This is the scarcity of trained and/or skilled labour in an industry which requires a very large proportion of skilled people compared to the total employed.

In Chapter IV we shall make a more detailed analysis of the specific features of this question. For the present, however, we can say that it represents one of the most serious problems the countries desirous of establishing a M.T. industry from scratch, will have to deal with, even though, together with the metalworking industry, it is an essential component of any progress towards industrialization.

4. Investments and production cost structures

Investment structure, and that of production costs in the U.S.A. and in the U.K. for 1963, in the German Federal Republic for 1967, and in the EEC countries for 1966 may be seen in the data given in Table 15 overleaf.

Table 15

Investments and production cost structures in some countries

Items	U.S.A. (1963)	U.K. (1963)	German F.R. (1967)	EEC (1966)
Turnover per employee $	18,000	7,450	7,943	8,110
Investments per employee $	550	305	no data	no data
Turnover div. investments %	3.1	5.2	"	"
Total prod.cost structure % raw materials and power	45.0	56.5	47.0	42.4
Work given out to others	2.0	3.5	3.0	1.6
Labour	53.0	40.0	50.0	56.0
Value added in relation to turnover	65.5	53.5	no data	no data

Source: Elaboration from SOBEMAP, Economic Handbook, U.S.A 1971 and UCIMU report 1969.
(for the EEC countries in 1966 total employment has been assumed at 160,000: divided as follows: German Federal Republic 112,500, Italy 26,000; France 23,400; Benelux 4,300).

As Table 15 does not give data about investments per employee for the EEC countries, nor for the German Federal Republic separately, we have sought this from various sources for Italy and France for 1966:

Italy: investments per employee (in $) 649
France: " " " 550

More recent data on total production cost structures are only available for the U.S.A. and for the German Federal Republic, and these are given below in Table 16.

Table 16

The M.T. industries in the U.S.A. (1968) and in the German Federal Republic (1967): cost production structures, in percentages

Item	U.S.A. 1968	German F.R. 1967
Turnover	100.0	100.0
Raw materials and utilities	35.3	47.0
Work commissioned outside	2.0	3.0
Wages** and salaries	62.7	50.0
Total	100.0	100.0
Percentage of turnover	76.5	76.0
Inventory structure		
Finished products	26.5	10.1
Products being made	53.0	61.5
Products in stock	20.5	28.4
Total	100.0	100.0
Value of inventory (compared to that of raw materials purchased	85.0	113.0
Rate of rotation (purchases: stock)	5.8	3.9

**Wages in the U.S.A. represent about 30% of the turnover and are divided between: direct labour(29%) and indirect labour (about 1%). In the construction of numerically controlled machines, the proportion represented by wages falls to 25%, (17% direct and 8% indirect labour).

Sources: elaborations from the Economic Handbook U.S.A. 1971 and from SORESMAP.

As will be noted, Table 16 brings out the following:

- the high rate of rotation in U.S. establishments compared with that in German ones;
- the big structural differences between the two countries both in raw materials and in utilities (partly explained by lower production costs upstream of the American establishments) and for labour, the costs of which are well known to be higher in the U.S.A.

(Note: In 1963 wages per employee that year were $7200 in the USA, $2300 in the U.K. and $2300 in the German Federal Republic).

We will now take a closer look at investments.

Those indicated in Table 15 cover both repairs and maintenance as well as new investments and are related to the number of employees already working in the establishments concerned. (1)

Another criterion for estimating investment levels might be that of relating them to the new jobs created by the inflow of new fixed capital. In this case too, all we

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(1) According to Table 15 and subsequent tables, these values go from a minimum of $305 per employee (U.S.1963) to $649 per employee (Italy 1966). They are in line with the results of a survey conducted by SOBEMAP in France in 1966 covering 40 establishments (representing 64.2% of the country's total M.T. turnover, and 67% of the employees); according to this, investments per employee were as follows:

- establishments with over 500 employees: $610 per employee i.e. 6.4% of the turnover;
- establishments with under 500 employees: $360 per employee i.e. 3.7% of the turnover.

Given the structural features of the M.T. industry, the 2nd figure should be the most common. It should be noted that in 1963 not even in the USA were investments per employee different from those in Europe.

can do is to take data of a general nature, in some cases not fully reliable.

According to the forecasts made by the C.G.I.I. (Italian Industrial Federation), fixed net investments (i.e. the total after deduction of those for repairs and maintenance) to be made in the M.T. industry during the four-year period 1970-1973, will amount to a total of about 30,000 million lire, creating about 8000 new jobs.

