THE TECHNO-ECONOMIC DEVELOPMENT OF THE INDIAN MACHINE TOOL INDUSTRY WITH SPECIAL EMPHASIS ON ASPECTS AFFECTING EFFICIENCY

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TO MY MOTHER AND IN

MEMORY OF MY FATHER

Acknowledgments

Despite the crucial significance of the role that machine tool manufacture plays in the process of industrialization, a dearth of empirical studies exists on the contribution of this sector to the economic development of particular countries. An example is India where, quite amazingly, a sectoral analysis of this type has never been undertaken. The present study, therefore, is a modest attempt to rectify what is clearly an unsatisfactory shortcoming in the literature.

To this end, I would like firstly to thank the Social Science Research Council which, through the provision of a three year research scholarship, made the study possible, and further, for the generous additional finance that the Council afforded me during my nine months fieldwork in India. In addition, I would like to express my appreciation to the University of Glasgow for a three month supplementary scholarship which allowed me the opportunity to continue and complete the study unfettered by monetary pressures.

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Simply put, this study is an attempt to provide an in-depth analysis of the techno-economic development of India's machine tool industry. Although this opening statement fairly and accurately reflects the objective and general theme underpinning the work, it is perhaps highly superficial in that it tends to gloss over the original piece of stage-setting for the study : by reference to the Soviet machine tool manufacturing experience of the 1930s, a comparative theoretical framework is built-up which, it is argued, might have had great relevance to the economic conditions facing the India of the 1950s at the start of its thrust for rapid industrialization.

The Soviet 'model' of machine tool production could well have been particularly appropriate to India's economic circumstances because of its emphasis on capital-saving; an approach which related not only to the character of the machinery produced but also the manner of its manufacture. Therefore, in an Indian economy which was already rigorously emulating the Soviet two-sector growth strategy, a case could be argued for India's tool industry to have similarly followed the Soviet development pattern.

However, as the development of the industry did not in the event follow the Soviet experience, then the initial concern of this study has to be with the establishment of what the alternative manufacturing philosophy was oriented to, if it was not to the achievement of maximum cost-price reductions à la the Soviet approach. In answer to this, the proposition is tentatively though nevertheless it is believed safely advanced, that machine tool production in India developed along well entrenched Western industrial lines. Here, it is the role of innovation that has been the dominant feature. Under this scenario, little importance is

attached to cost-price reductions of the machine tools produced, rather, emphasis is placed on improvements in design as a means of maintaining or increasing the sales of an enterprise through the creation of a fresh market. The suitability of this type of manufacturing strategy : bringing pressure on the machine building customers of the machine tool branch to replace still productive machine tools is, to a capital-scarce country such as India, a highly dubious exercise even if it could be shown to operate satisfactorily.

Efficiency in production lies at the heart of the issue. It is important to realise that a capital-saving mode of development should have regard to more than simply producing labour-intensive technology; capital will also be economized if this technology is manufactured efficiently. It must be recognized though, that in the case of India, the possibilities which existed for raising productive efficiency in the tool branch have to some extent been inhibited by the need to pursue other development aims. The goals of growth and technological self-sufficiency are two such factors which have figured prominently in the sector's development strategy.

Thus, although the primary aim of this study is to examine the various aspects which bear upon the efficient operation of India's machine tool industry and, as a result, provide indirectly some insight into the capital-saving performance of the branch, nevertheless, the success in attaining the other objectives of high growth and technological independence is also assessed. The conclusions derived from these specific analyses allied with the more general observations of the industry's techno-economic development assists in a culminating discussion that contrasts the appropriateness of the development strategy that was followed, on the basis of the efficiency obtained, against the adjudged advantages to be gained from pursuance of the Soviet approach.

Chapter 1

A Comparative Analysis of Capital-Goods Led Growth Strategy in Developing Countries : Theory and Practice

During the latter half of the 1920s, the Soviet Union launched a drive for industrialization which was revolutionary in character; its novelty lay in the central control and allocation of scarce resources. The unparallelled success since then, has prompted many of the newly emerging nations to emulate, to a lesser or greater degree, the pattern of Soviet development. A considerable number of these third world countries, recently freed from the chains of colonialism, naturally equated capitalism with exploitation. For them, the arrival of planned development provided the means by which their rising aspirations could be sated : the socialist panacea to economic dependence.

One of the first disciples of this 'Eastern' model was India. Jawaharlal Nehru, the immediate post-independence Prime Minister, espoused the virtues of socialism and attempted to translate them into pragmatic form through a series of 5 year economic plans. Thus, industries of national and strategic importance were brought under the direct control of the central government; where they lacked the required capacity or simply did not exist, then invariably a public sector was established. The particular case of the machine tool industry is one such example. What is so surprising about this branch however, is the manner in which its development has followed a 'Western' production philosophy: this, when the Soviet model would not only have been consistent with the vogue political ideology but, in point of fact, might also have been more appropriate.

It is from this perspective that the present study takes its cue. Two factors though, ought to be emphasised from the outset.

The first has regard to the nature of what has been referred to in the text as the Soviet model of machine tool production. There must be no confusion as to the correct interpretation of this term : it is not crucial that Soviet production practices in machine tool manufacture may, or may not, have been a deliberate and concerted act of Soviet policy-making. What is important is that a number of measures were enacted which, when combined into a whole, displayed a pattern that could have had 'ex post' significance to the more contemporary developing countries such as India.

Secondly, whether the Indian machine tool industry would actually have developed on more efficient lines had it instead taken heed of the Soviet experience is a moot point. The stance that this study takes is that it could have been the appropriate course of action and certain arguments are put forward in justification of this posture. Ultimately though, the question is conjectural : the wheels of time cannot be reversed. Thus, with India having chosen to tread the path of conventional manufacturing practices, this study will concern itself with an evaluation of the efficiency levels that the industry has, in consequence, achieved.

The objective of this introductory chapter is to provide a speculative tour d'horizon of the strategy of capital-goods led growth theory. The key to this form of industrialisation is, in essence, the emphasis given to the growth in the 'heavy' goods and machinery industries; within this, the machine tool branch plays a critical supportive role by supplying the basic capital equipment necessary for such expansion to take place. For the Soviet Union and India in particular, the role of the capital-goods sector in economic development has been the subject of some debate.[1] Although the approach of the two countries' planning authorities has been broadly similar, the controversy exists because the results have not.

The starting point to the chapter is the argument that capital formation is a necessary though not sufficient factor in the achievement of rapid industrialization. Equally important is the manner in which the capital is used. This point echos Cairncross's doubts as to whether, ..."additional capital ... would by itself suffice to start off a cycle of industrialization. The problem is often one of organization quite as much as of capital creation."[2] In this context parallels for India can be drawn from the experience of Soviet planning. The success of Soviet development policy was due not only to the high priority it gave to capital-goods production but also, within this, to the promotion of the machine building industry. The viability of this policy in a 'closed economy' depended on the expansion of a machine tool branch to serve the growing needs of the machine tool using industries. As clearly, ... "the demand for such machines [machine tools] is closely linked to the evolution of the metal-transforming industry "[3] ... the Soviets realized that raising the efficiency in the production of machine tools would result in capital-savings percolating, ultimately, to the entire machine-using economy. It was from this perspective that the Soviets perceived the importance of machine tool manufacture. From the outset they seized the opportunity which central planning provided to improve efficiency in the organization of total production. This principle had the following elements: (i) Specialization by product; (ii) Standardization and interchangeability of components; (iii) Long production runs; and (iv), A centralised policy on innovation. Almost certainly, the efficient organization of production was a significant contributory cause in the emergence of the Soviet Union, by the late fifties, as the largest manufacturer of machine tools in the world.

The Harrod/Domar identity is the fulcrum on which the theorizing of this chapter rests. It will, therefore, be worthwhile to recall briefly the rationale behind the model.

The most important feature of the theory is that capital is seen as the engine of growth. Harrod and independently Domar, realized ... "that full employment income in period t would not be sufficient in period t + 1 because of the additional capacity created by investment in period t."[4] The necessary level of increased expenditure may be found by examining the interaction between capital and output. Since investment in period t is determined at the equilibrium level of national income by the marginal propensity to save, economic growth becomes a function of the marginal propensity to save and the capital-output ratio. Symbolically, if Y is national income, K is capital, I is investment and S is savings, then the growth rate is :

$$G = \frac{\partial Y}{Yt}$$

the savings ratio $S = \frac{St}{Yt}$ and (since It = St) this $= \frac{It}{Yt}$

$$\partial Kt + 1 = \frac{It}{\partial Y}$$

$$\text{the 1COR} = \frac{\partial Kt + 1}{\partial Y} = \frac{It}{\partial Y}$$

$$\text{Since } \frac{\partial Y}{Yt} = \frac{It/Yt}{It/\partial Y} \quad \therefore \quad G = \frac{S}{V(K/O)}$$

From this construct, growth can be increased in either of two ways : (i) expanding the savings ratio, or
(ii) lowering the capital-output ratio.

In summary, the intention of Section one is to examine the structural characteristics of the Soviet and Indian economies during their early periods of planning. In this manner, it becomes possible to isolate the constraints operating against the expansion of the savings ratio (the numerator in the Harrod/Domar growth model) and, in consequence, the rate of growth. In addition, while Section two provides a further main justification for capital-goods led development in the form of technology (a given variable in the Harrod/Domar model), the concluding section emphasises the efficiency in the production of 'machines which make machines' as a source of capital-saving for the economy as a whole. This is a process which, ultimately, raises the rate of growth by lowering the capital-output ratio of the economy (the denominator in the Harrod/Domar equation).

Section 1 - Structural Considerations

(i) The Two-Sector Growth Model

Before discussing the mechanics of two-sector growth models it will be sensible to open with a consideration of the classification of capital-goods. The need is to provide a working definition of capital-goods so that they may be distinguished from consumption items. A statement by Joan Robinson acts as a good introduction to the problem, ... "capital is not what capital is called, it is what its name is called. The capital goods in existence at a moment of time are all the goods in existence at that moment. It is not all the goods in existence. It includes neither a rubbish heap nor Mont Blanc. The characteristic by which 'goods' are specified is that they have value, that is, purchasing power over each other. Thus, in [the capital-surplus] country Alpha an empty petrol tin is not a 'good' whereas in Gamma where old tins are a source of valuable industrial raw material, it is."[5] In practice, this generic interpretation of capital goods is not particularly helpful. Frances Stewart illustrates this fact when examining whether a distinction can be made between capital and consumer goods on the basis that the former renders future services whilst the latter are consumed instantly. With this criterion a temporal perspective is introduced as Mrs. Stewart states, ... "but this makes the classification dependent on the period of time taken to constitute 'instantly'; if interpreted literally it makes all goods

Capital goods à la Robinson and only services, which by their nature are consumed instantly, Consumer goods."[6] Later however, she does put forward a different approach which is, ... "to define capital goods as goods which are not demanded for themselves but as inputs which, together with other inputs render further production possible."[7] This classification though, suffers from similar definitional weaknesses as the time-oriented way of viewing things. Only now, difficulties are concentrated on how to define 'further production'. Any goods consumed by the labour force which maintain their health and strength must, under this definition, be classified as capital goods because if they contribute to the worker's productivity - further production becomes feasible.

It is evident that the classification of goods into capital and consumer items is fraught with pitfalls. But to avoid the question would without doubt seriously undermine the structure of the study at hand. Therefore, notwithstanding the absence of a rigid dichotomy between capital and consumption goods, it is surely logical to lead on from Mrs. Stewart's reasoning and address the problem in terms of the allocation of current resources to goods which in the future expand the productive base of the economy, and those that do not. This is a Marxian pattern of analysis whereby total material production is divided into two main departments :

I <u>Means of Production</u> : Commodities having a form in which they must, or at least may, pass into productive consumption.

II <u>Articles of Consumption</u> : Commodities having a form in which they pass into the individual consumption of the capitalist and the working classes.[8]

It should be stressed that Marx included both industrial and agricultural goods in the above departments. Thus, for the purposes of examining solely the division of industrial production, it is conventional to speak of 'group A' -

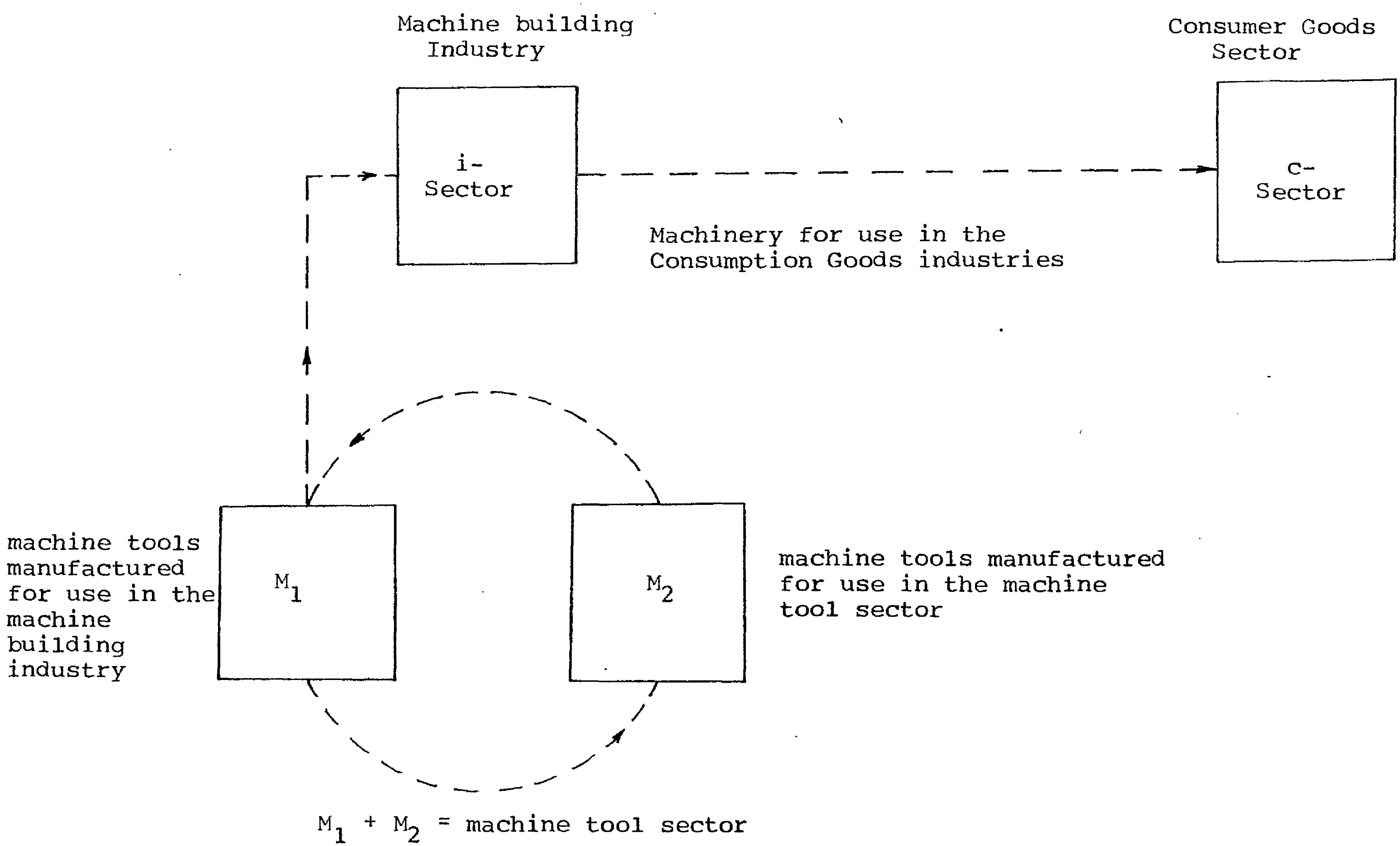
capital/investment/producer goods, and 'group B' - consumer goods. Contemporary writers on the subject sometimes cloud the issue by supposing A and B to be synonomous with 'heavy' and 'light' industry. This is erroneous, as Professor Nove once wrote, ... "the entire machine building (engineering) industry is classed as 'heavy', but passenger cars and domestic refrigerators made by this industry are classed as B, along with such products of 'light' industry as clothing and shoes, while that part of the textile industry's output which consists of cloth for the clothing industry is included with A. In principle, it is the use of any unit of the given product which determines its category, which means that many products are to be found in both groups."[9]

Classical theories of growth operate on the premise that the level of real investment in an economy is determined by the surplus of the category B producers above what they consume for themselves. Although, it should be noted that this surplus is a "gross" concept : intermittently capital goods do require replacement. In this respect, it is only the goods of group A, in excess of this replacement level that constitutes net investment and as such generates the growth potential of an economy. The limitation of this 'classical' approach involves the realization that in underdeveloped countries, the rate of investment may be more a consequence of the existing stock of capital than the flow of wage-goods. Consequently for economic growth to take place some enlargement of capacity in the group A industries is required. Maurice Dobb, according to Raj in his 1967 article - 'Role of the Machine Tool Sector in Economic Growth', was the first economist in the West to recognise this fact. Dobb was aware of the initial retarding effect this might have on growth of output on account of the diversion of some of the existing capital equipment to the manufacture of more such equipment, but pointed to the higher rate of growth of output which expansion of productive capacity in the capital goods sector would make possible at future dates.[10]

In a later, more detailed study, Dobb concerned himself primarily with problems regarding the choice of technique in underdeveloped countries. He began this analysis by constructing a two-sector growth model with the limiting assumption that machines in the investment sector are made with 'unassisted' labour. This assumption is dropped when Dobb concedes to reality : machine-makers like machine-users also require machines with which to produce. To fully appreciate the theoretical implications of this point, it is valuable to quote Dobb at length: ... "To handle this more complex situation we shall need to break down our investment sector into at least two sub-branches within it. Let us label these two branches i and m, the first as before being occupied with producing capital equipment for the C-sector, and the second with producing machine tools that can be used alternatively in making the capital equipment for the C-sector or, in branch m, in making machine tools themselves. This latter branch will accordingly be capable of a circular process of self-expansion, as well as of producing to meet the needs of expansion of branch i. It can, however, only pursue this self-expansion process at the expense of diverting to itself some proportion of the investment sector labour force that could otherwise have been making equipment for the C-sector and hence contributing directly to the growth rate as measured by L_C/ t .. [the change, over time, in the labour force of the C-sector]."[11] Dobb refers to the two distinct destinations of the output of the machine tool sector by the use of suffixes m_2 for itself, and m_1 for i - the machine building industry. In fact, he spends considerable time enlarging upon the importance of branch-m, both for the manufacture of machine tools necessary for the expansion of i, and for the increased tooling itself requires as necessitated by this expansion. Figure 1 should help to clarify this complex set of relationships.

A salient feature of the 'machine tool sector' in Dobb's model is its productivity, and the consequential

Figure 1 : A Schematic Representation of Dobb's Two-Sector Growth Model



effect that it has on the growth rate of the economy. The effect of increased productivity in m is to reduce the size of its labour force relative to branch i. This process has an 'enervating' effect on growth (which, it may be remembered is defined as a positive change in the labour force of group B industries) via the increased supply of capital goods to the consumer sector which the released m workers make possible. This is so, because workers in the model are denied the possibility of seeking employment outside their sector. Moreover, sub-branch m_2 possesses the peculiar ability to initiate and sustain a circular production process of its own, ... "turning out machines capable of reproducing, if need be, improved types of themselves ... as such branch m_2 is capable of breaking out of the determinism laid upon it by our structural equation."[12]

Dobb's model represents a planned economy and because of this he conceives the mechanics of its operation as an "accelerator - relation in reverse"[13] with group B industries dependent on the productive capacity of the capital goods sector instead of the converse situation. With emphasis respecified away from promoting the maximum rate of expansion of the surplus product of the consumer goods sector, the alternative growth strategy is broached : that of concentrating investment resources into the self-reproducing process of m_2.