It follows from this that each new job will mean an average investment of about 3,755 thousand lire (about $6000).

From this calculation we find that each new job requires a quantity of new fixed capital at least ten times more than that calculated per employee already working (a very approximate calculation and, in our view, probably an understatement).

Bearing in mind that the net investments per new employee only include the extra plant and/or additions to the already existing buildings and services, such investments are much lower than those needed to set up an entirely new establishment. In the latter case, investments required for purchasing land, for buildings, services and infrastructures etc. would have to be added. Still only very roughly, it may be estimated that the investments needed for every new job would have to be at least doubled if it were a question of starting up an entirely new M.T. establishment. In other words, investments of about 800-900 million lire (about $1½ million) would be needed to create a new medium-sized M.T. establishment employing 100 people.

5. I oductive capacity

In completion of the data supplied in paragraph 4 on the structure of production costs, we are giving a table from the survey carried out by SOBEMAP on the values created by each employee in some important M.T. producer countries. This table however is incomplete and its actual meaning is not very clear. It should also be remembered that, as regards the number of employees included in the M.T. industry, the figures supplied by the various statistical institutes must be considered with extreme caution. This makes the real value of the table still more uncertain. It must therefore be taken as a mere indication of the approximate order of size.

Table 17

Output per employee in the machine tool industries in some countries

Country	Output per person (in $ p.a.)	Years
EEC	7,000 - 8,000	1963-1966
(German Fed.Republic)	(6,700 - 8,900)	(1963-1966)
U.S.A.	11,600 -16,000	1963-1966
U.K.	4,500 - 6,500	1963-1966
Switzerland	8,700	1966