(ii) The Approach to Planning in the Soviet Union and India

All two-sector growth models are based on the assumption of a planned economy. This accords perfectly well with the political ideology of the Soviet Union. It also has relevance to the socialistic character of the Indian industrial environment which evolved from Nehru's archetype, ... "of combining economic mobilization with political conciliation, a Soviet economy with a Western policy."[14] Bearing this in mind, attention is first directed to the Soviet planning model.

The Soviet two-sector growth model is customarily associated with an equation constructed in 1928 by the Russian economist Fel'dman; it was to act as the basis for the Soviet State planning Commissions' 'General Plan' which was expected to cover a period of between ten to twenty years. Fel'dman's division of the total output of the economy was a modification of the Marxian scheme. As Domar states, his initial aim was to ... "place all activities merely sustaining output at the present level in category 2, while all capacity increasing ones were located in category 1."[15] This approach suffers from the same definitional deficiencies discussed earlier in the chapter. Though in Fel'dman's final version, category 1 produces all capital goods for both categories, while all consumer goods including the corresponding raw materials are produced in category 2, the output of each category consisting of its respective final products only.[16] Problems of definition still remain, with some industries providing goods and services to both categories, e.g. chemicals and transportation. Nevertheless, Fel'dman's model does have general application to Soviet developmental experience. For the purposes of the current study though, it will not be necessary to delve into the econometric intricacies of his work; it will suffice to mention briefly his main considerations.

In unison with other growth models, Fel'dman's is based on a number of simplifying assumptions such as constantprices and the non-transferance of factor resources in the short-run from one category to another. In the context of capital, this latter assumption implies that the rate of investment is determined by the capital coefficient and the stock of capital in his category 1 industries. Equally, the output of category 2 is determined by the capital coefficient and the stock of capital in the investment sector. This, in turn, poses the question which has direct relevance to many underdeveloped countries : if an investment sector is so small as to be only able to cater to the replacement needs of both categories then growth can only be attained by the non-replacement of capital goods in the consumer sector. Thus, ... "the division of total output between consumption and investment at any moment depends on the relative productive capacities of the two categories, and not on the propensity to save, though the latter can re-assert itself by causing an under-utilization of the capital stock in one category or another, a waste ruled out in the model."[17] The division of investment between the two categories holds no such limitation, in fact (τ) - the allocation of investible funds directed to category 1 emerges as the major attribute of the model. Domar, in his appraisal of Fel'dman's study pursues this aspect and observes the close relation between (τ) - the fraction of total investment allocated to category 1 and ($\acute{\alpha}$) - Keynes' marginal propensity to save. Domar explains this phenomenon as, ... "merely a reflection of the fact that if a certain fraction of the increment in national income ($\acute{\alpha}$) is to be devoted to investment, a corresponding fraction of investment (τ) must be allocated to capital goods industries to make the production of this increment possible. In other words, in a growing economy some capital is used to make more capital."[18] It is in fact, ironical, as Domar notes, - that Fel'dman insisted throughout his work that the final goal of all production is consumption.

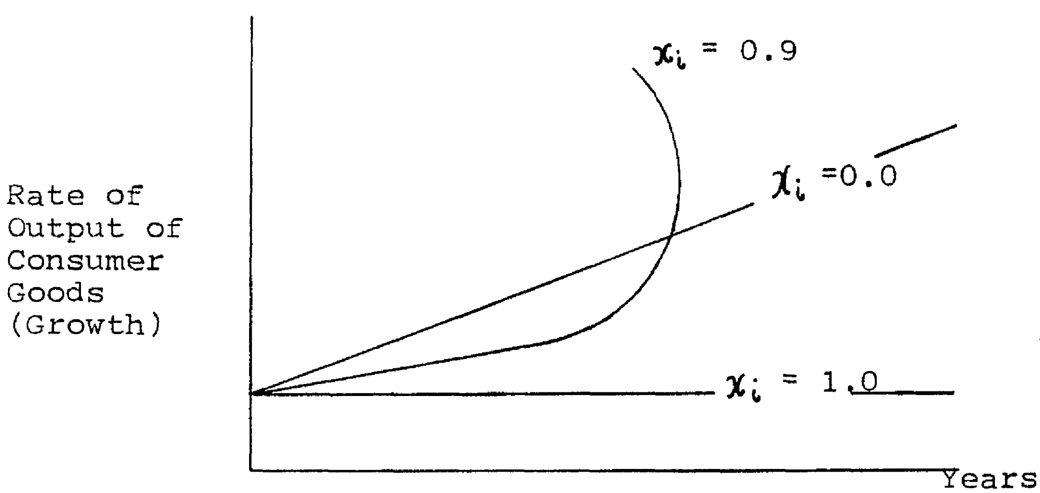
The growth model that India followed for its development push was very similar to that of Fel'dman's. It was developed by a senior economist in the Indian government, P.C. Mahalanobis and outlined, originally, in an article published in 1953.[19] In actual fact, however, there were two growth models. The first, approximated very closely to the Harrod/Domar equation and was formulated in 1952. This model was constructed for the purposes of the First Five-Year Plan although it aimed at providing for targets of income, consumption and investment over the next twenty-five to thirty years. After experimentation with the Harrod/Domar growth model, Mahalanobis finally devised his famous two-sector growth equation [20] which was later to be implemented in the Second Five Year Plan. It was India's first attempt to influence the growth rate by recourse to sectoral allocation of investments and this new approach came about via Mahalanobis' identification of the rate of growth of investment in the economy with the rate of growth of output in the capital goods industries within the economy.[21]

Like Fel'dman before him, Mahalanobis followed the Marxian classification of production; and, though both writers diverge from the lumping together by Marx of all raw material producing industries into Department 1, Mahalanobis does go further than Fel'dman. Specifically, he conceptualises that industries producing raw materials for consumer goods industries are included in the consumption sector and industries producing raw materials for investment goods industries are included in the capital goods sector - no mention being made of services.

The two key variables in the Mahalanobis model relate to α and β, both defined as constants. The former is the ratio of net investment to net national income, at factor cost in a given time period, and the latter is the increment of income divided by investment also in respect to some stated time period. Thus, in the Mahalanobis equation, the rate of growth of an economy is found by $\alpha\beta$ (though, the author depicted growth in per capita terms so that the formula became $\alpha\beta - P$, where P represented the constant increase in population). This is of course, equivalent to the familiar Harrod/Domar identity G = S/V, which was given in the introduction to this chapter. Only here, Mahalanobis' β is the inverse of V (capital-output ratio). In addition he elaborates on this basic framework by separating out the investment in the investment industries from the investment in the consumer goods industries. The particular assumption being that, ... "a constant percentage λ_c of investment goes to consumer goods industries and the complementary percentage λ_i going to the investment good industries ($\lambda_c + \lambda_i = 1$)."[22]

Common to both the Soviet and Indian patterns of development is the emphasis on a high relative level of investment in the capital goods industries. The optimum size of both Fel'dman's (γ) or Mahalanobis' (λ_i) depends on the development strategy pursued by the respective planning authorities. If raising consumption in the immediate future is deemed to have maximum priority, then it is necessary to aim for a higher level of investment expenditure in the consumer goods industries. On the other hand, a higher ultimate growth of the economy will be achieved, the greater the proportion of investible resources devoted to the capital goods sector. However, this higher future rate of growth in consumption and employment is only achieved at the expense of current consumption. As Mrs. Stewart states, ... "While growth in consumption will initially be lower, the higher γ ... [(γ) or (λ_i)] ..., eventually growth in C-good capacity will speed up, as the larger size of the I-sector compensates for the smaller proportion of its output going to investment in the C-sector."[23] Figure 2 illustrates this point.

Figure 2 : Allocation of Investment between Capital-Goods Industries and Consumption-Goods Sector



The lower horizontal line ($x_i = 1.0$) in Figure 2 depicts the situation whereby all investment is apportioned to the capital goods industries with the consumption sector receiving none. This is a highly unrealistic case involving zero growth in the consumer good industries - politically unpalatable for a government under any ideological banner. The second example, a constantly rising straight line ($x_i = 0.0$) corresponds closely to the traditional economy where the major portion of investment is directed to the consumption sector. This type of growth implies both a constant level of capacity in the capital goods sector as also its output - the annual flow of investment suggesting a relative decline in the rate of growth over time. The Soviet Union and India have both attempted to follow the third course of action, symbolised by ($x_i = 0.9$). It is the curve which exhibits a rapid rate of growth in consumption after a very short elapse of years.

The relationship between the choice of investment rate and the choice of investment project is perhaps the most significant feature to emerge from the foregoing appraisal of the Fel'dman/Mahalanobis growth models. As Sen asserts, ... "once the specificity of productive capacity is recognised to have an important bearing on the question, the problems of allocation of investment between different sectors becomes the present-day equivalent of choosing future rates of saving. If, for example, we assume that investment goods are of two types, viz., those that make consumer goods and those that produce investment goods, the present-day allocation of productive capital between these two sectors comes to very much the same thing as the determination of the future division of national output between consumption and investment. The allocation of investment between the two becomes the means of influencing the rates of investment in the future.

If one assumes further specificity, so that investment goods to make investment goods to make consumer goods are different from investment goods to make investment goods to make investment goods, the decision has to be taken one further step backwards, and so on."[24]

(iii) An Evaluation of the Relative Effectiveness of Sectoral Planning

The discussion thus far, has delineated the major theoretical aspects of capital-biased growth as it related to the early industrialization of the Soviet Union and India. But how 'successful' have each of these countries been in pursuing this policy?

The strategy of Soviet industrialization encompassing as it did, high rates of capital formation with priority on basic capital goods industries has been vindicated by the consistently high rates of economic growth achieved. This is evidenced by citing the official and estimated growth rates contained in various studies by eminent scholars in this field. Table 1 provides data on the growth rates of G.N.P. and N.N.P. which clearly brings out the tempo of Soviet economic development. In comparison with the other countries' rates of growth during their respective initial stages of development, it is hardly surprising that the Soviet Union's performance has had such a profound effect on the policy-makers of India. This is the more so, if Bergson's argument is accepted that the composite statistics on Soviet economic growth represent a greater reflection of reality than do the base-year factor cost calculations.[25] (See Table 1)

Table 1 : Annual Average Growth Rates of GNP and NNP in Selected Countries

	% GNP	% NNP[b]	% Per Capita (GNP)
USSR :			
1928-1963			
Ruble Factor Cost of 1937[c]	4.9	4.1	3.7
Composite, 1937 base[d]	6.5	6.0	5.2
1928-1940 & 1948-1963 (effective years)[a]			
Ruble Factor Cost of 1937	6.4	4.8	4.9
Composite, 1937 base	8.5	7.0	6.9
USA :			
1840-1880	4.0	-	1.3
1880-1920	3.5	-	1.6
Great Britain :			
1765/85-1785/1805	1.5	-	0.6
1801/11-1831/41	2.9	-	1.5

Source : C. Wilber : 'The Soviet Model and Underdeveloped Countries', loc.cit. p.5

A. Bergson : 'National Income' in Bergson and Kuznets (eds.) Economic Trends in the Soviet Union, Cambridge (Mass.), (1963), p.6.

Notes :
(a) Omitting the War and reconstruction years of 1940-48.
(b) Covers the period 1928-58
(c) Output in all years is computed in terms of values prevailing in the base year.
(d) A composite is intended to approximate serial data where, in the comparison of each given year with the base year, output is computed in terms of given-year values.

Similarly impressive have been the growth rates of industrial production. In an article by Hodgman[26], the expansion of Soviet industrial production in the years 1927/28-1950 is measured by both the official Soviet indices and by his own 1934 value-added figures. The resulting growth patterns of the varying time periods which he chose, correspond to events of importance in recent Soviet history, e.g. the Five-Year Plans; the war; post-war recovery; etc. Hodgman's data, in terms of annual average percentage rates of growth are contained in Table 2 below. On examination, it becomes immediately apparent that extremely high rates of growth in industrial production were attained throughout the periods of the twenty-three year span.

Table 2 : Annual Average Rates of Growth in Soviet Industrial Production

Years	Revised Index (%)	Official Index (%)
1927/28-1932	14.5	23.6
1932-1937	16.6	18.7
1927/28-1937	15.7	20.9
1937-1940	4.7	11.6
1946-1950	20.5	23.0
1927/28-1950	8.9	12.5

Source : Hodgman : Ref.26

Taken together, the evidence does seem to suggest that the sectoral investment policy pursued by the Soviet Union did prove effective in the growth of the economy.

India's involvement with planning, and essentially its emphasis on a capital-goods led strategy of growth has, it is safe to say, made only limited progress towards the country's ambition of high self-sustained economic growth. In contrast to the Soviet Union over the first two decades of planning India's performance pales under almost any criterion. Table 3 illustrates the 'track-record' of

India in respect of economic growth, both from an absolute and a per capita perspective.

Table 3 : Annual Average Growth Rates of National Income, Absolute and Per Capita by Each Plan

	NNP	Per Capita
First Plan	3.5	1.6
Second Plan	4.0	1.8
Third Plan	2.9	0.4

Source : J. Bhagwati and P. Desai : 'India : Planning For Industrialization' O.U.P. (1972) p.62.

Although the figures in Table 3 represent an improvement on the previous growth of the economy, which over nine 5 year periods between 1900/1 and 1946/47 had grown at an average rate of less than 1 per cent, clearly up to and including the Third Five-Year Plan, a rapid growth of the economy had not been achieved.[27] Subsequent results have been equally disheartening: by ignoring the three "Annual" Plans of 1966/67 - 1968/69 and focussing attention on the Fourth Five-Year Plan, it is found that the annual average rate of growth of N.N.P. approximates to 3.5 per cent whilst in terms of per capita N.N.P. only a barely positive figure of 0.2 per cent was recorded.[28]

Judging by trends in the growth of the economy, the results of India's capital-goods led planning policy have been far less auspicious than the comparative figures for the Soviet Union. Growth in industrial production, however, did perform somewhat better. For the period from 1956/57 to 1975/76, the mean annual average rate of growth came to 5.7 per cent.[29] However, this needs to be compared to the rate of growth of industrial production which the Soviets averaged between 1927/28 and 1950, amounting to 8.9 per cent - Hodgman's revised index, and 12.5 per cent - official index (see Table 2).

More disconcerting is the trend in consumption. In gauging the economic welfare of the people of India, the most appropriate index would be per capita private consumption expenditure. In this context it has been quoted that, ... "The overall increase in per capita consumption during 1960/61 and 1967/68 was 3.9 per cent but the top 40 per cent in rural and urban population increased their per capita consumption expenditure by 4.4 and 4.8 per cent respectively. On the other hand, the middle and lower income groups in rural areas experienced very little increase in per capita consumption and, in fact, the bottom 5 per cent actually had a decline of per capita consumption expenditure. The position of the urban poor is much more serious, for the lower 40 per cent of the population suffered a decline in consumption and this was particularly severe for the bottom 10 per cent which amounted to 15 to 20 per cent."[30] This must be contrasted with a 4.7 per cent annual average increase in Soviet per capita private consumption expenditure between 1928-40 and 1948-58.[31]

Implicit in the priority given to growth in the Indian Five-Year Plans was the belief that all other objectives would be subordinated to the achievement of this goal. This assumption was made explicit in the introduction to the Fifth Plan, thus ... "In elaborating our strategy of development in earlier plan documents, we seem to have assumed that fast rate of growth of national income will by itself create more and fuller employment and produce higher living standards of the poor."[32] Unfortunately, this optimistic approach has not been rewarded in practice. The facts speak for themselves. During the Second and Third Plan periods when unemployment would have been expected to have shown some decline with the implementation of the government's "big-push" philosophy in the capital-goods industries, the reverse occurred. From Table 4, it may be observed that by the close of the Third Plan, not only had the growth of the economy failed to provide for the increase in the labour force over the preceding ten or so years, but more ominously, extant unemployment had not even been touched.

Table 4 : Estimates of the Volume of Unemployment and Employment Generated 1956-66 (millions)

	2nd Plan (1956-61)	3rd Plan (1961-66)	at 1966
Unemployment at beginning of Plan	5.3	7.0	9.5
Addition to labour Force	11.7	17.0	23.0
Total Unemployment	17.0	24.0	32.5
Employment Generated during Plan	10.0	14.5	-

Source : P. Chaudhuri : 'The Indian Economy : Poverty and Development', Vikas Publishing Ho., New Delhi (1978) p.48.

A major factor in the growth of unemployment has of course been the explosive increase in the population of India. At the time of the 1951 census, the population stood at 361 million; in 1961 it was 439 million; and by 1971 with an average 2.2 per cent growth per annum over the two decades, it stood at 547 million. The seriousness of this level of population increase on the achievement of planning goals can be highlighted by comparison with the Soviet population expansion during the thirties. Over the period 1929-39, the Soviet Union's population grew from 154.3 million to 170.6 million in 1939, registering a more moderate 1.5 per cent rate of growth. Clearly, the sustained increase in India's population must have been a significant influence in the tardiness of the country's economic growth. A manifestation of this fact comes from a study by Morawetz[33] who ranks 77 developing countries by GNP per capita for the years 1950-75. In 1950, India's G.N.P. per capita was $95 ($U.S. in 1974 prices) which by 1975 had only risen $43 to a discouragingly low $138 G.N.P. per capita. The culminating testimony of India's "failure" to remove poverty through growth has regard to its ranking amongst the other developing countries : in 1950, India was ranked at 66 and twenty-five years and zero movement later - the ranking remained the same.

Therefore, in terms of growth, consumption and employment, it appears that India's policy of encouraging the development of the capital-goods sector has not proved successful when compared with the Soviet performance. It may well be that the applicability of the Soviet experience is, as one commentator put it, ... "Contingent on the presence of Soviet-type economic, social and political conditions."[34] Although the autocratic nature of Soviet development can take some credit for the rapid transformation of the economy, the suspicion of the present author is that this was certainly not the only reason and possibly not the main one. It is more likely that the divergence in the performance of the Soviet and Indian economies is a consequence of the assumptions on which both the Fel'dman and Mahalanobis two-sector growth models are based. Hence, the need now is to show that although the conditions prevailing in early Soviet industrialization were conducive to the policy of sectoral planning, they were not in the case of India.

(iv) <u>The Impact of Operational Constraints</u>

Essentially, the sectoral allocation of investment resources conforms to Hirschman's 'unbalanced growth' theory which articulates economic development in terms of "bottlenecks". It is from this platform that the raison d'etre of two-sector growth models - as reflected in the stress they place on the strategic role of capital formation - should be understood. Investment capacity is perceived to be the major bottleneck in the growth of the economy. The reasoning being, of course, that although it is possible in a relatively short period of time to increase output with the existing capital stock, additional capital is always needed to increase output over the long-run.[35] Hence, the logic behind two-sector growth models cannot be faulted if domestic capital-goods capacity (remembering the 'closed economy' assumption) is the primary bottleneck. In so far as it is, the emphasis on the growth of the capital-goods industries is then justified. However, this 'blinkered' approach to the problem tends to ignore the possibility of other factors operating to retard the growth of the economy. Mrs. Stewart, has drawn attention to the existence of three further constraints[36], namely :

(i) Savings Capacity : the extent to which consumption in the economy can be compressed to release resources for investment;

(ii) Absorptive Capacity : relating to the scarcity of those factors which are likely to confine the capacity of an economy to utilise capital productively; and,

(iii) Willingness to Invest : a 'hotch-potch' of considerations ranging from technical conditions to psychological factors.