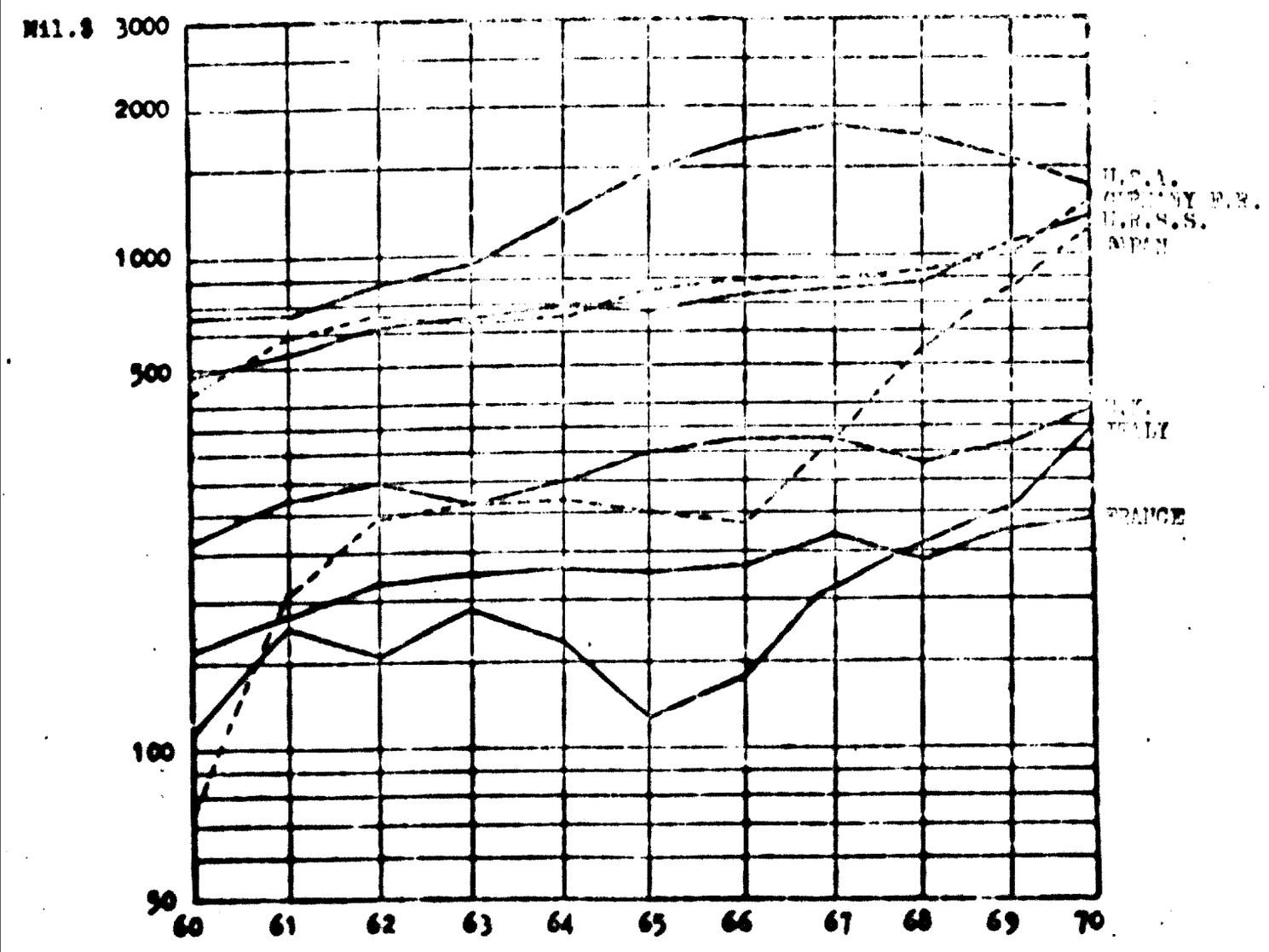
Source: SOBEMAP

6. Productive capacity utilised

The productive capacity of the M.T. industry is continually rising at an annual rate of 10-12%, this of course in favourable trade cycles. In Italy for example, between 1966 and 1968, the total increase was 43%.

Plant utilization, in favourable times, is about 85% reaching peaks of 90%.

Finally, as regards total M.T. output in the whole world, see Table 5; while for the output trend in the last ten years, see the following graph worked out by the American Association of Machine Tool Industries showing the curve of M.T. deliveries in the ten-year period 1960-1970 in the seven principal producer countries in the world.



This graph clearly shows:

a) the decline in American production from 1967 onwards;

b) the rapid development of the German Federal Republic's production and that of Japan;

c) the overall satisfactory trend of production in Italy.

CHAPTER IV

Some problems fundamental to the M.T. industry

1. Labour training

It has already been said that the lack of skilled labour places a limit on productivity and, even in the most advanced countries, this remains one of the key problems to development of the M.T. industry.

The percentage of highly skilled labour required naturally varies according to the finished product, i.e. this percentage is greater where the productive process involves more advanced technologies and lower where it concerns mainly conventional or many-purpose M.Ts. A survey recently made in Italy by CENSIS shows that this percentage varies from a minimum of 35% to a maximum of 75% of trained and/or skilled workers out of the total employees (the survey does not cover M.T. establishments building numerically controlled machines which, from this point of view as well, represent a separate problem).

To avoid as far as possible a reduction in the rate of output caused by lack of skilled labour, the establishments resort to:

a) training or up-dating courses;
b) double shifts;
c) giving out work to other firms.

Obviously only the bigger firms (of which there are not many as we have seen) can afford training or up-dating courses. The problem must therefore be tackled as a whole by some Governmental scheme.

The possibility of resorting to double shifts is also doubtful in view of the difficulty of finding labour,

in a limited area and, in addition, only at times of peak production.

It follows that solution (c) is the most feasable for the majority of establishments. But this in turn conflicts with the possibilities of concentration and, sometimes of specialization: be that as it may, the larger firms are flanked by an enormous number of small workshops and this certainly does nothing to help forward technological development in the M.T. industry as a whole.

No precise indications can be given about the ratio between clerical and factory personnel in the M.T. industry because of the different trade union classifications existing from one country to another. Once more we refer to the data provided by the above-mentioned SODEMAP survey.

Table 19

Proportion of clerical workers out of the total employees in M.T. industries in some countries; 1967 (in %)

German Federal Republic	31 - 37
France	30 - 35
Italy	23 - 29
Belgium	16 - 33
Netherlands	30
U.S.A.	35 - 45
Switzerland	22 - 35

In spite of the little meaning such data has, there is a clear correlation between the percentages supplied and the technological levels of the M.T. industry in each country. Table 19 does in fact also confirm the proportion

of clerical staff at university level employed.

Table 20

Proportion of graduates out of the total employees as given in Table 19 (in %)

German Federal Republic	1 - 4
France	no data
Italy	0.4 - 1.2
Belgium	0.4 - 2.3
Netherlands	1.6 - 2.5
U.S.A.	0.5 - 12
Switzerland	0.4 - 1

Here too the gap existing between the U.S.A. and the countries of Europe is generally striking. It must however be noted that not only do the percentages become less significant passing from the proportion of trained and/or skilled workers to that of clerical workers and on to that of graduates, but, especially in this latter case, the differences from one company to another, or between types and ranges of production, may be very great indeed. Let us cite the example of two large-scale American establishments: Bridgefort which makes many-purpose machines on a big scale and employs less than 1% of personnel with a university degree, and Kearney & Trecker who make extremely complex special machines and about 12% of whose staff are graduates.

In the most advanced establishments in each country, the most recent trend is to increase clerical staff in relation to factory staff and to employ more graduates on the clerical side.

2. Sales organization

Sales of M.Ts are directed towards expert technical users for whom only efficiency and output trials, performance data and testing results count at all.

Publicity as such, therefore, has very little effect on sales in the home market, though it is obviously necessary for foreign users to see trade magazines and other specialized publications in order to know of the existence of M.T. makers and about the special features of their products. Qualified salesmen are thus needed, with sufficient technical knowledge both of many-purpose machines and of the special ones. In the case of these latter, the salesman's main work is that of solving the technical problems the client submits to him, which problems may not only require the presence of a technical department at the factory staffed by highly qualified people possessing a spirit of innovation, but also salesmen who are capable of accurately interpreting the customer's needs on the spot, and who keep up-to-date about the technological features of the machinery which competitive firms have managed to sell successfully. Once again we come up against the problem of lack of specialized personnel, even at university level, in the M.T. industry which, as someone has acutely observed, seems almost unwilling to break away once and for all from its artisan beginnings.

A fundamental quality the producer-seller must possess is that of identifying himself with the purchaser's productive logic, both when designing a special machine and when seeking solutions to technical problems of utilisation and/or of servicing.

The part played by technical servicing at all levels, in providing spare parts and seeing to repairs, in check-

ing now the machine is used, in training the customer's staff to operate it, is fundamental both for standard-ized machines and for special ones. This is why the main M.T. producing establishments have well-equipped technical ser-vicing departments and consulting offices for customers. Especially in the case of the bigger establishments, the servicing centres must be so placed as to give suitable coverage to a particular area of the market.

The sales structures are of the usual type found in manufacturing industries, except that there is no interme-diary between producer and purchaser in the home market; here the maker sells both standard and special machines direct to the user (or rarely, to a wholesaler). For sales to foreign markets, however, the usual services of the dis-tributor are required.

3. Technological research

If we had to list the basic problems facing the M.T. industry, we would not emphasise the quantitative aspect so much as the qualitative, because in this field, special-isation and quality are of paramount importance with res-pect to standardisation and concentration. The following problems however appear pre-eminent:

a) the scarcity of trained and skilled labour in produc-tion processes, and of university graduates on the tech-nical and commercial sides (as stated above);

b) technological research;

c) standardisation of parts and of constructional details.

As regards point (c) much progress has been made in standardisation in the last decade, in spite of the hindrance

caused by trade cycles and variations in demand about which M.T. makers can themselves do nothing. Progress has however been made both in the use of productive technologies of a higher level and rationalization in actual processing operations (for example, standardization of adjustments, in dimensional tolerances, etc.), as well as in the application of more advanced methods of company management. (1).

On the other hand, the Governments in the different countries are now realising, to a greater or lesser degree, what a key position M.T. production holds in their economies, and are trying to maintain the upswing and downswing in demand within reasonable limits. This is not being done by resorting to forms of protectionism, but by application of the more modern techniques of financial and economic stimulants. From among the most successful of these mention may be made of the provision of credit facilities and, in particular, among these, the investment credits which have had a very effective impact on the M.T. market. It should however be added that these policies are not always followed with the necessary tenacity and planning, and this makes it difficult for the makers to work out long-term production programmes.

Finally, as regards <u>technological research</u>, we feel two points should be made:

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(1) Regarding the technical and economic effect of standardization on output and on the quality of M.Ts, see R. Le Brusque, "Le normalisation" in Machine-Outil Française" N° 268 and 269, 1970. Amongst other things, standardisation also serves to lighten the consequences of lack of trained labour.

1. Research work on M.Ts can have strong repercussions on the degree of technological evolution concerning the entire industrial structure of a country; the M.T. defines and sets a limit upon the quality and technical level of every manufactured product in its final form.