Under these circumstances, the determination of the savings ratio and, in turn, the maximum level of investment is set by the lowest of the four capacities. In other words, the application of a two-sector growth model in an economy where constraints other than capital-goods capacity operate, leaves open the possibility that the wrong bottleneck may be chosen.

To what extent did these other constraints operate in retarding Soviet economic growth during the early phases of its industrialization? 'Willingness to invest' can quickly be discounted: obviously it becomes the responsibility of the state in a country which is governed by an autarchic regime. The 'supply of savings' was probably not a constraint either. This may be explained by reference to the economic conditions at the commencement of Soviet planning in which a relatively large industrial base - primitive though it was - already existed. Hence, a supply of savings was forthcoming because living standards for a large measure of the population were sufficiently high to permit consumption to be depressed without affecting efficiency. Due to the fact that the state of the economy was relatively advanced, the availability of viable investment projects would also have been less of a limiting factor. 'Absorptive capacity', therefore, would not have acted as the primary constraint to growth. Coupling these points with the high rates of growth the Soviets did in fact achieve, it would appear that the correct policy of encouraging the growth of capital-goods industries was followed.

The situation for India over the first two decades of its planning programme was totally different. It is difficult to conceive of 'savings capacity' not acting as a limitation when the figures for per capita private consumption expenditure are recalled. For the great mass of the population it would have been impossible to depress consumption still further. Given this fact, almost certainly the 'willingness to invest' constraint would also likely have become operative, in as much as 'expectations' concerning the rate of growth of consumption would have acted as a strong psychological barrier against investment taking place. In addition, limited 'absorptive capacity' posed (and continues to pose) a major constriction on the growth of the Indian economy. Even in those industries that experience comparatively high rates of output growth, such expansion invariably co-existed with low levels of capacity utilization. It is probable, therefore, that although the low level of capital-goods capacity in India did act as a constraint to rapid economic growth, the likelihood is that it was not the principal factor involved. This contention is further supported by reference to the data on capital formation for the period 1955-65 where Net Domestic Capital Formation as a percentage of Net Domestic Product was relatively high at 12.3 per cent and yet the annual average rate of growth of G.D.P. over the same period only reached 3.4 per cent.

Neo-classical economists might well be in agreement with the above discussion, albeit for different reasons. Complications would arise because of ... "the assumption behind such [two-sector growth] models" ...being ... "in complete contradiction to the assumption of substitutability, diminishing returns and continuity, that are at the heart of neo-classical economics."[37] Furthermore, neo-classicals would reject the notion, implicit in the growth models of the Fel'dman/Mahalanobis variety, that resources are in abundant supply (at constant cost) until such a point is reached when no more become available whatever the price. Such an assumption is incompatible with the facts of neo-classical life in which a 'project appraisal' approach to economic development is utilised. From their viewpoint, an assessment of competing projects to identify that which gives the highest net present value is a more sensible strategy than sectoral planning. The rationale behind this preference centres around the idea that shadow pricing more accurately reflects the opportunity cost of resource allocation. This would be the case whether it applied to a capital - or a consumer - goods industrial project. The going gets decidedly stickier for India in its pursuance of the two-sector growth doctrine if the neo-classical approach is extended to cover the definition of "investment capacity". If this were to happen, little would textually remain of the growth model concept: instead of an upper barrier to capital-goods capacity, capital-goods would always be available, though at steadily increasing prices.

Section 2 - Capital-biased Growth Strategy : Additional Justifications

While there is now almost universal agreement on the importance of industrialization, there is still much debate regarding the proper pattern of industrial development.[38] In the case of India, it has, since the early fifties, embarked upon an ambitious programme of industrialization.

The orientation of this policy centred around the Mahalanobis philosophy of a rapid build-up in capital-goods capacity. However, in consonance with Dobb's theorizing, Mahalanobis drew a distinction between capital-goods industries in general, and machine-making industries as a sub-sector within this group. This point can be illustrated by reference to the draft he wrote for the Second Five-Year Plan in which was ... "stressed the need of establishing and expanding the basic industries to manufacture heavy machinery with all possible speed. This would enable India to install new plants for the production of steel, cement and other investment goods with the help of machinery manufactured out of domestic resources" ... and later in the same paragraph is found the crucial statement, ... "in my opinion, the development of the heavy machine-building industry is so important that, if necessary, targets of even steel, coal, or transport should be reduced to give higher priority to heavy machines because this would facilitate a much quicker rate of industrialization ..."[39]

However, the impact of the machine-making sector on economic growth ought not to be the sole criterion of its importance. India's decision to follow a capital-goods led growth strategy may not seem as irrational as the reasoning of the previous section would suggest if an additional technological justification is cited.

(i) Appropriate Technology Issue

It used to be common belief in India (and indeed elsewhere) that the problem of unemployment could be solved merely by augmenting the size of production potential. However, the continuing phenomenon of increasing unemployment occurring coincidentally with an expansion in industrial capacity has quite recently brought about a review to such thinking. Slowly, the realization has dawned that, ... "decisions regarding the setting up of any industrial establishment are not only a question of scale of operation but also of the special technology adopted for the purpose with its consequential impact on the volume of employment."[40]

The possession of an indigenous machine-building industry offers the host country greater latitude in the 'choice of technology'. In this respect, it is baffling why the question of establishing local machine-making capacity has only rarely been given serious consideration in the development literature. Even when it has been discussed, the emphasis has been largely in terms of either saving foreign exchange, or cost comparisons of domestic production with that of equipment currently produced in the developed world.[41] Inadequate attention has been directed towards the strategic role of an indigenous machine building industry capable of producing efficient labour-using techniques for other industries. Although Hans Singer in 1954, did allude to the necessity of underdeveloped countries fostering domestic technological capacity when he put their case thus, ... "modern technology is not compatible with their endowments and their natural requirements. They cannot develop a technology harmoniously unless it is their own technology."[42] More recently, Celso Furtado in his celebrated work, 'Development and Underdevelopment' wrote in more specific terms, ... "Depressed productivity [in underdeveloped countries] exists because of the relative rigidity of technical co-efficients - no possibility of combining factors except in given proportions - and because technology develops along lines determined by the availability of factors and resources of the countries leading the industrialization process. Thus, if it be taken for granted that underdeveloped countries grow by simple assimilation of known techniques (and by the corresponding accumulation of capital), it follows that the transplanting of those techniques almost always implies structural underemployment of factors. This problem can be met only through the adaption of technology which is all the more difficult since underdeveloped countries, as a rule, lack a native capital goods industry. In this fundamental maladjustment between factor supply and technological orientation may lie the major problem facing the underdeveloped countries at this present time."[43]

Contrary to what might initially be suspected, the experience of several developed countries such as the United States and Japan suggests that the manufacture of machinery is one of the more labour-intensive branches of industrial production.[44] W. Leontief in his study,[45] found that the capital-labour ratio in the machine producing branches of the United States was relatively low. Though perhaps more interesting from the point of view of underdeveloped countries is the very low capital-labour ratio found for the Japanese machinery industry in 1951, as shown in Table 5.

Table 5 : Direct Capital-Labour Ratios in Japanese Manufacturing - 1951

Petroleum Products	1.200	Metal mining	0.172
Coal Products	0.682	Fishing	0.170
Non-Ferrous Metal	0.363	Machinery and Electrical Equipment	0.161
Chemicals	0.338	Apparel	0.132
Iron and Steel	0.337	Textiles	0.131
Non-Metallic Mineral Products	0.298	Paper	0.120
Non-Metallic Minerals	0.199	Rubber	0.119
Processed Foods	0.193	Lumber and Wood	0.111
Grain Mill Products	0.193	Printing	0.093
Shipbuilding	0.174	Leather	0.068
Transport Equipment	0.174		

Source: Institute for Social and Economic Research, Osaka Uni. Japan, (mimeo), quoted from Pack and Todaro : Loc.cit. p.399

Pack and Todaro believe the explanation for this phenomenon lies in the nature of machinery production. To quote, ... "the foundation of the misconception of the branches capital intensity lies in the confusion between the direct and total input structures. While some branches which produce important inputs to the machine branch, particularly metals, are themselves very capital-intensive, there is no necessity to produce these domestically even if domestic machines are produced."[46]

A corollary to the process of machine construction is the development of an industrially skilled labour force. It is widely believed that important 'learning effects' are involved in the production of machinery.[47] In fact, one of the characteristics of India's 'informal' sector as also of the lower reaches of its organised industrial sector is the multitudinous number of skilled artisanal machine-makers.

Thus, it now appears that machine building is both a labour - and skill - intensive activity. Further support for this belief comes from Kenen who states, ... "many low K/L industries turn out to be skill-intensive and vice versa. A popular explanation of the 'Leontief Paradox' is indeed based on the assumption that K/L and S/L (skill ratio) are negatively correlated."[48]

An indigenous capacity for machine fabrication is an essential objective if labour-intensive technical change is to be generated in a developing country. No attempt to increase labour-intensity is likely to be successful unless it is accompanied by technical change in a labour-intensive direction. This is important, since most of the technical progress which takes place in the developed countries is inevitably capital-using and, if imported, will tend to impose a similar pattern of technical change in the emerging countries. The development of a local machine-building industry is required to supply 'appropriate technology' to the organised sector. It achieves this aim by facilitating the introduction of new machine designs and labour-using technologies and processes that are more suited to the local factor endowments of the developing countries. In the absence of such an industry, the range of technical choice will tend to remain narrow.

Assuming that a country decides to establish a machinery sector - is its output likely to be competitive with that of foreign producers? Pack and Todaro view the question as irrelevant, ... "there would be no comparative equipment of old design currently being produced in the developed countries for export to less developing countries."[49] Moreover, even if there was a world market for technologically out-dated equipment, the manufacture of appropriate technology in developing countries need not result in higher unit total costs than labour-saving equipment of the advanced countries. There is some evidence to suggest that even where competitive equipment is being produced, adverse cost conditions are not necessarily the case. An analysis of the structure of the Israeli economy for 1958 indicated that the real costs of saving a (U.S.) dollar of imports in the machinery branch were among the lowest to be found in any industry, despite the small size of the sector.[50] Support is also provided in a study of the effective tariff rate (the rate of protection of value-added) in Pakistan. The data showed that the effective rate of protection of machinery was the lowest for any group of products in Pakistan. Nevertheless, the rate of growth of output has been very rapid - implying that the branch may have a comparative advantage.[51]

The fundamental fact remains, however, that for those countries not possessing an indigenous machine-building industry, the importation of machinery will be required with the result that the range of actual technological choice is to a large extent limited by the technical specification of the foreign machinery. As long as the developing countries have no control over the direction and speed of technical change, the goals of industrial growth with significant labour absorption will remain exceedingly difficult to realize. Given the structure of World trading patterns, with technological capacity concentrated almost exclusively in the advanced nations, the relatively insignificant demands of the developing countries for these goods will have only a negligible impact on both current production decisions about the type of machine to be produced and more importantly, on the direction that factor-saving bias will take in the future. It is for this reason that a good argument can be made for the creation and encouragement of domestic machine building industries in developing countries, the production of which can be geared to their own technological requirements. Besides this technological aspect there are, moreover, two further considerations which figure prominently on the credit side for establishing machine building capacity.

(ii) 'Key Status' Argument :

An important issue in advocating preferential treatment for the machinery industry regards the key role it assumes during the process of industrialization. In fact, the machine-building industry is recognised as a 'leading sector' by most economic commentators as it tends to grow faster than industry as a whole. Over the period 1961 to 1972, the growth rate of the Indian machine building industry was approximately 50 per cent higher (at 9 per cent) than that of all other industry (excluding the machine building industry). This experience, similar to that of the Soviet Union during 1928-40 and in Japan during 1932-38, lends some credence to the observation of Hirschman and Gerschenkron who regard the development of producer goods branches as a great advantage to latecomers in economic development.[52]

Despite the low level of capital formation in India at the commencement of its planning programme, the country has effectively established a machine building industry which traditionally only emerges at the latter stages of industrialization. Rostow, who was perhaps the original exponent of the 'leading sector' hypothesis traces the take-off period of Japan back to 1878-1900; in 1958, more than half a century after the take-off began, the machinery industry occupied only 18 per cent of Japan's total industrial output. In India, the share of machine building output rose from 4.5 per cent in 1946 to 23 per cent in 1960 and about 31 per cent in 1974.[53] It would appear then, that the growth of the machine building industry in India, relative to all industrial output, was greater than in Japan during the early phases of its industrialization.

Mention should also be made of an influential study by Hoffman, entitled - 'The Growth of Industrial Economies.'[54] It is an attempt to trace how the pattern of manufacturing output in industrializing countries is affected by the emergence and growth of a capital goods sector, defined by Hoffman in terms only slightly wider than the present study's coverage of the 'machine building industry'. According to Hoffman's thesis the first stage of industrialization is characterized by the net output of consumer-goods industries being on the average 5(±1) : 1 that of capital goods. In the second stage, the ratio is reduced to about 2.5(±1) : 1, while in the third stage the net output of these two groups is approximately equal, 1(± 0.5) : 1. Although Hoffman's analysis is primarily concerned with capitalist countries, he does have this to say on the Soviet Union, ... "The Soviet Union is, of course, the most striking example of a country which has deliberately fostered the production of capital-goods industries by state action. During the first three Five-Year Plans (1928-42) investments in capital-goods industries were between 84 per cent and 86 per cent of all capital investments in industry (excluding repairs to existing capital equipment). In 1937 and 1940 the gross output of capital-goods was already about equal to the gross output of consumer goods. The relationship between the net outputs may have been similar."[55] Ignoring the allocation of investment resources in India's First Five-Year Plan, where priority was given to the development of agriculture and the social and economic infrastructure, it has been quoted that as a proportion of planned expenditures in industry, 70 per cent were devoted to the metal, machinery and chemical industries during the Second Plan and 80 per cent during the Third Plan.[56] Thus, by 1968 India's ratio of consumer goods to investment goods in terms of gross value-added was in the order of 1.8 : 1.[57] To progress from the first to the third of Hoffman's stages normally took several decades in most industrial countries. The Soviet Union, however, in just one decade had reached the third stage and India over an equivalent length of time had only just failed to achieve the same. This again gives substance to the Hirschman/Gershenkron hypothesis that contemporary underdeveloped countries can work their way from "last back to basic and intermediate industries", a process that completely reverses the traditional path of most developed countries which started industrialization with consumer-goods industries.[58]

The 'leading sector' argument is integral to Hirschman's unbalanced growth strategy briefly mentioned earlier in the text. The philosophy behind this approach is to concentrate investment on those industries most conducive to transforming the economy to a higher stage. Hirschman maintains that this is preferable to dissipating scarce investment funds by attempting to advance on all fronts at the same time. A metaphor by Wilber highlights this distinction, ... "to be breathlessly climbing a peak in a mountain range is considered more important than standing poised on the crest of a ridge in the foothills."[59] Planning in the Soviet Union provides a historical example of this policy. The country pursued a 'shock' strategy of bottlenecks successively created and resolved.[60] Something which Professor Nove calls planning by 'campaigning'.[61] The Soviets directed large chunks of their total investment to certain industries interpreted as having "key status" by the authorities. This policy then caused severe shortages and stresses within the economy which, as a consequence, created fresh bottlenecks and therefore new targets for the Soviet planners.

The level of interdependence between various industries is an important indicator as to the appropriateness of any particular 'campaign'. Thus, external economies would be gained by the economy if it invests in those industries exhibiting high linkage effects. Hirschman documented two types of linkage : (i)the input provision or backward linkage effects, and (ii)the output utilization or forward linkage effects.[62] From a development perspective, it is backward linkages which have the greater stimulative effects. The advantage of an industry with high backward linkages relates to the part it plays as an inducement mechanism to the development of a feeder-network of ancillary industries (in addition, of course, to industries supplying the basic raw materials). If the expansion of a particular industry leads to a general increase in economic activity embracing a considerable number of subsidiary and basic industries, then it must be classified as a "key" industry meriting a high priority in development.

Under this definition, the machinery branch must be considered a 'key' industry. The strong backward linkage effects of the machine building industry stem from the fact that it has a high ratio of purchased inputs to the value of its total production.[63] During the initial Five-Year Plan of the Soviet Union, the investment emphasis was on heavy industry and, in particular, machine-fabrication. The annual average growth rate for Soviet heavy industry between 1928/29 and 1937 was 17.8 per cent with the machinery industry registering 18.9 per cent.

The logic of Hirschman's unbalanced growth theory with its associated concept of 'linkage' has relevance to India. Since the doctrine focuses on the structural and dynamic forces at work in an economy rather than on the enlargement of overall industrial capacity, a further justification for emphasizing the development of producer-goods industries can be advanced in terms of the dynamic externalities involved in the manufacture of machinery.

Finally, to close the section, a brief mention should be made concerning the role of the machinery industries in the saving of foreign exchange.

(ii) The Foreign-Exchange Aspect

Recalling the discussion of the Fel'dman/Mahalanobis growth models, it was mentioned that they operated under the assumption of a 'closed' economy. In these circumstances, a country without well-developed metal, machinery and subsidiary industries (the complex of the so called, heavy industries) is unable to produce a sizeable quantity of capital goods and thus, to invest a high fraction of its income however high its potential saving propensity may be.[64] Obviously though, the 'closed' economy assumption is unrealistic as in the early stages of both Soviet and Indian development a significant measure of capital-goods were imported. The ticklish issue can be side-stepped if instead of 'closed' economy is read 'foreign exchange constraints'. The models then take on a greater element of reality. Quoting again from Mrs. Stewart on this point, ... "In an 'open' economy, an upper limit to possible investment is imposed not by domestic I-capacity, but by that capacity plus foreign exchange available to buy I-goods from abroad. Assuming zero local I-good capacity, then foreign exchange availability provides the upper constraint on possible investment."[65]

The implication of this is that it is not now essential that all the capital-goods required for investment in the early stages of industrialization be produced domestically. In fact, most developing countries would not even possess the means of producing the 'first generation' machinery on which all machines have to be manufactured. Under these circumstances, where not even a nucleus of a machine tool industry existed, it would have to be assumed that some foreign exchange is available which the economy could use to import machine tools. Raj believes this is a fairly realistic assumption to make, since most developing countries have some foreign exchange available, either through aid or trade.[66] In this way, he states, ... "the allocation of a high proportion of investment to the machine tool sector would then be reflected in the growth path corresponding to the case in which the bulk of this foreign exchange is used for importing machine tools."[67] Once the domestic machine building industries "come on tap", however, the growth rate of the economy will then mirror more accurately their performance. Thus, the development of local machine-making capacity may finally be justified on the grounds that foreign exchange to an underdeveloped country is a scarce resource, and once past the import-substitution phase, its use can be economized through the non-import of machinery.

Section 3 : Import-Substituting Industrialization : But Was There an Alternative Path?

(i) The Crucial Assumption

However, once the import-substitution phase has passed there is now much evidence to suggest that industry would be left in a disastrously high-cost, inefficient and uncompetitive state. But, of course, this is to argue with the advantage of hindsight. In the early 1950s, import substitution was a bold new strategy which had worked well for the Soviet economy two decades before. Besides, since the early part of this century India had been pursuing the conventional market economy approach to development and had been patiently getting nowhere. To gauge the results of India's two-sector growth strategy depends on the standard of comparison chosen : clearly, if the touchstone is the country's past history, then, as was noted in the earlier discussion to Table 3, the economy under the planning regime performed reasonably well; however, if the comparison is with other countries during their development phase (see Table 1) and the presently newly industrializing countries of South East Asia, then the results are less satisfactory. But in terms of the Indian Government's own planned targets the capital goods strategy would have to be described as a failure, if the decision was based on the growth rate alone. Given this unexciting growth performance, it has to be asked whether India might not have done better if it had embarked on a different path to industrialization?

At the sake of being tiresome, the critical distinction in the growth strategy adopted by the Indian and Soviet authorities is that between the consumer goods industries and the producers' goods industries : the, by now, well-known contrast between 'machines' and 'machines producing machines'. In the closed-economy model that Soviet industrialization represents, the lack of opportunity to import capital goods to initiate growth foreclosed that path as an alternative strategy of development. But did the closed model approach to trade, which made sense to the Soviet Union, necessarily apply to India's circumstances? After all, it is only on a closed-economy criterion that it becomes essential to develop the machinery industries via a Soviet-type strategy. In a closed economy without the opportunity for international trade, capital goods must be produced if the savings of an economy are to be translated into investment. Capital goods production in this case determines the level of investment.[68] This is the situation India's planners 'believed' they faced at the start of their industrialization campaign; and the justification for this view may have lain with the desire to achieve a high degree of autarchy in the economy or more likely to the general lack of confidence in the export earning capacity of the Indian economy at that time.

Mahalanobis, in his two-sector growth model, assumed that India was a closed economy; it was, without doubt, a crucial assumption. But what was the basis to this judgement? Very little, it would appear from Bhagwati and Desai, who have argued that Mahalanobis was ignorant to the fact that emphasis on indigenous production of capital goods presupposes constraints on domestic and foreign transformation. In criticising Mahalanobis on this point, the authors have written:

> "... It seems likely that, being a physicist by training and a statistician by practice, he directly identified increased investment with increased availability of capital goods, which in turn he identified with domestic production thereof, ignoring foreign trade in particular. It is interesting that the Second Plan did not explicitly state the rationale of the shift to heavy industries in terms of foreign trade constraints, so that the later justification of this strategy by alluding to 'stagnant world demand' for Indian exports comes somewhat close to post facto rationalization. Indeed, the Second Plan's examination of export earnings through the Plan is so cursory that it is difficult to believe that the stagnant world demand for Indian exports' assumption, by virtue of which the shift to heavy industries was later sought to be justified, was seriously made : such a crucial assumption, if made, would surely have been examined more intensively."[69]

The fact should also be noted that both India's balance of payments position and its export earnings were satisfactory during the period of the First Five-Year Plan. It does seem strange, therefore, that the country's export potential could be viewed with such pessimism at the start of the Second Plan. In fact, during the last four years of the First Plan, India's foreign exchange reserves actually increased. Government planners may have felt that a dramatic decline in India's foreign exchange reserves was a prerequisite for obtaining the Rs 12 billion in foreign assistance called for in the Second Five-Year Plan.[70] The assumption of Mahalanobis was that foreign aid would become available to fill the gap between the import requirements of the nascent capital goods sector and the level of export earnings. As it happened, this reasoning was not altogether unjustified in view of the escalation of the aid programmes subsequent to the 1956/57 crisis in the balance of payments.[71] The inflow of external loan assistance, however, has created problems of its own : the cost of credit financed imports has often been significantly higher than of those purchased through its foreign exchange earnings; and the debt service has imposed on India a burden which over the years has become truly onerous.[72] It seems, then, that Mahalanobis' assumption that India was a closed-market was based on a false premise, so that India may well have possessed a viable alternative option to have developed its machine building sector and indeed its economy through foreign trade. In this way, some of the costs associated with excessive import-substitution could have been avoided. The economic literature is replete with the various inefficiencies and costs engendered through inward-biased growth strategy; it would be well,at this juncture, to review some of the more obvious of these costs.

(ii) <u>The Costs of Inward-Biased Growth Strategy</u>

There now exists quite a large body of writing on the inherent costs involved in persistent import substitution strategies. The studies on the seven countries contained in Little, et al, indicated that ... "industrialization sheltered by high levels of protection has led to the creation of high-cost enterprises; these enterprises are producing expensive products, many of which are for use by a restricted middle class, and so production is rapidly coming up against the limits of the home market".... Moreover ... "The increase in cost and over-valuation of the currency have also discouraged exports, both agricultural and industrial. The import of raw materials and capital goods has resulted in foreign currency costs as high and sometimes in excess of the savings made on the imports of finished goods."[73]

In a most widely regarded study on the role of import substitution in industrialization, Chenery argues that import-substitution would not be effective unless there was some change in comparative advantage during the process of growth; it is therefore deemed a supply rather than a demand effect.[74] However, if import substitution is pushed too far this will result in a neglect of comparative advantage. There are numerous examples of enterprises or industries established by governments with little or no regard given to their economic feasibility.[75]

A major element to the arguments favouring import substitution is that it economizes on foreign exchange by the reduction in imports. In general the evidence points to the fact that in recent years where import substitution has taken place this saving of foreign exchange has been successfully achieved, although in some countries, for example Brazil, Israel and Chile, the foreign exchange savings have been very considerably reduced, if not eroded, by increases in imports of raw materials.[76] That many industrial ventures lose foreign exchange is essentially due to a poor selection of projects and industries to develop : indiscriminate and high protection is both a cause and a result of this poor selection.[77] A major negative effect of industrialization by import substitution is that there is an inherent bias against exports. The problem is that governments pursuing inward-looking developing strategies have not only emphasised the role of saving above the earning of foreign exchange but the policies employed have actually made the task of exporting that much worse. Essentially, inputs whose importation is controlled and restricted become more expensive, leading to higher production costs; but also, where the currency is 'over-valued', this reduces the exporters' return on a given quantity of exports in relation to what would have been earned under free trade. This state of affairs naturally affects the development of a competitive export sector.[78]

In the Indian economy, since the commencement of the Second Five-Year Plan, a significant characteristic of the import substitution strategy has been the high degree of excess capacity that has emerged in the industrial sector. As Chaudhuri has observed, this was ... "the result of severe import controls and the limited ability or willingness of the Government to use the fiscal or monetary instruments of control to ease pressure on resources originating from non-developmental expenditure in the private and public sectors. The absence of any degree of external competition has enabled the growth of very inefficient firms. In some lines of production, levels of domestic costs two or three times as high as comparable world prices are not unknown."[79] There is also the complaint that Indian planners have over-emphasised the objective of minimising long-run average costs with the consequence that, at least in the machine tool sector, the technical mix of factors of production was planned on such a basis as to allow for substantial idle plant capacity even for high levels of demand.[80] Furthermore, aside from the traditional discussion of delays, lack of co-ordination among different licensing agencies and similar administrative deficiencies which reduce the efficiency of a QR-regime the Indian import control policy has also been alleged to have operated in the ultimate analysis, without any economic criteria.[81] The now famous 'rule of the thumb' metaphor usually being coined to describe the process here. The diversion of resources away from India's export sector, at least up until the late 1960s, has been excessive. Whether India's foreign trade policy is evaluated (1) according to technical economic criteria such as efficiency (allocation of resources and ability to minimize costs) and impact on domestic savings or (2) from the vantage of India's triad of growth, equity and self-reliance, the conclusion is that India has gone well beyond what 'infant-industry' logic would justify.[82] The loss of efficiency associated with India's congenitally ill-formed and complex trade regime is regarded by many economists as staggering.[83]

(iii) The Process of Export-Expansion

In actual practice, Indian planning today steers clear from excessive pre-occupation with self-sufficiency as a result of the necessity to export more.[84] The devaluation of the rupee in June 1966, quite apart from the contemporaneous measures taken to liberalize import and industrial licensing, was perhaps the most dramatic episode in the shift of Indian economic policies towards greater and more sophisticated reliance on the market mechanism.[85] The import entitlement schemes (which, by then, covered about 80 per cent of exports) were abolished, and replaced by export subsidies which, however, applied only to non-traditional exports covering only a small fraction of total exports.[86] Cash subsidies paid to exporters of selected products were designed to provide compensation for the relatively high cost of domestic tradable inputs, as well as subsidization of the infant stages of export marketing.[87]

The enthusiasts for the alleged benefits of the present international division of labour have in the main concentrated on the cost advantages that follow from continuing to export agricultural raw materials and finished products based thereupon and to import capital equipment.[88] An alternative pattern of economic expansion is provided by the possibility of industrial exports in which some primary-producing countries could have a comparative advantage.[89] Like import substitution it allows industrial output to grow more rapidly than domestic demand for manufactures, and is therefore another means through which the expansion of employment might overtake the growth of the labour force.[90]

The increased attention given to the implementation of export promoting strategies of manufactured goods is something which occurred in several Latin American countries in the sixties. The original 'phase' of developing their economies was the traditional one of inducing expansion through the export of primary commodities.[91] Hirschman describes the historical transition of their economies thus:

> "...The phase of export-propelled growth ... in Latin America lasted roughly from the middle of the nineteenth century until the Great Depression; and it took another twenty years, from 1929 to the Prebisch Manifesto of 1949, before the end-of-export-propelled-growth became official Latin American doctrine. Then came the next phase of Latin American growth ... via the domestic market. It gathered strength during the Depression and World War II, flourished briefly in both theory and practice during the fifties and was pronounced either dead or a dud in the sixties. It looks, therefore, as though the acceleration of technical progress in the developed countries were [sic] matched in the underdeveloped ones by an increasingly rapid accumulation of failures in growth experiences."[92]

There may be some exaggeration of the announced failures of import substituting industrialization, nevertheless, the fizzling out of the 'Brazilian economic miracle' was a great disappointment to Latin American observers who had begun, somewhat prematurely, to draw parallels between Brazil and other more successful late industrializers such as Japan, Russia and Germany. It was from the import substitution 'hot-house' that Brazil and several Latin American countries moved, in the sixties, to embrace the strategy of export substitution.

It can be argued that an export substitution process has some distinct advantages over an import substitution regime. Some of the more significant benefits claimed are that:

(i) The resources used in import substitution could have earned a greater amount of foreign exchange through export expansion than the foreign exchange saved on import substitution that relies on high effective rates of protection.

(ii) To the extent that it rests on exogenous world demand, the process of industrialization through export substitution is not limited to the narrow domestic market of the import substitution process.

(iii) If indivisibilities and/or economies to scale are important, an export oriented strategy will provide better incentives for expansion of capacity in existing lines. As such, an export-oriented growth strategy is better suited to achieving whatever economies of scale are present than is an import substitution strategy where firms are generally limited in their horizons by the size of the market.[93]

(iv) Export substitution aids employment creation in the urban-industrial sector by the avoidance of agricultural bottlenecks. By exporting manufactured goods the developing countries are able to import agricultural commodities and thereby keep the real wage low as expressed in terms of industrial goods.[94]

More generally, there is evidence that the shift to trade strategies have led to an increase in growth rates.[95] A recent study has further indicated that once allowance is made for the direction of trade, the labour-abundant developing countries would be well-advised to specialize in the export of labour-intensive products.[96] There is now much optimism that a comparative advantage can be acquired by many countries of the third world in the production of manufactures or semi-manufactures that has traditionally been regarded as developed country activity. It may be expected that eventually a given technological advantage will be dissipated and will give way to conventional factor-cost advantages, so that the new line of production may become more accessible to developing countries. Indicative of this has been the rapid advance in recent years of exports from some LDCs of what were formerly considered to be fairly sophisticated products : photographic and cinematographic supplies, watches and clocks, medical and pharmaceutical products, plastic materials, and tele-communication apparatus.[97]

The Heckshėr-Ohlin-Samuelson postulate predicts that more industrialized LDCs will export relatively capital-intensive goods to less industrialized ones, but certainly not the reverse; and the theory has little to say about trade between equally industrialized economies.[98] However, there is some recent evidence which indicates that semi-industrialized countries are finding the best markets for their manufactures amongst themselves.[99] A major reason for this could, of course, be the diversionary effect of non-tariff barriers erected by the advanced countries against the labour-intensive exports of the developing ones. For example, the history of British policy towards textile imports from less developed countries and the EEC restrictions on their 'generalised' system of preferences is proof of this.[100] Trade diversion of this nature appears to have assisted the trade in capital goods between underdeveloped regions. Capital goods generally enjoy less protection than other commodities in Latin America and this also may be a factor in India's exports of capital goods to other developing countries under bilateral trading arrangements (e.g. Algeria, Kenya, etc.). Exports of machine tools from Argentina and Brazil flow largely to other less developed countries. The Taiwanese machine tool industry also exported almost exclusively to other less developed countries in the early 1970s.[101] Exports of capital equipment under turn-key arrangements may be the next step in the cycle; a development in which India should have a headstart with ready experience of this type of project in the Philippines and elsewhere.

Frances Stewart has argued for a reorientation of trade which encourages export substitution in the direction of South-South trade, perhaps by the establishment of regional economic groups.[102] This could be a positive step. Balassa's review of the experience of the Latin American Free Trade Association and the Central American Common Market with intra-industry trade renders rather a positive picture of its welfare effects in terms of specialization, the realization of scale economies, 'X-efficiency', and 'learning-by-doing'.[103] It may be that through such trading agreements the 'revealed' comparative advantage (the low cost of skilled workers and appropriateness of the exported technology) in manufactured exports by developing countries will be maximised.

However, before closing this section on India having followed an alternative industrialization strategy, a few observations are called for. The point ought to be made that 'switching' from inward-oriented growth strategies to those of export substitution will not for many economies be a costless exercise once the former strategy has been followed. One Indian commentor even holds the extreme view that an implication of India's industry development policy ..."which neither the Government nor its critics have realized is that a policy stressing the development of an investment goods producing sector as a strategic factor in the development process yields an overall strategy which is to a substantial measure irreversible."[104] This is, perhaps, too severe a standpoint. The actual course an economy requires to take should only be charted by reference to detailed assessment of available alternatives and it is quite probable that for many countries the appropriate strategy may lie within the two extremes of import substitution and export substitution. Changing comparative advantages could provide the dynamic benchmark to government policy.

Import substitution as a strategy of industrialization may still have a role to play, albeit in a more limited form, for the still emerging third world countries. The fact that there has been a remarkable degree of criticism of import substitution in Latin America, Pakistan and India does indicate that there is real substance to the concern being expressed. But the rapidity of the reversal in the climate of opinion makes one rather suspect that import substitution industrialization had, 'from its very onset', both positive and negative aspects, with the latter simply coming into view a few years after the former.[105] It would also be pertinent to enquire whether import substitution strategies may be a necessary pre-condition for the export expansion of manufactures at a later stage in a country's industrialization. In the case of Latin America, C. Diaz-Alejandro had this to say:

> "Granting that old and new primary products remain a key element in Latin American export plans ... [even for the big four Latin American countries, primary products accounted for more than half of the export expansion between 1960 and 1971] ... and that misguided import substitution policies could have only hurt their prospects, it may still be argued that import substitution was a necessary pre-condition to the expansion of 'manufactured' exports. This viewpoint may be summarised by the dictum that 'Brazil could not have exported

Volkswagen without having import substituted them first.' It can also be noted ... that 'only' the biggest countries which followed aggressive import substitution policies, have been able to achieve substantial exports of manufactures outside Latin America."[106]

Furthermore, it needs to be said that the line between economic growth and export expansion is not a determinate one. While it is true that most of the countries which experienced rapid growth rates in GNP 'per capita' between 1960 and 1969, experienced rapid growth in manufactured exports, it is also true that many of the slow growing countries also experienced rapid growth in manufactured exports.[107]

Thus, the issue remains contentious. However, it could be argued that a strategy of export-promotion although not a sufficient condition for economic growth might just be a necessary one for 'long-term' growth of the economy. Back in the early 1950s, India's policy-makers did not view industrialization through trade a feasible option. On the basis of Mahalanobis' 'stagnant export earnings' assumption, the choice was made to pursue a programme of planned industrialization through the operation of a two-sector growth strategy. Even though, from the discussion contained in this section, the closed-economy assumption may well have proved unfounded, this study now takes it as given, examining the development of the Indian machine tool industry under the economic conditions that were imposed by the rigorous import substitution policy of the time. Before moving on to the methodological and empirical aspects of India's experience in this respect, it is necessary to describe and evaluate a 'model' peculiar to the development of the Soviet Union's machine tool industry. It is to this objective that energies are now devoted.

Section 4 : The Question of Efficiency

(i) The Soviet Approach

The success of the Soviet model of economic development has been strongly argued. There is no doubt that the aim of rapid growth was very quickly achieved; and that rapid progress was also made in the drive towards technological independence. But an additional factor existed which has not thus far been mentioned: it concerns not so much the problems of how to increase the supply of capital but how to economise on its use. It may be because it is an inevitable condition of production that the factor has not received the attention in the economic literature which it perhaps deserves. Whatever the reason though, there is a case for believing that the Soviets were also successful in attaining high levels of operational efficiency, and never more so than in the machine tool industry.

Conceptually, machine tool production is the most important of all machine building activities. In this concluding section, therefore, an examination of the Soviet development of this core industry is undertaken which will act as a frame of reference for the later analysis of India's machine tool sector, especially in the context of productive efficiency. Such an appraisal also has the additional advantage of highlighting what could have been possible solutions to problems that were common to India's machine tool industry in the course of its economic development. Particularly since metal-fabricating units in both countries developed under conditions of central-planning and thus, operated in a similar economic environment. The specificity of the discussion to machine tools is further based on the fact that they are the technological 'embryo' from which all other mechanized activities derive. The development of the industry is, therefore, of the utmost importance in a country's thrust for industrialization. Support for this view is enlisted from Granick who has commented on the significance of the industry in Soviet Planning policy, ... "The machine tool branch has been regularly described in Soviet priority statements as the <u>very heart of the machine building industry</u>. For this is the branch which produces the machines which are needed to make all other types of machinery. It is the core industry of an autarchic investment programme. This Soviet viewpoint fits neatly into Stalin's "key sectors of the economy" approach to economic development. Stalin believed that a major task of planning was to determine which sectors were the key ones at any moment of time and to concentrate on expanding them rather than on spreading thin the country's resources in a balanced growth type of development policy. The machine tool branch would appear to be a natural 'key sector'."[108]

The emphasis given by the Soviets' to the growth of their tool industry has certainly proved a success in regard to production figures. By 1958, it had emerged as the largest manufacturer of machine tools in the world, in respect of the volume produced annually.[109] In 1964, the industry's production was about three-quarters, by value, of American machine tool production; slightly greater than the production of West Germany, and equivalent to the combined machine tool output of Great Britain, Japan and France. The increase in the numbers of Soviet machine tools produced has also been significant. In 1928, the Soviet Union produced only 2,000 metal-cutting tools; this output increased to 38,400 in 1945; 156,000 in 1960; and about 200,000 in 1967.[110] It has also been calculated that the annual average rate of growth of Soviet tool output over the period 1928-55 was a phenomenal 16.3 per cent.[111] These statistics offer some clues to the strategy of Soviet planning regarding the development of the industry. However, to gain a fuller understanding requires that the central features of the machine tool industry's production organization be identified. This is a task which will now be undertaken and as the examination progresses, it will become apparent that the development path the Soviet machine tool industry followed is far removed from the traditional stereotype usually associated with the branch.