2. Particularly as regards the special and complex machinery, technological research goes a long way beyond the field of pure mechanics and deals with important problems relating to the development of electric and electronic technologies, etc.

The contradiction inherent in these two considerations lies at the basis of the difficulties which technological research on M.T. production is having to face everywhere, and a concentration of forces in this work is hindered by the decentralized structure of the industry itself. Only at some of the bigger establishments has any headway been made, and even there it is done in fits and starts, i.e. when an important contract has either been concluded or lies in the offing. From the results of a survey recently made in Italy, it may be estimated that M.T. establishments devote from 3.5% to a maximum of 8% of their turnover to direct or indirect research work (including technical consultancy and market surveys).

On the other hand the difficulty of even partially conditioning the demand, seeing that it is the users in the metalworking industry who decide what techniques they want, combined with the somewhat ineffective protection given by patent rights, all serve to discourage M.T. makers from devoting much time or money to research.

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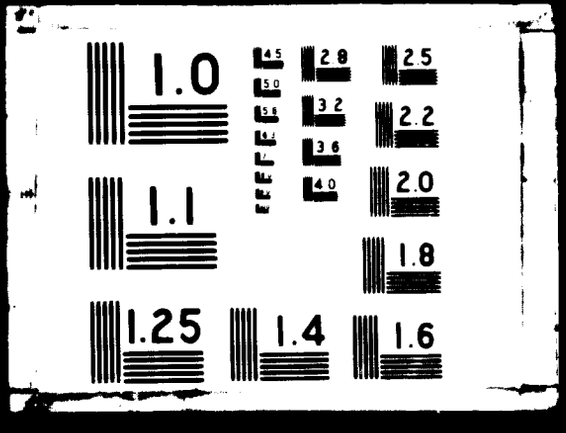

It is thus clear that in many cases this work must be done downstream of production, by the users themselves who, for that matter, are those most concerned with developing the technological level of the tools they use. This does in fact occur whenever the contracts concluded enable the technology already acquired by the purchaser to enter the seller's productive processes. It should finally be noted, when the user is interested in a particular type of M.T., he often starts making it himself thus closely incorporating technological research on M.Ts into that of the engineering, electrical and electronic industries, or others still.

It is clear that research done in this way is uncoordinated and cannot lead to an overall improvement being in fact directed by agents and for purposes outside the independent development of this branch of industry.

We may add that imports of M.Ts rise higher the more a country produces and exports, and that the exchange of know-how between the bigger producer countries always remains at a very high level. For example Western Europe, today the greatest producer and exporter area in the world, uses much American know-how, and this reality represents a further obstacle to the autonomy and co-ordination of research in the M.T. industries of each country.

For all these reasons, makers and Governments in the main industrialised countries, and also in those at present organizing their industrial advance, have felt

the need for setting up institutes of technological research on M.Ts, with contributions from the industry itself, but largely subsidized by the Governments of each country concerned. These institutes, research centres or specialized laboratories are tending more and more to co-ordinate their work inside the different countries, giving rise to a growing degree of cooperation on research at an international level as well.

CONCLUSIONS

1. Trade cycles and the machine tool industry

In relation to the economy as a whole, the M.T. is an article which is more sensitive than most others to market conditions. This applies both in times of economic crisis as well as in periods of revival. The M.T. is affected in this way because it holds a key position in industry while at the same time providing an accurate indication of market trends. The first aspect, already dealt with at length, derives from what we may briefly describe as the catalyst effect it exerts on the metalworking and electricity industries, its main users; these in turn being the main pillars of the manufacturing industry and of the economy as a whole.

The second aspect is typical of the industry because one of the features of M.T. production is that of forecasting economic trends since the user will delay or put forward ordering a tool according to whether the economic outlook appears favourable or not.

The periodical fluctuations to which the demand in market economies is subject, have such a sharp effect on M.T. production that absorption inside the country seems as if it were thrust forward or backward by a multiplier. In other words, the trends taken by orders

become a pre-amplifying indicator. (1)

For example, the Italian economic crisis of 1963-1965 caused a 43% drop in value in the home demand for two years running: thus in 24 months sales of M.Ts in a large industrial country fell to less than one third of the level at the outset. Conversely, during the period of expansion in 1966-1970, average annual output rose by over 7% (only a part of which, however, went to the home market; exports in fact reached about 55% of the total, almost the safety high-water mark).

The consequences of the great sensitivity which this branch of industry shows towards economic trends and periodic fluctuations, typical of a free economy, are:

a) Negative

(i) they hinder expansion of output and, from some points of view, specialization as well. When busi-

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(1) The National Bureau of Economic Research in the USA has chosen the new orders for M.Ts to be one of its 26 basic statistical indicators. These form a group providing advance indications consisting of 12 pilot indices possessing a forecasting capacity of up to as much as eight months.

In times of economic depression, the time series concerning cancellations of orders reaches 20% of the total, but tends to fall to about 2% in times of expansion. Both ways the forecasting capacity can be as much as 14 months.

However in order to be able to use the new orders and/or cancellations as really valid indicators, data must be available on a very long series reflecting the demand over a period of years, and it would seem that only the United States statistical bureaux have this data at their disposal.

ness is good, the manufacturer prefers to contract out extra work rather than invest in more machinery which might turn out to be anti-economic within a short time. As a precautionary measure too, he tends in any case to diversify his range of articles to some extent;

(ii) they hinder concentration, automation of productive processes, and personnel training.

b) Positive

On the other hand, to counterbalance the negative effects of unfavourable trade cycles, manufacturers try to reach out beyond the home market and export their goods abroad. The machine tool is an article universally accepted on all markets, and the M.T. industry may be described as a super-national service. Statistics in fact show that one out of four is exported, and that the main exporter countries are, at the same time, those which import most of them.

2. National and international production planning:

The very fact that the M.T. is an "international" product emphasises the need to plan its production at different levels. This may be divided into three stages:

a) planning by each establishment: in planning their production, establishments at present prefer to build all of one type until the planned quantity is reached, then start on another one, rather than keep several going at once. In this way warehouse stock is avoided as much as possible and they can also maintain a rational proportion between standard lines, based on frequent market analyses, and

machines made to order.

The medium and large sized establishments tend more and more to get market surveys made by specialized bureaux. Generally speaking, however, trade cycles make manufacturers unwilling to adopt medium and long-term production and selling plans. Only in the United States are advanced methods of production (e.g. automation) and management (forecasting) being used to an ever growing extent.

b) production planning at a national level: in this field there is no gap between the M.T. industry in America and that in Europe. The U.S.A., however, maintains considerable superiority in production technologies and in managerial techniques, as well as devoting a bigger overall sum to research. Further, the U.S. engineering and electrical industries use many more transfer and numerically controlled machines than are used in the same industries in Europe, and it cannot be left to private enterprise alone to overcome this disadvantage. It is up to Governments to devise policies of economic and financial concentration, of rationalization of production,(see the successful U.S. scheme of taxation relief on investments) of specialization and, finally, organization of research.

c) international planning and co-ordination: as stated under (b) above, each producer country, especially in Europe, should devise its own machine tool development plan, but it is clear that there must be co-ordination (inside the EEC, within the twelve member countries of the European Committee, between the latter on the one hand and the U.S.A. and Japan on the other; finally between the market economy countries and the Socialist countries). Such co-ordination

should harmonize with the initial schemes of the countries now organizing their industrial take-off. Only in this way can the output of a product of such an intrinsically international character be raised to such a level where it takes the form of a service for the world community.

3. Price and quality in the production of machine tools

Reference has already been made to another aspect of this industry: the ratio between price and quality. Though at a high level in the more advanced establishments, specialization in production involves neither a process of standardization comparable to that in progress in other fields of industry, nor a tendency towards concentration to obtain internal or external scale economies. Further, at least where special executions made to order are concerned, every kind of M.T. producing establishment must operate a policy of productive diversification. These conditions already make it hard for firms to carry out a policy of containing costs while maintaining quality. For that matter, the industries ordering the greatest quantities of new machine tools go for quality rather than a low price. In the case of these users - the engineering and electrical industries - investments in M.Ts (which as we have seen do not exceed 30% of their fixed capital) are not generally decisive in making their final products competitive or not.

Where the price of an M.T. assumes considerable importance (generally in the case of the small user or artisan type of workshop), a second-hand machine can be bought especially if it is many-purpose which practically never

become obsolete. There is an enormous market in second-hand machines (rebuilt or overhauled), and its sales are not much below those for new machines.