(ii) Production Organization

Several factors which figured prominently in the expansion of the Soviet machine tool industry can aptly be described as the three 'S's' in its industrial policy, namely: specialization, standardization (and interchangeability of components), and scale. These three factors are interrelated and taken together constitute a peculiarly Soviet approach to the question of attaining an efficient organization of production in machine tool manufacture.

One of the initial areas of conflict in which Soviet strategists become embroiled was the choice of technique in the manufacture of machine tools. At the time, the question probably involved a choice between projecting the "gigantomania approach" into machine tool production with its attendant features of large-scale units employing advanced capital-intensive technology or, in marked contrast, sticking to international convention with numerous small units invariably employing non-specialized equipment. The contentiousness of the issue was not solely confined to the debate over size and technique but extended also into the area of product-mix. This was because, conventionally, machine tool production was not only characterized by a myriad of small plant but additionally, within each range of output, the individual firm possessed a fairly broad product-mix.[112] By its very nature then, the traditional model was unamenable to the basic technological approach of the Soviet Five-Year Plans which concentrated on the creation of huge, specialized factories.

The outcome of this conflict was a victory for the protagonists of the Soviet philosophy of large-scale development. Consequently, in stark contrast to the practices of Western machine tool procedures, the authorities attempted to rationalise the range of machine tools manufactured in the Soviet Union. M. Berry, in a recent report on the industry, has described the main tenets of the policy in the following way: ... "Production was based on the "tipazh" or range of types and sizes, the idea being that in a planned economy there was no need to produce as many types and sizes as in a market economy. Instead, it was considered possible to plan scientifically which types and sizes should be produced to satisfy the main needs of the country - which should be imported and which should not be produced until later."[113] Soviet economists believed that specialization could be advanced a great deal further than it had been in Western tool firms. Pertinent to this point is a statement by Granick, ... "The head of the [Soviet] machine tool branch declared [in the early thirties] that out of 500 to 600 machine tool firms in the U.S. and Western Europe only five or six had as many as two to three thousand workers apiece. Even these few had a broad product-mix. The typical plant employed only three to six hundred manual workers .... two other Soviet writers declared in 1935 that experience showed that the optimum size of plant in the machine tool industry employed a labour force of twenty-five hundred to three thousand."[114] Therefore, the emphasis given to large-scale plants occurred simultaneously with specialization by product, through the reduction in the number of types and sizes of machine tools produced in each factory. The motive behind this policy was to capture not only the economies of specialization customarily associated with the manufacture of machine tools but also economies of scale through techniques of mass production.

This argument, concerning increasing the scale for the production of a narrow range of machine tool products, is supported by the results of empirical work conducted by Pratten of Cambridge University. A conclusion of his study having regard to this point suggested that, ... "there were substantial economies [to be made] , but these economies were not all attributable to economies of scale in the traditional sense; they included the economies of breaking bottlenecks, using machine capacity more fully, and learning through time."[115] Pratten's findings were based on cost and price movements, recorded by firms in his sample which during the past had varied output. For the purposes of making these estimates, Pratten made two assumptions which are congruent with the Soviet strategy of machine tool manufacture in the thirties.

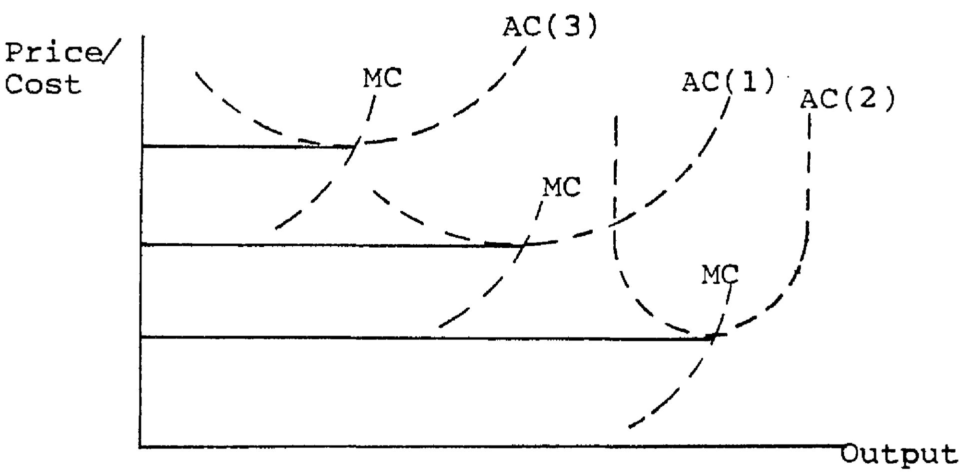
Firstly, he assumed that only a limited number of standard models are manufactured, so that each firm obtains the economies of longer runs as its output increases. This assumption is in accordance with the Soviet policy on specialization which was pursued with great vigour. The standardization and interchangeability of components were major facets of this approach. The Soviets, it would appear, realized from very early on that proliferation of different components for a multiplicity of machine tool products was wasteful of resources. It has been found, for instance, that from 5 to 10 per cent of all components designed in industry are unnecessary, and occasionally as many as 20 per cent.[116]

Zamilin in 1965, offered a practical definition of standardization as it refers to engineering : ... "the replacement of a superflous variety of items designed for any particular purpose, with a more rational and optimal number of types."[117] This definition, although similar to that stated by Britain's Lemon Committee in 1949[118], is as Hill points out restrictive, since it only considers the 'variety reduction' or 'simplification' aspects of standardization policy. Other Soviet writers have used broader definitions to include another important feature of standardization - the regulation of quality characteristics. This aspect of standardization has particular significance in a centrally planned economy where there is no market incentive to improve quality.[119] Quoting again from Soviet sources, Hill puts forward a definition of the associated concept of 'interchangeability' as ... "the ability of a component to work satisfactorily in a given assembly without subsequent machining or hand fitting when the items to be fitted together have been manufactured independently."[120]

The advantage of standardization and interchangeability of components is that it permits increased production runs. To capitalize on this advantage a variant of standardization evolved which came to be known as modular design. This is a principle which can readily be applied to the manufacture of machine tools, as a UNIDO Report explains, ... "a group of metal-cutting machine tools may be designed as a single family, utilizing standard stands, drives, clutch assemblies, workpiece-holding devices, tool pads etc., and keeping the non-standard sub-assemblies of each machine to an irreducible minimum. In this way, production runs for most components and sub-assemblies are considerably lengthened."[121] According to Soviet policy, the manufacture of these standardized components was to take place in specialized factories, producing them in large quantities. This was the policy, though in practice, reality was very different;[122] it is a problem that will be discussed later in the section.

Pratten's second assumption dictated that firms with different levels of capacity, design their plants to produce this output at minimum cost. Again, it must be noted that Soviet production practices in respect of machine tools were consonant with such an assumption. The point is best explained by reference to simple production theory. In most American and European tool plants a high degree of flexibility is built into the production technology. This implies that high efficiency at many possible levels of output is attained at the cost of not attaining the highest possible efficiency at any one level of output.[123] Flexibility in technique also ensures that plants are able to overcome imperfect adaptability, that is, without flexibility, production at any level other than optimum would involve unprofitably high marginal costs. This Western-type machine tool plant characterized by its small scale and relatively wide product-mix is represented in Figure 3, by the shallow, bowl-shaped average cost curve AC(1). In contrast, the U-shaped curve AC(2) illustrates the typical Soviet machine tool factory. Due to the inflexibility of its production technology, the bottom of the Soviet AC(2) curve lies below the lowest point of its counterparts curve in the West.

Figure 3 : Comparison of Production Optimums in Machine Tool Manufacture



The differences in the shape of the cost curves are related to the types of economy in which the respective machine tool plants operate. In the capitalist economy, it is rational to build flexibility into the unit. This is due to uncertainty concerning the level and composition of future output. By contrast, in a planned economy oriented to attaining a particular goal, uncertainty is considerably reduced and the construction of plants which yield minimum average cost only over a narrow range of output becomes rational.[124] In these circumstances, long production runs of technically invariant tools becomes a sensible policy. A feature of this Soviet strategy was that if a customer of a machine tool required that it be modified, the onus was on him, not the tool manufacturer, to make the adaption.[125]

It will be noticed that Figure 3 depicts a further cost curve AC(3). This is the case of an Indian-type machine tool unit which has developed along lines that are alien to both Soviet and Western experience. The Indian plant is representive of a high-cost producer due to such factors as low batch sizes; a high underutilization of capacity, and a non-competitive market in both the machine-tool and machine-building sectors. Moreover, 'international demonstration effects' are reflected to a considerable degree in the product-mix of many of the larger Indian machine tool concerns. This is a development inappropriate to the technological requirements of the majority of the machine tool users in the country. It is also a consideration which brings the discussion conveniently around to examination of the next positive element to emerge from the Soviet model having regard to the fact that ... "there has been no history of copying foreign technology in such a way as to substitute capital for labour."[126]

The transplantation of advanced labour-saving technologies can be justified only for those poor countries which have similar factor proportions to those of the advanced nations. This will be a rare situation. Soviet policy over its initial Five-Year Plan reflected an awareness of this fact: a dualistic strategy was pursued, not only between 'key' industries and industries held to be of lower priority but also within plants as to 'key' processes and other auxiliary activities. The 'key' industry argument was touched on earlier in Section 2 but to recap, these were the industries given high-growth status in the Soviet plans and were allocated investment funds accordingly. Thus, ... "the 'key' industries ... utilised to the maximum the advantage of borrowing the most advanced technologies developed in economies with very different factor endowments" ... but, and this is the other half of the Soviet dualistic policy ... "they allowed for these differences by utilizing manual labour in auxiliary operations and by aiming at high performance rates per unit of capital instead of per man."[127] The amount of labour employed in these auxiliary processes was significant. A very high percentage of all workers - almost half of the wage-earners in the machine tool industry in 1948 were employed in these operations.[128]

It should not be thought that there is anything inherently irrational in mechanizing only part of the operation of a factory. As Gerschenkron has pointed out, it may well be that the main production line is mechanized because by saving the scarce kinds of labour, it affords the greatest economy, while auxiliary tasks can be performed by unskilled peasants.[129] But this is only part of the picture. Mass production techniques, necessitating the installation of specialised automatic machinery, on which a narrow range of machine tool output was produced meant that the skill requirements of the operators were considerably reduced. On the other hand, the tool industry's customers, the great majority of machinery-fabricating shops serving local markets right across the Soviet Union used basic general-purpose machine tools. The advantage here, was that it brought the mass of the industrially employed population into contact with machinery. Even in the large factories of the heavy machine construction and aviation industries, continuous-flow operations were not considered until 1939, and only then on the basis, ... "that output per machine tool should not be allowed to drop; if such a drop occurred in the case of any individual machine tool it was recommended that this machine be returned to the previous system of one-machine-one-operator."[130]

This 'technological dualism' between the machine tool industry and its machine building customers is corroborated by Sutton in his mammoth study of 'Western Technology and Soviet Economic Development'. In Vol. III of the study he gives three quotations of statements made by independent observers (as recent as 1956) concerning the character of the installed machinery at one Soviet machine tool plant -

Ordzhonikidze in Moscow. The first statement is of no interest to the present discussion but, ... "the second and third statements identify its [installed capital as being of] Western origins and makes it clear that in this plant, at least, production .... is based on equipment imported from the West. In other words, the machines that build machines originated in the West."[131] Moreover, Sutton in Vol.II of his work, also provides support for the argument regarding the labour-intensive nature of the Soviet machine tool industry's output. Commenting on a table of the composition of Soviet machine tool production between 1932-45, reproduced as Table 6 below, Sutton states, ... "Between 1932 and 1945 approximately one half of the steadily increasing machine tool production was composed of just two elementary types : simple lathes ... and vertical drilling machines" ... and his conclusion in the next paragraph reads ... "thus, the structure of machine tool production in 1945 is quite clear, output was concentrated on producing very large numbers of very simple machine tools."[132]

Table 6 : Composition of Soviet Machine Tool Production 1932-45

Tools Produced	1932	1940	1945
Total Machine Tools Produced	19,978	58,437	38,419
Group A : Lathes (not turret or semi-automatic)	7,145	11,523	13,063
Group B : vertical drilling machines	6,838	15,251	7,168
Groups A and B as per cent of total	72.8%	45.8%	52.7%

Source : A. Sutton : 'Western Technology and Soviet Economic Development', 1930-1945' Vol.II Loc.cit., p.139.

Clearly, the Soviet planners interpreted production technique as basic to the industry's efficiency. In their view, considerable economies of scale could be achieved through standardization of components and products, and by the use of automatic, capital-intensive equipment on which the machine tools were to be manufactured. The belief was, that as long as the price of the machine tool was low enough, sufficient numbers could be purchased to justify the heavy expenditure on automatic equipment. It was no coincidence either, that the machine tools that were mass produced, corresponded to the needs, and resource base of the Soviet economy. At first sight, such a policy of capital-intensive machinery in the 'key' processes of machine tool plants would seem inconsistent with the Soviet objective of lowering the capital-output ratio. The point can be contested on two grounds. Primarily, it was the case that the productive processes in machine tool units were capital-intensive in nature but to compensate this, the auxiliary operation, as has been noted, remained essentially labour-using. Moreover, there seems little justification for the presumption that the use of equipment with labour-saving or automatic features generally leads to an increase in the capital-output ratio. It should not, as Granick has argued, ... "be assumed that an equipment stock of old fashioned types of machines can be employed with a lower capital-output ratio than is achieved by a stock with more modern equipment."[133] He cites three factors in support of his argument:

(i) In American metal-working since World War I, modernization of equipment has been accompanied by a reduction in the capital-output ratio in the industry as a whole. Such overall reduction has occurred despite an accompanying substitution of capital for labour in the industry.

(ii) In advanced capitalist countries, where it may be expected that the relative scarcity of production factors is reflected in the choice of equipment, one might look for major differences in the type of equipment used in Europe as compared to the United States. But a strong impression drawn from various reports of the Anglo-American Council on

Productivity is that basic production equipment does not differ particularly between the two countries in most industries. There is no indication that lower British wages led to the use of less modern production equipment.

(iii) Finally, a few isolated Soviet studies indicate that, under specific Soviet conditions, use of more modern equipment may lead to the reduction of capital-output ratios. Thus, when the quantity of production is sufficient - broaching not only yields a higher labour productivity and greater precision than the alternative process of milling but also provides a lower capital-output ratio.

Thus,it might be that the introduction of labour-saving machinery in 'key' processes could initiate a process of capital-saving through improvements in levels of efficiency.

But, it should be admitted that the Soviet strategy is not without criticism. Two alleged deficiencies are briefly noted. Firstly, mention is made of a criticism by Nove in his book, 'The Soviet Economic System'; his objection, in fact, covers two issues, though they are closely related. One, stresses the excessive expenditure in money and labour-time on repairs while the other attacks the slowness in the replacement of old machines by new.[134] In reply to the first criticism, it needs to be stressed that the provision of a mechanized base to a country the size of the Soviet Union was a daunting task and thus, the replacement of obsolescent or obsolete machine tools would perforce be a gradual process. However, it may well be that obsolescence due to rapid innovation, has not been allowed to play such a prominent role in Soviet industry, as it has in the West. The Soviet machine-making industries lacking an atmosphere of competition will not, as a consequence, place such a degree of emphasis on the concept of rapid replacement. There is also the additional and important point which Granick makes that, ... "a country in which labour is dear compared with capital will inevitably scrap equipment at an earlier stage than will a country concerned primarily with economizing capital."[135]

The second criticism of the Soviet industrial system has regard to the high level of integration within their plants. Due to the lack of a specialized feeder-network of ancillary industries,the Soviets initially opted for factories which had a 'closed cycle' of production thus inhibiting the movement towards improving the division of labour in the economy. This is therefore a valid criticism, for even as recently as 1955 the majority of machine tool manufacturers tended to produce approximately four times as many standard components as they purchased.[136]

In the early years of Soviet planning there was an attempt to implement a policy to establish large specialized component factories. However, by the 1950's this institutionalised sub-structure of industry was still far from satisfactory. Thereafter though, the authorities made concerted efforts to re-kindle their earlier verve and by the middle of the next decade, significant progress had been claimed. In terms of the production capacity of component factories, an increase was planned which, by 1965, would have enabled them to satisfy 47 per cent of the industry's demand for these items, compared with 21.5 per cent in 1957.[137] Finally, certain measures to improve specialization in the manufacture of components had, by 1968, made some impact as Berry has detailed, ... "of the 82 specialized factories 20 produced only one type, 38 produced two or three types, 13 produced four types and 11 produced five to nine types."[138]

(iii) Soviet Policy on Innovation

An important aspect of Soviet thinking concerning the development of machine tool production centred on the role of innovation. Through the process of planning the Soviets had specified the types of machine tools that were to be manufactured in the country and those that were to be imported. As was stated earlier, this approach was based on the concept of the "tipazh". From the beginning of planning, the types of machine tool products to be included in the 'tipazh' mirrored the Soviet authorities' desire to take advantage of particular factors, e.g. the surplus rural labour in the industrialization of the economy. However, a consequence of incorporating the 'tipazh' concept into planning strategy meant that the state now assumed overall responsibility for 'invention - innovation'. This requirement is an expression that in a centrally planned economy, competition does not exist - a fact of great significance to machine tool production.

According to the 'Brown-Rosenberg' paradigm outlined in Chapter 2, innovation in machine tool manufacture occurs in response to the exigencies in demand from the machine tool users of the machine building industry. The paradigm attempts to describe these innovational motivations from within a capitalistic context. In a non-market economy such as the Soviet Union the situation is somewhat different, as a recent OECD report states, ... "In spite of the increasing importance in Western research and development of the government sector, the growing role of government policy and the great importance of large oligopolistic firms it remains true that for a substantial part of private and some state industry in all Western countries, it is the spur of competition on the market which presses firms to develop improved products and to cut costs by developing new production processes; if a firm does not seek to maximise its profit in the simplest terms of our economics textbooks, it at least seeks to maintain its share of the market; it is primarily in response to the challenge of the market that research and experimental production facilities are developed. Even in the case of companies which work mainly for the state, the wish not to lose development contracts to one's rivals often still plays a major part. In the Soviet system as it emerged, about 1930, in the course of the industrialization drive, and as it still exists today - the drive for technical progress comes not from a competitive market but from central government." [139] Thus, the Soviet machine tool industry operates in an industrial environment very different to that of Europe or America. In particular, no 'special relationship' exists between the tool producers and their machine tool using customers. In fact, not only is there an absence of interaction between the machine tool and machine building industries but also between units within them. Hence, the critical factor for innovation to take place in the Soviet Union, as Berry has poignantly remarked .. "would appear to be the identity of interests between the state and its economic organization ... This means that the state takes on itself the risk involved, and those responsible for carrying out the work are not involved in any risk since they are merely carrying out the instructions of the plan. In their case failure is often penalized as little as success is rewarded - they are not true entrepeneurs." [140]

A determinate approach toward innovation emerged simultaneously with the introduction of the 'tipazh' and the other related policy aspects covering machine tool production in the Soviet Union. It was in the early thirties that machine tool design and manufacture was established as a centrally administered industry when the Chief Administration of the machine tool industry was set up. This body was originally responsible to the peoples Commissariat of heavy industry but later became a separate all-union industrial ministry. The technical administration of the ministry was responsible for all the research, development and design work carried out by the industry. The cornerstone to the ministry's innovation policy was its desire to avoid the costs of research and development. Indigenous design work was delegated to a series of 'special design bureaux' (spetsial 'nye konstructorskie Byoro - SKB) each of which concentrated on the design of a limited range of machine tool types.[141] In all probability though, the primary function of the SKB's were as 'copying offices' where selected foreign machine tools were 'stripped, analysed, and tested.'[142] Then, after adaption to suit local factor conditions, the modified machine tool was ready to be considered for inclusion into the industry's production programme. There can be little doubt, therefore, that innovation in the Soviet machine tool industry was, in substantial degree, reliant on progress elsewhere.