4. Why the machine tool industry is vital to a developing economy

Being so flexible as regards technology and type, the production of machine tools is one of the most interesting for any country but especially for those now developing their industries; this is so because:

a) it occupies a central place in interrelations between the difference branches of production, and is of paramount importance for the development of the engineering and electrical industries;

b) its range of types is very wide indeed, to such an extent that no country can monopolize it, or a big part of it;

c) even so, it lends itself to great specialization and any country, according to what it has available, can play a special role in world production;

d) in the initial stages, and even in more advanced ones, the M.T. industry does not, as a whole, require very big investments;

e) M.T. production means active participation in world markets because import and export business forms an essential, technical and financial part of its evolution;

f) at least within certain limits, this industry does not

obey the laws of industrial concentration and does not need vertical integration with industries with a high rate of capital (iron and steel, primary metals, etc.);

g) it enables producers to work in a market where quality counts more than price. The smaller users can benefit from the existence of a second-hand market, as the many-purpose machines do not get out of date quickly, and in view of the length of amortization characteristic of machine tools, including the automized models.

We feel that the positive features listed above, apply to any country making M.Ts whatever its political structure may be: whether a market economy or a socialist economy. In this second case, however, in addition to the well known problems relating to price fixing which is of particular importance in an industry which must hold its place in world trade, what is said under point (f) above does not apply (concentration etc.) since, as we have seen in the case of the U.S.S.R., in countries with a Socialist economy the M.T. industry is concentrated to a high degree.

5. Essential preliminary conditions and obstacles to overcome

At this point it would seem advisable to sum up the main difficulties which a development of the industry is facing. These difficulties are even more serious when it has to be started from nothing as in the case of countries where the development of an industrial economy is in the early stages, and may be described thus:

a) In a market economy the birth of a machine tool industry

is strictly subordinate to a previous development of a metalworking industry: indeed, in the already industrialized countries this fact has strongly affected the question of where it shall be localised. This condition is not limited to the initial period but becomes permanent because the percentage of end components used is very high; it is in fact closely linked to the metalworking industry both for its raw materials (from primary metals industries in particular), for its semi-finished products (the engineering industry in particular for bearings, gears, etc.) for an extremely wide range of finished goods (motors from the electrical industry etc.), involving the most widely diversified industries (electronics in particular). Thus the degree of interdependence between the M.T. industry and the class to which it belongs is very close seeing that 90% of the M.T industry's output is absorbed by this class from which in turn it receives 90% of its inputs (cf. Table 3).

This interdependence is not of course limited to the relationship between this branch and its class of industry at national level but is also evident in world trade. A quota of the imports of each country (of considerable size both in the advanced countries and in those in the developing countries) concerns parts or components (electric motors, electronics) as well as manufactured goods and/or special materials (special steels, bearings, etc.).

b) The difficulty of creating a category of trained and skilled labour, and of maintaining a constant level of availability.

c) the lack of independence felt by the M.T. industry in

deciding what its final products shall be, seeing that these decisions are mostly made by the users.

d) Normally speaking, technological development of a M.T. industry cannot be even (see point (c)), partly because its productive dimensions are usually smaller than those of the user establishments and this puts it in a subordinate technological position.

6. Some specific problems and long-term prospects

We think it may also be helpful to bring out some specific problems arising in the M.T. industry, as these are of particular interest to the economically developing countries:

a) the possibility exists of passing through an intermediate stage of assembling machines designed abroad, consisting of parts which may or may not be produced locally. This stage may precede the creation of a local M.T. industry, but must be carefully considered in relation to the condition of economic, financial and technologic subordination to the country supplying the parts and the know-how, to which such a stage might lead.

b) once the local industry has been set up, as previously mentioned, its products must enter the channels of world trade as soon as possible. Each country must therefore be aware of the function it may have, either as a producer of standard machines or as a producer of special and/or complex ones. It must always be borne in mind, however, that machine tools are "mature" products, and, from a certain qualitative level upwards, they pre-suppose a fairly high

degree of technological development.

For these reasons, the efforts to set up and develop a M.T. industry, within the economic framework of a country must be most carefully considered and graded.

An essential condition for organizing exports, or sales on the home market too for that matter, is the existence of a proper supporting infrastructure (servicing, spare parts, stocks, promotional activity at home and abroad, attendance at international exhibitions, etc.) all of a very high order.

It should finally be recalled that the long-term prospects for developing a M.T. industry, so that it may take its proper place in world economy, converge in a number of fundamental directions, these being:

(i) the increasing extent to which automation is applied to machine tools, partly due to the state of unbalance between the rate of development of production and consumption and availability of skilled labour;

(ii) the tendency towards the construction of ever more complex and automated M.Ts leading to an ever closer interrelation between this industry and the electronics industry;

(iii) the tendency within the industry as a whole to increase the number of forming machines compared with that of cutting machines. The forming machines incorporate more and more advanced technologies (laser, numerical control, plasma etc.), further confirming what is said under (ii).