It must be stated though, that it was not a whole-sale transfer of technology but rather a selection of those 'bits of the package' deemed relevant to the Soviet pattern of development. This selectivity may have been, in part, due to the conservatism of the machine building industry. Machine builders perceived that little or no immediate advantage could be gained by them through the introduction of new techniques. Thus, unlike the dynamic elements of innovation fostered in the capitalist model, through the interaction between the machine tool producer and his customers - a dysfunctional relationship existed in the Soviet Union. The fact remains, however, that machine tool technology in the early stages of Soviet development did match the needs of its users. Even as recently as the 7th-Plan Period (1959-65) when all orders for machine tools were aggregated, 70 per cent were found to be for universal machines, i.e. labour-using machinery.

A related point connected to the role of the 'copying offices' regards what may be termed as 'scaling-up innovation'.[143] On a general level, for a machine tool project or any part of that project to be viable in the Soviet Union, it must first be amenable to mass techniques of production. In this respect, all that indigenous technical progress may in effect have been, is a logical scalin up through numerous design modifications, of an original 'classic' Western technolgy - being appropriate to the

Soviet strategy of conserving scarce capital resources. Hence, technical progress in the Soviet Union conforms to, ... "the application of engineering and experimental resources to a given known technology" ... and thus, ... "is not innovation in the sense that innovation establishes new and formerly unknown technological horizons."[144] This fact is important because it illustrates the apparently co-ordinated programme of action the Soviets pursued in terms of machine tool manufacture. Only in this instance, the objective was avoidance of the huge costs involved in research and development.

The inference to be gained from the foregoing examination of the major tenets of the development of the Soviet machine tool industry is that it was geared to producing low-cost machinery appropriate both to creating a mechanized base to the economy and to absorbing the abundant labour resources. It was an approach which led Granick, ... "to the tentative conclusion that capital-saving is the motivating principle for Soviet technical change."[145]

(iv) The Soviet Model of Machine Tool Production : A Cognitive Framework of Reference

The aim of this chapter has been to provide a foundation for the empirical analysis of the 'techno-economic development of the Indian machine tool industry'. Inherent in the Soviet strategy of industrialization has been the objective of expanding the rate of investment (savings ratio) in line with formal growth theory. This is a policy goal which is well documented in the economic literature. There has been a further goal though, of attempting to lower the economy's capital-output ratio which has received minimal attention by theorists of economic development. The policy reasons for this latter goal derive from the generally accepted view that economic growth, although fundamentally a function of the volume of capital used, is equally determined by the efficiency of its application. It was from this stance that the Soviets recognised the crucial importance of machine tool manufacture. Thus, efficiency in this core industry was essential.

The Soviets made no attempt to follow the conventional model of machine tool production as it emerged in capitalistic countries. Instead, an alternative industrial philosophy was substituted which placed emphasis on the concept of what is currently termed 'total factor productivity' In a theoretical sense, this residual - a proxy for efficiency - is a 'pot pourri' of various economic factors. Nevertheless, the early Soviet strategy of machine tool manufacture appeared to encompass three of the more significant components comprising the residual : specialization, standardization and interchangeability of components, and scale. An additional aspect influencing total factor productivity in the Soviet machine tool industry concerns the role of innovation. The institutionalization of innovation was, it must be noted, again a consequence of the Soviet approach towards conserving capital. By copying selected foreign designs the Soviets avoided the enormous expenditures that research and development involves. An additional advantage of the policy was that scientific effort could be directed towards fulfilling the requirements of the machine building industry in totality, rather than the cosmetic wants of a limited number of manufacturers.

The strategy of development followed by the Soviets in respect of their machine tool industry presupposes high rates of capital formation; priority of basic capital-goods industries; an import-substitution policy in international trade; utilization of underemployed agricultural labour for capital formation; and, a product-mix orientated toward labour-using machinery. It is a 'model' of machine tool production of great originality and pertinance to other developing countries with large populations and similar resource endowments: It would make sense for India, China, or Brazil though not for

Bangladesh or Sri Lanka.

In fact, the Indian machine tool branch in the early fifties was well placed to have emulated the Soviet experience; however, its development took the more conventional Western course.

Although the structure of the industry with a handfull of enterprises accounting for over 80 per cent of output value, closely conforms to the large machine tool parks in the Soviet Union, specialization has not been pursued to the same extent. In fact, one firm, Hindustan Machine Tools Ltd. (HMT) claims that it produces the widest range of machine tools in the world. A feature incompatible with individual production units in either the Soviet or Western models.

Also, in the Indian industry, production is organised on a batch basis as per the Western experience of satisfying the particular requirements of each customer. This pattern of production is inappropriate to the economic conditions pertaining to India. Small production runs mean that overheads cannot be spread which, in turn, raises the cost of the final product. The lack of standardization and interchangeability compound the issue.

In consequence, it seems that the Indian machine tool manufacturers fail to obtain economies from either specialization or scale.

This fact alone is clearly disturbing but worse is the part foreign technology has been allowed to play in the industry's product-mix. Technological change in the machine tool industry's product range has, to a considerable extent, been achieved via collaboration with foreign tool companies. However, whereas in the Soviet model the substitution of capital for labour was not the 'modus operandi' of the development approach, the opposite seems to have been true in the Indian case.

Armed with this appraisal of the early Soviet approach to machine tool manufacture, the study now moves forward to examine the development of India's machine tool sector. Chapter 2 provides an outline of the methodological approach to the study. A paradigm of innovation in machine tool production as based on Western practices is constructed. But, even though the industry has consistently emphasised the importance of product-innovation, in reality, only limited progress has occurred; the improvement of technology coming about instead via foreign collaboration. The paradigm would therefore seem to breakdown under Indian economic conditions. However, to argue on the basis of this, that India's choice of machine tool manufacturing strategy was inappropriate would be a premature rationalisation of the problem. An equally important element in the decision must surely have been the need to secure maximum levels of efficiency in the production process. Given that this was the case, the aim of this study becomes an attempt to reach some determination on the success of this issue. Contrary to what might be expected though, this is not a straightforward exercise because, in similarity with the Soviet pattern of development, the industry was set two other goals besides capital-saving (the inevitable condition): rapid growth of output and technological self-sufficiency. Chapter 3 assesses the progress India's machine tool manufacturers have made toward the goal of growth whilst Chapter 4 does the same for the goal of self-sufficiency. The efficiency objective is explicitly analysed in Chapter 5. A multi-directional approach has been followed because it is felt there exists no single method that is capable of providing a satisfactory appraisal of the problem. Thus, a number of analytical techniques have been incorporated into the Chapter in an attempt to reach an evaluation of operational efficiency based on a comprehensive approach to the subject. Specifically, the chapter undertakes an examination of: single-factor productivity indexes; an aggregate production function; a capacity utilization study; and finally, a survey of the progress that the branch has made in research, design and development work. The intention is that, in summation, all these various perspectives on the question of technological development will afford a more reflective and accurate picture of the state of efficiency reached by the industry. The study closes with a final chapter which attempts to bring all the various strands of the analysis together. From this, judgements are offered on the success and appropriateness of the development strategy that the Indian machine tool branch pursued.

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118. Lemon Committee : 'Report of the Committee for the Standardization of Engineering Products', H.M.S.O. (1949) p.4.

119. M.R. Hill : Op.cit., p.3.

120. M.R. Hill : Op.cit.,p.22.

121. U.N.I.D.O. : 'Industrialization of Developing Countries', Monograph No.4, Engineering Industry (1969) p.25.

122. M.J. Berry : Op.cit., p.35.

123. C. Wilber : Op.cit., p.96.

124. C. Wilber : Op.cit., p.98.

125. However, it should be noted that this feature was not of apocalyptic proportion: it first appeared during the development of the American machinery industries in the 19th century. In an explanation of the divergence in the introduction and diffusion of technology during this period between Britain and America, Rosenberg has had this to say: 'But I am anxious not to leave the impression that Anglo-American differences can all be explained in terms of differences in consumer tastes, although I do think these were important. They seem to have been part of a much more widespread phenomenon in Britain as compared with the United States of 'customer initiative' as opposed to 'producer initiative'. If we examine the relation between producers of capital equipment and their purchasers in both countries, we also find analagous differences. That is, in America the producer of

capital goods took the initiative in matters of machine design and successfully suppressed variations in product design which served no clearly defined purpose. He brought about, in other words, a high degree of standardization in the machinery, which very much simplified his own production problems and in turn reduced the price of capital goods. Producer initiative was a very important factor in developing patterns of efficient specialization in American capital goods production .... In England, on the other hand, the capital goods producer remained, to a surprising degree, what Landes has aptly called a 'custom tailor working in metal' ... and ... the result was to perpetuate in Great Britain, a preoccupation with purely technical aspects of the final product rather than with the productive process'. N. Rosenberg : 'Economic Development and the Transfer of Technology : Some Historical Perspectives', in Perspectives on Technology, Cambridge Uni. Press (1976) pp.159-60 (emphasis added

126. D. Granick : Op.cit., p.8.

127. C. Wilber : Op.cit., p.94.

128. D. Granick : 'Economic Development and Productivity Analysis : The Case of Soviet Metal-Working', Quarterly Journal of Economics, Vol.71 (1957) p.200.

129. A. Nove : 'The Explosive Model', Journal of Development Studies, Vol.3 No.1 (Oct.1966) p.9.

130. D. Granick : 'Economic Development and Soviet Metal-Working' etc. Op.cit., p.219.

131. A. Sutton : Op.cit., Vol.III p.311 - also p.143 Vol.II shows that these foreign machine tools were predominantly automatic in character.

132. A. Sutton : Op.cit., Vol.II p.140.

133. D. Granick : 'Economic Development and Productivity Analysis : The Case of Soviet Metal-Working', Quarterly Journal of Economics, Vol.71, (1957) p.215.

134. A. Nove : 'The Soviet Economic System', Allen and Unwin (1977) p.165. It should be noted that the Professor's criticism does not relate specifically to the thirties.

135. D. Granick : 'Economic Development and Soviet Metal-Working' etc. Op.cit., p.223.

136. M.R. Hill : Op.cit., p.276.

137. M.R. Hill : Op.cit., p.276.

138. M.J. Berry : Op.cit., p.40.

139. 'Science Policy in the U.S.S.R.' : O.E.C.D., Paris (1969) p.403.

140. M.J. Berry : Op.cit., p.15.

141. M.R. Hill : Op.cit., p.274.

142. A. Sutton : Vol.III p.310.

143. A. Sutton : Vol.III p.362.

144. A. Sutton : Vol.III.p.364.

145. D. Granick : 'Economic Development and Productivity Analysis : The Case of Soviet Metal-Working', Op.cit., p.211.

Chapter 2

Scope and Methodological Approach of the Study

The importance of the machine tool industry to a developing country's quest for industrialization is highlighted when attention is directed to the fact that any artifact of modern civilization is made either on a machine tool or on a machine made by a machine tool. Hence, machine tools can rightly be described as 'mother machinery' and basic to the concept of modern economy. Supporting the machine tool and essential to it, of course, are various processes which include casting, forging, stamping and so forth. These operations produce the raw metal embryo from which the machine tool manufactures the components involved in the fabrication of machinery. In this way, all ideas and technical progress are tempered by the efficiency of the machine tool industry and its allied processes.

For the developing countries, there are three major reasons why they should attach a high priority to the possession of indigenous machine tool capacity:

Firstly, it is clearly the case that the economic health of the machine tool industry is inexorably linked to the level of mechanization in the economy. The demand for machine tools is positively related to economic growth and as this is, in turn, affected by the attractiveness of investment, the promotion of efficiency in this 'core' industry becomes of paramount concern. Improvements in the operating efficiency of machine tool production should, through an 'economic rippling' effect, raise the marginal efficiency of capital in the rest of the machine building sector. This will have favourable repercussions on investment opportunity and hence also on the pace of industrialization.

Secondly, the machine tool industry may be looked upon as constituting a pool or reservoir of skills and technical knowledge which are employed throughout the entire machine building sector of the economy. The industry has been described by Rosenberg as a 'transmission centre' in the diffusion of new technology as it deals with processes and problems common to an increasing number of other machine building industries. Moreover, this pattern, peculiar to the machine tool industry, i.e. the distribution of its sales to all other machine building industries, has, if viewed from a long-term criteria, a significant impact on the degree of 'technological cross-fertilisation'. That is, the original innovation in the machine tool industry's product induces increased competition among firms comprising the market for machine tools and may therefore influence further innovation in the tool branch, so benefiting all its customers.

Thirdly, from a development strategy point of view, developing countries possessing indigenous machine tool capacity are in a position to control the product-mix to suit their own requirements. As most developing countries suffer from acute unemployment, it is not unreasonable nor uneconomic due to their factor endowment, to suggest that machine tool output should be concentrated around appropriate, labour-intensive technology. This is especially the case when it is considered that the majority of world machine tool exports today consist of highly capital-intensive technology. Circumstances will arise, of course, where advanced technology with its attribute of enhanced accuracy will need to be allocated manufacturing capacity. But the creation and level of this capacity ought to be decided in the light of such considerations as effective demand and comparative cost.

If a machine tool manufacturing base is created and accorded 'key' status, thus ensuring the availability of scarce investment resources, special consideration could then be given to the design and production at optimal efficiency, of techniques most appropriate to the economic conditions prevailing within the economy of a developing country. Although it is being argued that the product-mix of the machine tool industry should, in the main, be geared to 'appropriate' technology, it should not be assumed that this also applies to the equipment with which this output is manufactured. What is being put forward for examination is a model whereby, in its most crudest form : labour-intensive machine tools are produced in a capital-intensive way.

Even though the significance of the machine tool industry in the process of industrialization has been recognised in the economic literature, the subject has received only limited empirical investigation. This study then, is an attempt to redress the situation by examining the experience of India in its efforts to establish and develop machine tool capacity. India is chosen becaase it is a good example of a developing country which recognised at the start of its industrialization programme the strategic importance of an indigenous machine tool industry. On this interpretation, policies were formulated which gave considerable emphasis to the growth and development of machine tool output.

An added justification for undertaking the study is that, in a poorly documented field, it might enable other developing countries planning the creation of their own machine tool industries, if not to avoid, then at least to be made aware of the difficulties that are likely to be encountered. The major object in what is, in effect, unchartered territory is to examine the approach to, and efficiency of machine tool manufacture in a country such as India. The approach is mainly empirical with the emphasis being to study, measure and explain the actual conditions, relationships, and trends which have had a bearing on the development of the machine tool industry. Their significance can then be assessed in terms of India's industrialization and economic growth.

Section 1 : Empirical and Definitional Aspects of the Study

(i) Data Base

There has never been a study on the development of the Indian machine tool industry. One effect of this situation is that there are almost no primary sources of academic writing on the subject. For information, therefore, there was no alternative but to approach, via a survey, the industry itself. So to begin the chapter, a description is given of the organizational aspects of the research by briefly detailing the scope of the data; the approach to the fieldwork; and finally, the problems encountered during the period of survey.

This study limits itself to an examination of the machine tool industry in the organised industrial sector of India which according to the Directorate General of Technical Development (DGTD) comprised in 1977 of 120 machine tool manufacturing units with a production capacity of Rs.110 crores. The term 'organised industrial sector' requires clarification; the simplest way of achieving this, is through an explanation of the coverage of the government's statistical surveys of industry.

The principal data-source for India's industries is the Annual Survey of Industries (ASI). The statistical records of the ASI became available in 1959, replacing the previous, less comprehensive, 'Sample Survey of

Manufacturing Industries' which were begun in 1950. For the machine tool industry under the ASI criteria, all factories in what is referred to as the 'census sector' are completely enumerated. The census sector being defined as those units employing 50 or more workers with the aid of power or a 100 or more workers without the aid of power. In addition, there is what is termed the 'sample sector', and the ASI covers this on a sample basis. Establishments in the sample sector are defined as those employing 10 to 49 workers with the aid of power or 20 to 99 workers without power. Thus, the ASI data includes all establishments except those employing less than 10 workers using power, and less than 20 workers without power. These exceptions in most instances are usually referred to as the 'informal' or 'tiny' sector. The 'organised industrial sector' then, given that it is inconceivable that machine tools can be manufactured in the absence of power corresponds to the ASI coverage of: those companies employing 50 or more workers in the census sector and 10 to 49 workers in the sample sector.

The original intention of the study was to utilize the ASI statistics, and supplement it with the more disaggregated data that could be obtained from a survey of the major companies in the organised sector of the machine tool industry. Certain statistical information was to be sought in an attempt to establish comparative efficiency levels on a sectoral (public versus private) basis. At the same time, data of a more qualitative nature would be gathered to assist in the formulation of assessments on non-numerate areas of enquiry. To assist in this aim, the decision was taken, after discussion with ASI personnel in India, to structure the numerical parts of the questionnaire so that they closely resembled the format of the ASI's own questionnaire. The rationale behind this move centred on the possibility of utilizing the ASI's fieldwork operations.

The ASI's survey of the machine tool industry is conducted by its field officers who visit each company in the sample. With the assistance of representatives of the company a standardized questionnaire is then completed. The companies are legally obliged to co-operate with the ASI staff and to provide any data as is required to compile the return. At the same time, a copy of the questionnaire is prepared for the benefit of the participating company. On examination, this copy of the ASI questionnaire was found to contain most of the statistical information sought by this study. Thus, the fact that the terminology and layout for the quantitative sections of the present study's questionnaire were influenced almost entirely by the design of the ASI document can be justified on two grounds:

(i) from a purely operational point of view it meant that the statistical data required to complete the questionnaire already existed in final form in the files of the companies' copies of the ASI returns; and further, that

(ii) analytical technique would be strengthened by introducing a greater measure of consistency into the numerical data since now, the statistics from the survey would also conform to ASI definitions.

However, at the close of the survey, although more than sufficient material was obtained for a descriptive appraisal of the economic state of the machine tool industry the same, unfortunately, could not be said about the statistical side of the research. In consequence, while much of the qualitative information contained in the tables which thread their way through this study derive from the survey, the statistical data, by contrast, originates from the aggregated ASI data published by the government (Appendix 1). The quantitative analysis is thus constrained to that extent.

It is also worthwhile to mention that in many respects the data in India, as in other developing countries, is open to question regarding its accuracy. Therefore, it should be emphasised that such inferences as may be gained from the analysis should be interpreted as illustrative rather than conclusive; the aim being to argue general tendencies as against clinical statements of fact.

(ii) The Fieldwork

The Social Science Research Council had agreed to finance a survey period of nine months from the October of 1977 to end-June 1978. During that period, study accommodation had been arranged at the Indian Institute of Science which is situated in Bangalore. For the purposes of conducting a survey of the machine tool industry, Bangalore is an excellent base : not only because of its geographical location but also because it is the hub of machine tool activity in India, playing host to the headquarters and two units of the massive public sector undertaking, HMT, and also the offices of the Central Machine Tool Institute (CMTI).