For a precise understanding of point (i) we would recall that while in the automobile industry for example automation has gone beyond the stage of production and is

now applied to assembly work, in the M.T. industry it has not yet been possible to apply automation to all the processing operations.

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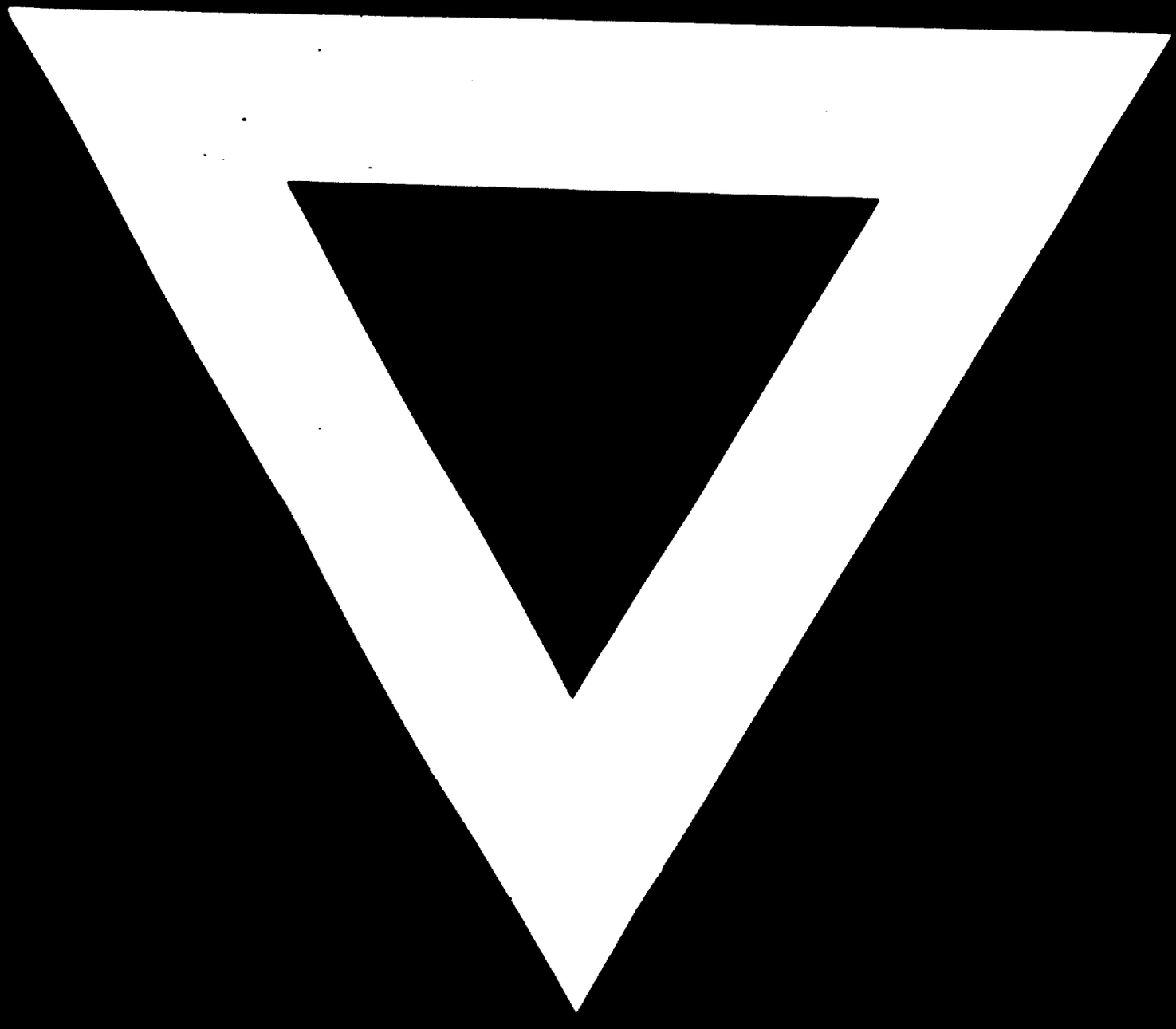

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