The first draft of a questionnaire was prepared at the University of Glasgow during the summer of 1977. Although, over the course of the first six weeks in Bangalore, the rough outline of this document was modified three times. Initially, alterations were made after consultation with interested parties at the Institute of Science. The Director of the CMTI, Mr. Vishvesveran also provided useful suggestions on the form the questionnaire should take. In addition, much advice was gained from discussions with the staff at the local ASI office in Bangalore, the outcome from which has already been described. The final alterations to the preliminary questionnaire came about through a pilot survey of five small and medium sized firms in the Bangalore area. The problems that arose were due mainly to the ambiguity of certain questions, all of which were subsequently clarified. On top of that, one or two questions were dropped altogether because they were revealed as either inappropriate or irrelevant to the circumstances of the industry.

In the December of 1977, one hundred copies of the final questionnaire were printed and made ready for the survey proper. This form of return (Appendix 2) was divided into three parts : (1)an introduction; (2)the questionnaire itself; and (3)a section itemizing topics for discussion at the interview situation. The questionnaire section was further sub-divided into the following areas of enquiry, seeking information on : employment, production, technology, capacity utilization, research and development, and other miscellaneous data.

Originally the names and addresses of approximately one hundred and twenty firms in the organised sector of India's machine tool industry were obtained from a publication housed in the library at India House, London.[1] However, on arrival in India and after a closer examination of these companies' manufacturing activities, it was decided to restrict the sample to roughly eighty firms by eliminating those that were involved in the production of machine tool accessory equipment such as carbide tips, welding machinery, inspection equipment and measuring instruments. The evaluation of each company's product range was facilitated by reference to the members directory of the Indian Machine Tool Manufacturers Association (IMTMA). This directory was, thus, the source for the eighty or so firms selected for survey. Moreover, as the members of IMTMA are recognised as producers of 'quality' machine tools it was felt highly likely they would also be included in the ASI survey. A judgement later to be vindicated.

For the purposes of the survey, four geographical areas of concentrated machine tool production were identified; they were located in (1) Bombay/Poona, (2) Delhi, (3) Ludhiana (Punjab), and (4) Bangalore/ Coimbatore. Ninety per cent of the firms surveyed were situated in these four regions. Those firms which fell outside these four areas and were deemed important enough for inclusion were mainly those with relatively large market share. Examples of such firms include Mysore Kirloskar based at Harihar, the largest manufacturer of machine tools in the private sector; Praga Ltd., of Secunderabad, and the Heavy Engineering Corporation at Ranchi, which are both in the public sector. A further ten companies of lesser, though not insignificant, importance were contacted through a postal survey. These companies were sited in scattered areas of India and were, in consequence, impractical to visit.

Numerous problems were encountered during the survey and although none proved insurmountable they did form a source of constant irritation. In the initial instance of establishing contact with a company, the first step was naturally to telephone and arrange, at a mutually convenient time, an interview with an agent. Foreknowledge of the name of the appropriate person to interview was always an advantage and even more helpful was the consent of the secretary of the Indian Machine Tool Manufacturers' Association (IMTMA), Mr. Sulakhe, to allow his name to be used as a mode of introduction.

Before arriving at the company though, there were normally difficulties encountered with establishing its location. Taxis could be used of course, but for Bombay, Delhi, and Calcutta which are all comparatively expensive cities, this method of transport would have been unrealistic on the budget at hand. Therefore, much effort was expended, particularly in the metropolitan areas of these cities, by using public transport and/or the services of the rickshaw wallahs to travel to the various companies. Problems also arose from the fact that the list of members of the IMTMA was some years out of date. The seriousness of this deficiency became painfully obvious when, after spending many hours attempting to locate a company, it was found that one of the following had occurred: the firm had ceased manufacturing machine tools and now concentrated instead on allied engineering activities; it had moved location; or finally it had ceased production altogether. Such disconcerting discoveries occurred on numerous occasions over the period of survey.

The interviews by contrast were, given a power-cut or two, conducted without major problems. Only for a limited number of firms in Ludhiana were there difficulties with language and these were usually small family concerns of minor significance to the industry as a whole. All the companies contacted held files on the ASI questionnaire although in many cases their copies only went back three or four years. At a number of the larger multi-product organisations, manufacturing an assortment of engineering items besides machine tools, it was found that the statistics contained in the copies of the ASI questionnaire related to the aggregated data of all the operations of the firm. This was clearly unsatisfactory as it would have produced an upward bias in the value of machine tool production of the firm. In these cases, requests were made to the companies concerned to calculate as far as was feasible - in the sense of the work involved and the accuracy of the estimates obtained - figures which represented the contribution of machine tool manufacture within the activities of the company. In the event, these requests were usually acceded to but in cases where the company was unable to comply or the accuracy of the estimates were in doubt, the firm's involvement in the survey was, without exception, not continued with. Follow-up contacts with recalcitrant companies were made by post, telephone, telegram and even, in a great many instances, by re-visiting the factory.

On return to Britain it was felt useful to survey six machine tool enterprises which in the recent past had, or in some cases still have, collaboration agreements with Indian concerns. The questionnaire used in this survey (Appendix 2) was divided into two parts. Part A sought descriptive information regarding the problems, if any, of the collaboration agreement. Part B, on the other hand, contained several tables which were judged to be of importance in attempting a comparative analysis of various economic variables in the industries of both countries. Unfortunately though, in similarity to the experience in India, there was a poor response to the quantitative part of the questionnaire. Where tables utilizing survey data are included in the text, an indication of the response rate to that particular question will also be given. The response rates for the Indian and British surveys as a whole are listed below:

Response Rates to Machine Tool Industry

Surveys in	India	Britain
Interviews	65	6
Completed questionnaires returned	40	4
Response (%)	61.5	66.7
Postal contact	10	-
Completed questionnaires returned	0	-
Response (%)	0	-

(iii) Definition of a Machine Tool

A spiral staircase involves problems of definition although easy to recognise, once seen; the machine tool, in contrast, is difficult in both respects.[2] It is important, therefore, that there exists a clear understanding of what is meant by the term 'machine tool', not only from a general point of view but also in the particular operational context of India.

During the early industrialization of Britain and America the demand for machine tool technology usually existed before the tool itself. The products of the industry were, and still are, built to the responses and requirements of its customers. There is no gain saying that James Watt built the first workable machine - the steam engine, without also mentioning that the successful arrival of this engine was delayed for years as he was unable to obtain sufficient compression from the fit between piston and cylinder. To quote from Hine ... "he [Watt] tried in many ways to fill the gap by stuffing it with anything available: cloth, leather, tallow - all to no avail. If the piston could not be made to fit the cylinder, it could not produce power." John Wilkinson solved the problem by inventing the first effective machine tool ... "a horizontal boring mill with a boring bar supported outside of the work and thus independent of the irregularities of the rough cut cylinder."[3]

Wilkinson's boring mill is an example of a machine tool which progressively 'cuts' metal and produces waste in the form of chips. Other machine tools to be found in this category include lathes, planing, drilling and grinding machines. Allied to this group is a category of machine tools which 'forms' metal into various shapes and sizes. Examples of forming machine tools are presses, shapers and hammers. There are two important characteristics of these cutting and forming tools which set them aside from other machinery. Namely, that they are installed (immobile in the short-run) and that they are power-driven. From this, it is clear then, that a handsaw, even though it cuts metal, is not a machine tool because it is neither fixed nor power-driven. Equally, a portable drill is not a machine tool because even though it cuts metal and is power-driven, it cannot be regarded as immobile. Thus, machine tools are defined as: metal-cutting and metal-forming machinery of an installed nature and having the facility of being driven by power.

The aforementioned factors are composite to the American National Machine Tool Builders Association's definition of a machine tool as ... "a power driven machine not portable by hand, used to shape or form metal by cutting, impact, pressure, electrical techniques or a combination of these processes."[4] Floud in his history of the British machine tool industry uses a similar defination but in this case particular mention is made of the role of the operator, thus ... " [machine tools are] contrivances in which a cutting tool is used to bring a piece of metal to the shape, size and degree of finish required by the operator and which to some degree reduce the manipulative skill and physical strength he needs to achieve his object."[5] On observation, there does appear to be a glaring error in this definition with the omission of explicit mention of metal-forming machine tools; this cannot be justified. Similarly, neither can a Soviet definition which deals with the subject in a highly superficial manner, defining a machine tool as ... "A machine for making articles of a given shape, size and accuracy (according to blue-prints) by removing metal from work pieces."[6] It is interesting to note, however, the attention that the same author later gives to the Russian Experimental Machine Tool Research

Institute's method of sub-defining machine tools according to their degree of functional specialization. As per:

(i) General purpose : (universal)	Machines used to work a wide range of parts; and machines used for a particularly wide range of work are known as multi-purpose.
(ii) Specialized :	Machines used for articles similar in shape but different in size.
(iii) Limited purpose :	Machines capable of a narrow range of operation on a wide variety of work pieces.
(iv) Special purpose :	Machines for making parts of one size and type.

Whilst the term machine tool normally encompasses non-portable, power-driven, metal-cutting and metal-forming machines, complications invariably arise when the definition is placed into an operational context. In India, the DGTD has, for statistical purposes, categorized machine tools into two groups of A and B. Included in group A are the familiar collection of metal-cutting and metal-forming machine tools, while group B consists of a motley assortment of : secondary metal-forming machines, machine tool accessories, portable tools, plastic extruding and injection-moulding machines, woodworking machines, foundry moulding machines and some other metal-working and forming machines not included in group A. The National Sample Survey Organisation, a government body in the industrial statistics wing of the Central Statistical Office aggregates the data from both groups when publishing its Annual Survey of Industries (ASI) Report for industry no.357 - 'manufacture of machine tools, their parts and accessories'. This fact must be borne in mind because a potential area of confusion exists here. The reason being that although numerous documents and reports in India refer to the ASI data, the comparative international statistics of the machine tool industry compiled annually by 'American Machinist' relate only to group A production figures including those of India. In the present study, all references to machine tool output, exports etc. will, unless otherwise stated, be in terms of the ASI definition.

(iv) <u>The Machine Building Industry</u>

In formulating a methodological approach to appraise the contribution the machine tool industry makes in the process of industrialization,it will be helpful if the analysis is articulated in terms of the relationship that it holds with the industries using its products. The theoretical implication of this is to breakdown the capital goods sector, in the Marxian scheme of reproduction, into two sub-branches.[7] One is devoted to the manufacture of capital goods for use in this sector : the machine tool industry, and the other to manufacturing capital goods directly for the consumer goods sector : the mechanical engineering industries. It is an approach reflected to some extent in the philosophy of early Indian planning.[8] Moreover, this dichotomy allows discussion to be directed toward the interdependence between the machine tool industry and the mechanical engineering sector which is fundamental to an understanding of the crucial role machine tool production plays in the process of innovation.

Mechanical engineering is a sector which possesses key status in the initial and on-going phases of industrialization. This is reflected in Rostow's assertion that engineering goods are a leading force in propelling a country forward in its drive for economic maturity. Thus, ... "after the railway take-offs of the third quarter of the 19th century - with coal, iron and heavy engineering at the centre of the growth process - it is steel, the new ships, chemicals, electricity and the products of the modern machine tool that came to dominate the economy and sustain the overall rate of growth."[9] That Rostow's supposition is reasonable is based on the fact that in recent times, of the nascent modern industries of the developing world, mechanical engineering is a sector which has attained high relative rates of output growth.

Perhaps the most important single unifying factor linking the varied output of the mechanical engineering sector is concerned with the processing of metals and in particular with the transformation of metals into machinery for further use in the operation of a myriad other industries. This transformation of raw or semi-finished metals into machinery is carried out by machine tools. Thus, the machine tool industry occupies a central position within the total capital goods sector. At the same time, it cannot easily be distinguished from many of the other branches of engineering activity since the processes of production are very similar, since most engineering firms are capable of making or at least modifying machine tools to suit their own purposes and since historically, many machine tool firms have also made other types of engineering products or have turned to machine tool production from other branches of engineering.[10] The development of the American machine tool industry is a case in point: ... "Whereas the production of heavier, general-purpose machine tools-lathes, planers, boring machines - was initially undertaken by the early textile machine shops in response to the internal requirements of their own industry and of the railroad industry, the lighter, more specialized high-speed machine tools - turret lathes, milling machines, precision grinders - grew initially out of the production requirements of arms makers. Somewhat later, the same role was played by the manufacturers of sewing machines and, toward the end of the period under consideration, by the demands of bicycle and automobile manufacturers."[11] Equally, the British machine tool company, Alfred Herbert Ltd., grew out of a steam engine building firm. The company commenced machine tool production when Alfred Herbert secured the agency for a French patent of great value in the manufacture of tubes for the fast expanding cycle trade in Coventry at the turn of the century. On the basis of his profits from this patent the company began to make the machine tools for the cycle trade.[12] Finally, in India, there are the examples of Mysore Kirloskar and Coopers Ltd. These firms are among the largest private sector machine tool manufacturers in the country, and both started life in the early thirties as general engineering concerns. The process by which the machine tool industry has developed and the process by which it has developed its products is, therefore, one of constant interaction with the other many branches of engineering which supply its customers, inspire its inventions and train its labour force and on whose investment plans its prosperity depends.[13]

Definitions of the mechanical engineering sector are, however, many and varied. The Association of Indian Engineering Industry includes thirteen major industrial groups in its definition.[14] An analagous situation exists in Britain. The first British Census of Production classified the output of the sector under forty separate headings.[15] Even the 1973 census recorded mechanical engineering as possessing twenty groups of industrial activity with a further twelve sub-headings contained therein.[16] For the purposes of this study, mechanical engineering is felt to be too broad a concept. It is a system of classifications which aggregates the engineering production statistics of such multifarious activities as the manufacture of watches and clocks to - in the case of India - the repair of bicycles and cycle rickshaws. Machine tool production on the other hand, is characterized by the fabrication of metal and electrical accessories into industrial machinery. Hence, it would be more appropriate when analysing the relationship of the machine tool industry with the mechanical engineering sector, to place emphasis on those industries which perform similar metal-transforming functions. Therefore, the following major industry categories within the Indian engineering sector have been grouped together to form what will be termed as the ' machine building industry' :

35 manufacture of machinery, except electrical machinery;

36 manufacture of electrical machinery, apparatus, supplies and parts; and,

37 manufacture of transport equipment and parts.

Although all three groups are clearly members of the engineering sector many countries identify electrical machinery and transport equipment as distinct production divisions separate from the 'machinery' industry. In the current study, all three groups will be combined to provide a conceptually rigorous definition. The justification for this approach is that it follows conventional practice. The method conforms to the approach of three major studies; two referring to the Soviet machinery industry, and the other to the Chinese. According to Rothstein,[17] the industry group entitled 'machinery' in the Soviet industrial statistics included the following sub-groups : machine tools and tools, prime-movers and electrical equipment, general machine building and production of technological equipment for individual branches of the economy, transportation machinery, automobiles and tractors, and agricultural machinery. Moorstein,[18] in his study of Soviet 'machinery' defined the concept according to Soviet statistical conventions including not only machinery (except electrical) but also electrical machinery and transportation equipment. Finally, Cheng's study[19] of the machine building industry in Communist China contained a similar definition as those of the above authors where the electrical and transportation industries were again explicitly included alongside the machinery (except electrical) industry.

Section 2 : The Theoretical Framework

(i) Towards an Understanding of Innovation in the Machine Tool Industry

It should by now be understood that the machine building industry is composed of firms engaged in a multitude of metal fabricating operations. The feature common to all these enterprises is the machine tool with which their products are manufactured. Indubitably, there exists a special relationship between the machine tool producers and the machine building industry which comprises the most important of the machine tool users. This nexus needs to be emphasised because the development of the machine building industry is influenced to a considerable extent by the choice and quality of the productive capital at its disposal. Furthermore, if there is limited recourse to machine tool imports then the ability to effect technical progression in the industry will be constrained ultimately by the competence of the indigenous machine tool manufacturers. Certain stimuli to innovation both internal and external to the machine tool industry emerge from this pattern of industrial involvement. The mechanics of the inter-play which are discussed below, are important because they highlight the central role machine tool production can play in a country's efforts to industrialize.

The major motivation for internal technological change within the machine tool industry stems from its unique 'reproduction function'. That is, the industry produces machine tools which are themselves used for the production of other machine tools. Although the production of machine tools for use in other industries is more important quantitatively, the reproduction function of the industry is especially significant for economic growth.

This is because the reproduction characteristic motivates the machine tool industry to improve technology for producing its own machine tools.[20]

In addition to the internal motivation to innovate, there are also two external stimuli which induce innovation in the machine tool industry's products. Both are transmitted from the machine building industry and both are the consequences of opposing extremes in the level of demand for the tool manufacturers' output. As this interaction holds textual importance for the present study, it will be worthwhile devoting time to a description of the processes involved in each of these external motivations.

Quoting extensively from an article by W.H. Brown,[21] the bare theorectical bones of the first external motivation are obtained. Brown's paper is a report on his empirical research into the determinants of innovation in the American machine tool industry. A theory of innovation is formulated which crystalises around the hypothesis that ... "the introduction of new machine tools and the timing of their introduction can be understood as a planned attempt on the part of the machine tool firm to increase demand for its product ... when the demand for machine tools falls."[22] It will be useful to identify and briefly discuss the theorectical building blocks Brown uses to construct his hypothesis.

Early on in his thesis, Brown asserts that ... "the specialization of machine tool firms has important implications for the process of innovation."[23] His argument is that the demand from the machine building industry is limited by the specialized nature of a machine tool firm's product. The theory is supported by empirical data Brown gained from interviews with machine tool companies. It appears they think of the demand for their products in terms of 'feast or famine' which in conjunction with their behaviour of 'stocking-up' the market induces them to believe the amount of tools they sell now will affect the amount that can be sold later. Therefore, in order to expand, the machine tool firm must create a fresh market by developing ... "a new design [which] must offer an improved method of operation."[24] Brown produces varied evidence which taken together tends to justify his contention that not only have machine tool firms been able to deliberately render the machine building industry's production machinery obsolete but more importantly, they possess the ability to hasten obsolescence.

To increase demand then, innovation must occur. However, the introduction of a new design involves costs and Brown distinguishes two types. To quote ... " [there are] direct costs which are associated with the research and design process involved in moving from the shelf of ideas to the actual design, and costs which are associated with the production of a new machine."[25] Thus, a definite stimulus is required in order to induce machine tool firms to innovate. It is at this point that the special relationship between the machine tool industry and the machine building industry becomes explicit. This is because the stimulus to innovate derives externally from the slackening demand of the machine building industry. Quoting from Brown again, ... "the costs associated with new design have an important influence on the timing of innovation. A positive incentive is necessary before a machine tool firm will introduce a new design. This incentive is to be found in the desire to maintain or increase sales."[26] Brown provides further support to his argument by stating that during periods of high turnover the engineering personnel in the machine tool industry are fully occupied with problems associated with current production whereas when demand is depressed they have more time to concentrate on designing new and improved machine tools.

To summarize Brown's theory: demand for a machine tool firm's output is limited by its degree of specialization. Thus, for it to maintain or increase its share of the market, innovation must take place. It is when the expected loss in revenue and hence profits from the falling demand for machine tool products becomes greater than the estimated costs of investment into new designs that the incentive to innovate becomes overwhelming. The motivation to innovate is, therefore, external to the machine tool firm and originates from the static or declining investment of its machine building customers.

The second external motivation inducing machine tool firms to innovate also has, as its source, the machine building industry. To attempt a reasoning on this model, discussion is again directed to the example of the American machine tool industry; however, it applies equally to the British. In this case, an article by Rosenberg entitled 'Technological change in the machine tool industry - 1840-1910'[27] weaves a theory of innovation into the key factors involved in the industry's development.

Rosenberg commences his examination of the 'portentously rapid' rate of technological innovation which accompanied American industrialization with an analysis of the development of the metal-using industries. The growth and increasing specialization of firms in this sector were characterized by the emergence of similar productive processes common to a large number of industries. Rosenberg ascribes the process to the application of decentralised power sources in the working of metals. He believes that this generated the employment of ... "similar skills, techniques and facilities at some of the higher stages of production for a wide range of final products."[28] The argument is important because it meant that some of the vertical sequences of production in various industries became related or 'technically convergent' in Rosenberg's terminology. As he states, ... "it is because these processes and problems became common to the production of a wide range of disparate commodities that industries which were apparently unrelated from the point of view of the nature and final uses of the product became very closely related (technically convergent) on a technological basis."[29]

The evolvement of technical convergence was also an important pre-condition which permitted growing industries to pursue what Stigler terms 'vertical disintegration'.[30] That is, the opportunity for firms to develop and specialize in the production of a particular sequence in the vertical operations of enterprises in separate industries. Rosenberg emphasises, moreover, that vertical disintegration without technical convergence would have been insufficient to have initiated the enormous growth in the American 'machino-facture' sector during the years under consideration. He suggests that the latter concept is of primary importance. Quoting again, ... "the degree of specialization achieved owed its existence, in large part, to the fact that certain technical processes were common to many industries. Individual firms producing nothing but milling machines could not have emerged in an economy where only firearms manufacturers employed milling machines."[31] The machine tool industry both evolves from and facilitates this process by specializing in the production of a fine range of heterogeneous output in response to the specifications of its customers. Thus, it may be said that the product specialization of the firms comprising the machine tool industry is a direct consequence of the expansion and vertical disintegration taking place in the machine building industry.

Integrated within the machine tool industry's high degree of product specialization is a 'learning process' which imbued its workers with a heightened dexterity in manual skills.[32] The dynamic externalities of this learning process are germinated in machine tool production. Once the new skills and techniques have been developed in response to the demands of particular customers, the machine tool enterprise then transmits them through the enhanced efficiency embodied in the design and/or improved manufacture of its products to other machine tool-using firms in the economy. The upshot of this diffusion is a continuum in the cycle of learning in the machine tool industry. This becomes evident if attention is focused on the industry's unique role in the solution of technological problems and the transmission and application of innovation throughout the entire machine building sector. These technological externalities derive from the machine tool industry being looked upon as a 'transmission centre' in the spreading of new technology. Moreover, the distribution of its sales to all types of enterprise within the machine building industry has, if viewed from a long term criteria, a significant impact on the extent of 'technological cross-fertilization'.

In any one sector, however, innovation in a machine tool company's product will induce increased competition between rival firms in the machine building industry. The more buoyant and competitive the market is, the more likely it is that rival firms would be forced to improve existing production technology in order to maintain their competitive position. The process will, due to heightened profit potential, motivate further innovation in the tool industry. Thus, Rosenberg's analysis[33] provides the second external stimulus to machine tool innovation which occurs, pari passu, with the increasing rivalry of units in the machine building industry.

Although, not specifically referring to the machine tool industry, a study by Schmookler[34] reinforces the foregoing analysis by arguing that demand-side considerations are the major determinant of variations in an industry's inventive efforts. By utilizing the abundant data on the American Railroad industry, Schmookler discovered a close relationship between increases in the purchase of railroad equipment and components, and slightly lagged increases in inventive effort as measured by new patents on such items. The lag is important because it suggests that it is variations in the sale of equipment which stimulates inventive effort. In addition, for a number of industries he finds a very high correlation between capital goods inventions for an industry and the volume of sales of capital goods to that industry. Schmookler's thesis therefore tends to lend credence to the 'competitive pressures' theorizing contained in external motivation (2).

It should be noted in passing that Rosenberg in a separate article qualified Schmookler's findings on the overriding importance of demand in the promotion of invention-innovation by suggesting that ... "it is precisely because of the versatility of man's enlarged inventory of scientific and technical skills that demand-side forces retain their primacy."[35] Further, he argues that the 'supply' of invention and innovation is not perfectly elastic as Schmookler implies because it depends on the perception of entrepreneurs to the costs - equivalent to those described in Brown's model - involved in its successful undertaking. Bearing this qualification in mind, regarding the capability and costs of a machine tool firm to innovate, then all contributers to the discussion would concur, it is demand - an external force, which stimulates innovative effort.

The features common to both Brown and Rosenberg's theorizing stress the centrality of specialization and the costs of undertaking innovation. Of no less importance is the implicit emphasis both studies give to the atomistic structure of the machine tool industry. Thus, in contrasting these opposing theories, it appears that the crucial difference lies in the respective assumptions regarding the timing of the introduction of the innovation. In Brown's model, a 'mature' machine tool industry's motivation to innovate turns on the vagaries of cyclical activity. Specifically, this will only be during periods of falling demand when the industry attempts to maintain profits, or at least market-share, through the creation of a new market. Rosenberg's analysis, by comparison, reflects rising demand and competition in the industry either in the initial industrialization of a developing country or via the upswing of the business cycle in a modern economy. Both points of view, however, have reference to Schumpeter's most prominent economic hypothesis in respect of inventive activity - that it is motivated by the prospect of maintaining or acquiring monopoly profits.[36] Therefore, the indeterminancy associated with the difference in the timing of innovation is undermined, to some extent, by the consistency of the underlying influence in both models, i.e. the desire to maintain or acquire monopoly profits. With this in view, it now becomes possible to synthesise the two theories into a single paradigm which in the next section can be tested against the developmental experience of the Indian machine tool industry.

(ii) The Relevancy of the Brown-Rosenberg Paradigm under Indian Conditions

A stage has now been reached where this theoretical framework can be rationalised in terms of the specific scenario of Indian industrialization. Initially, one of the aims of this study was to test the validity of the Brown-Rosenberg paradigm against the evidence of innovation in the development of the Indian machine tool industry. But this approach is untenable as only a cursory glance at the industry's patent registrations will reveal. Table 7 shows the patent registrations only for the years after 1945, as prior to this no Indian patents for machine tools existed. 'Total Patents' include those of foreign companies who have no manufacturing facilities in India but wish to protect their product from being copied. The evidence on patent registrations indicates that the Indian machine tool industry's innovative performance has been negligible.

Table 7 : Patents Issued for Machine Tools for Cutting and Working Metal (Patent Classification No.129)

	India	Total	% Share of Indian Patents to total
Drilling Machines[a]	15	99	15.1
Milling Machines[b]	8	53	15
Planing, Shaping and Slotting Machines[c]	9	50	18
Turning Machines[d]	20	135	14.8
Total	52	337	15.4

Source : Registration Catalogues, Government of India Patent Office, Calcutta.

a Jan. 1955 - April 1974
b Jan. 1955 - April 1973
c Jan. 1955 - Oct. 1973
d Jan. 1955 - June 1975

In fact, the situation is worse than it appears because included under the Indian patent registrations are firms with foreign collaborations. A proportion of these Indian patents, therefore, will not represent indigenous innovation but rather the attempts by Indian firms and their foreign partners to halt encroachment of their market through local firms copying their product. Thus the Brown-Rosenberg model of innovation breaks down in the context of the Indian machine tool industry; but why should this be the case? Three reasons are put forward for consideration though not necessarily in order of importance.

Firstly, it is implausible to believe that vertical disintegration in the machine building industries of the developing world can take place merely through a transplant of foreign technology. More likely an 'evolutionary process' is required whereby existing patterns of production are gradually transformed to incorporate not only those firms which would emerge to specialize in the various sequences of production that are common to many metal-using industries, but for the development of a network of specialist ancillary industries also. However, for a country to move from a pre-industrial manufacturing structure it is necessary to create a high level of demand for machinery producers' output. In stating this, it must be noted that an important assymmetry exists between the minimum market size requirements of the machine builders and those of the consumer goods industries. For specialization to be effective in the former, a large market possibly greater in size than that required to achieve all the economies of scale in the consumer goods industries is essential. But for countries like India with relatively low levels of capital accumulation, this minimum size in the machine building industry's market, as yet, does not exist.

It is in this respect that the dictum of Adam Smith ... 'the division of labour is limited by the extent of the market' is depressingly relevant to the circumstances of the Indian machine tool industry and constitutes a main cause of divergence from the conventional model. In fact Smith was reasoning on two interrelated though nonetheless distinct economic concepts : the division of labour and the extent of the market. It will be interesting to note the contribution of Allyn Young on this subject in his original though widely disregarded article written in 1928.[37] Young translated the substance of Smith's 'division of labour' into a contemporary context by observing that it is associated with the use of specialized machinery, thus ... "with the division of labour a group of complex processes is transformed into a succession of simple processes, some of which at least lend themselves to the use of machinery." On the further question of what is meant by the 'extent of the market', Young had this to say ... "but just what constitutes a large market? Not an area or population alone but buying power, the capacity to absorb a large annual output of goods."[38] Clearly, Young's clarification of the extent of the market was not in terms of physical size but rather in the degree of effective demand - a fact of unlimited significance to India.

In a recent study, Professor Alice Amsden elaborated on this point by distinguishing between Smith's narrower concept of the 'extent of the market' and what she refers to as 'market type'. The Professor defined market type in terms of the <u>concentration</u> of purchasing power. She offers an explanation which is now quoted in full, thus, ... "the distinction [between the extent of the market and market type] is worth making explicit, for two markets of equal purchasing power may contain far different capacities to consume a range of goods, or products with relatively high income elasticities. Assume 100 economic units in market A each with an income of $10,000. Assume 1000 economic units in market B each with an income of $1,000. Although purchasing power in the two markets is equal, obviously a market of type A is a better candidate than a market of type B for the absorption of non-essential goods with high unit costs, irrespective of how great increasing returns may be and hence, relatively high prices."[39]

Young and Amsden's interpretation of Smith's famous statement has profound ramifications for the development of a machine tool industry. They both suggest that effective demand is a vital factor in the process of specialization, as Professor Amsden has stated, ... "during the [Taiwanese machine tool] industry's formative years, the material conditions of machine tool users retarded the division of labour in machine tool construction."[40] The role of demand as a constraint on the development of India's machine tool industry will be examined in Chapter 5 of this study. Nevertheless, some statistics are given at this juncture to highlight the low relative level of fixed capital formation in the Indian machine building industry.

On initial assessment, the Indian machine tool industry's growth performance is most satisfactory and does not appear to have been constrained either by the 'extent' or the 'type' of market in which it operates. Only for the years 1967 and 1968 did the industry suffer negative rates of growth in what has otherwise been a continually rising trend in the growth of output value. Since 1960, the gross output value of production grew from Rs.635 lakhs to Rs.5317 lakhs in 1974, recording an annual average growth rate (in constant prices) of 12.8 per cent which is spectacular when compared to, for instance, the American growth figure of 5.3 per cent over the same period. It must be stressed though, that the annual average rate of growth may not be a precise yardstick for international comparison since rates of growth are notoriously dependent on the levels of production already achieved. A high production level tends to be associated with lower growth rates. Starting from a very low base the Indian machine tool industry would have been expected to achieve a higher rate of growth compared with 'mature' countries like America. Actual production levels provide a different kind of comparison. The gross output value of the Indian machine tool industry in 1975 was only 15.5 per cent of that in Britain; 5 per cent of that in the Soviet Union; and even less, below 4 per cent, in America and West Germany. India's share in the world production of machine tools was, in the same year, a meagre 0.74 per cent. This indicates powerfully the low level of absorption for machine tools in the Indian machine building industry.

A second area of divergence from the Brown-Rosenberg paradigm is the lack of product specialization. Since the inception of HMT in 1955, the market for other machine tool manufacturers has been squeezed with the resultant effect that the industry has suffered a cumulative contraction in its degree of fragmentation The natural corollary to this process is that the machine tool industry has exhibited a high degree of concentration. HMT, in 1976, accounted for roughly 45 per cent of the total value of output in the industry which, with Praga Ltd. and Heavy Engineering Corporation, brought the public sectors contribution to over 50 per cent. A further five firms from the private sector accounted for 35 per cent, with the remaining 15 per cent produced by the numerous small scale firms.[41] With only a handful of units producing 85 per cent of the output value of production very little basis exists for specialization to develop. HMT dominates machine tool production. It grew from an annual producer of 400 lathes in 1955 into one of the world's ten largest machine tool houses in 1976, manufacturing the world's widest range of more than seventy types of machine tools.[42] Not only has specialization been constrained under these circumstances but with the emphasis on 'internalizing' all production processes the growth of an infrastructure of ancillary producers has also not developed. Hardly any vertical disintegration has been achieved over the past three decades. All the major units in the industry possess blast furnaces and produce their own castings and in many cases precision components still have to be imported.

The third and concluding area of divergence hinges on the extent of institutional interference in the market. This phenomenon contrasts sharply with the competitive philosophy of the machine building industry in America, the country to which the Brown-Rosenberg paradigm relates. The central authorities control and manipulation of the Indian market may be viewed from both a domestic and a foreign trade plane.

In Indian planning, the growth objective has always been of primary importance and so from the domestic perspective, a comprehensive system in industrial licensing in combination with public sector control enabled the authorities to pursue a pre-determined pattern of investment. Competition was minimized by capital good licensing and Actual user (import) licensing on a 'fair share' basis among rival firms in the industry. These administrative controls had the effect of eliminating free entry by new firms as well as inhibiting efficiency induced expansion by existing machinery manufacturers. The dictate that each manufacturer was entitled to his share of Actual user licenses, and no more, ensured that efficient firms could not, legally at least, enlarge output from existing capacity by competing away the scarce inputs from less efficient firms.[43]

The foreign trade aspect of institutional interference has been via the policy of import substitution. This particular type of government intervention expanded through the imposition of elaborate administrative machinery originally aimed in 1955 at obtaining direct and comprehensive control over foreign exchange utilization. In effect, however, these measures inaugurated a rigid I-S programme which proved an enormous stultifying influence on competition in the machine building industries. In order to obtain imported goods the twin principles of 'essentiality' and 'indigenous non-availability' imparted considerable difficulties for the acquisition of quality inputs necessary for the manufacture of precision tools and machinery in general. Further, the import-allocation system, reflecting as it does the emphasis on attainment of technological self-sufficiency, virtually eliminated all forces of competition. Foreign competition was ruled out because of the principle of 'indigenous non-availability' : every item of indigenous production, no matter how much its cost of manufacture exceeded the c.i.f. price, was automatically shielded from competition through imports, indeed the onus was placed on the buyer to show conclusively that he could not procure the item from domestic producers.[44]

It is clear then, that competition, another requisite of the Brown-Rosenberg paradigm, has been notably absent in the development of the Indian machine building industry. There can be little doubt that a significant degree of inefficiency was introduced into the market as a direct result of government interference. The pervasiveness of this aspect is considerable when it is realised that the majority of the larger machinery industries established (and many of those planned) in the developing world are public sector projects.

The inescapable conclusion to the above discussion is that the motivations to innovate which are so important in the conventional model of machine tool production have been absent in the Indian case.

(iii) The Soviet Strategy : An Alternative Model?

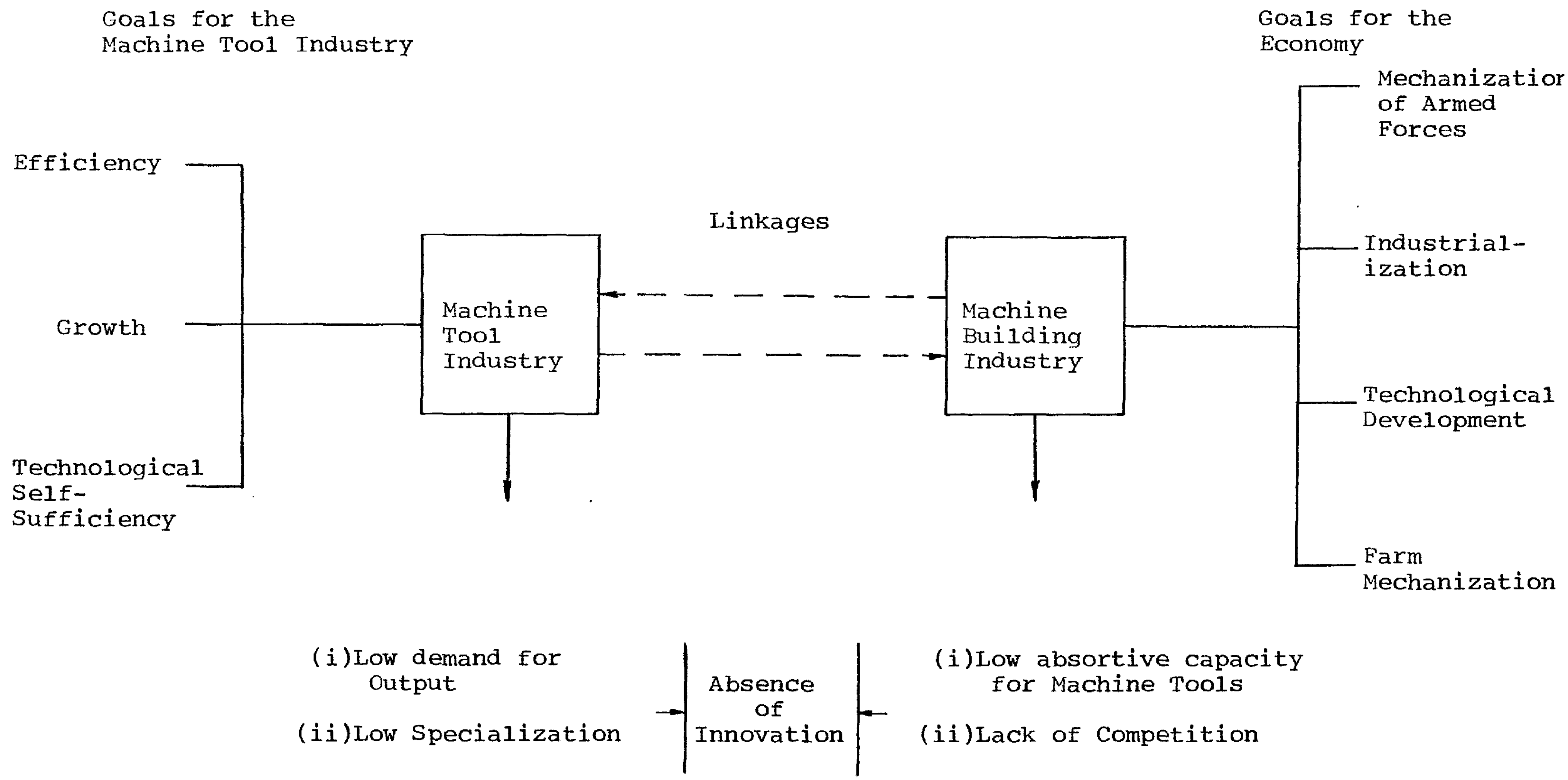
The discussion of the Brown-Rosenberg paradigm has shown innovation in the machine tool industry to be determined by external stimuli. It suggests that the dynamism of the machine building industry is a key variable influencing the industry's 'will to innovate'. However, because the paradigm breaks down in the case of India there must be considerable suspicion as to its applicability in countries having different economic conditions to that of America during its period of development. For the developing countries of today, perhaps a greater relevance should be attached to the 'economics of replacement' in which the replacement cost of a still operational tool becomes the crucial factor. This argument acts as a starting point for the present study; it suggests that in a capital-scarce country like India the replacement cost of machine tools should not be so high as to prove prohibitive. In a country where tools of up to sixty year vintage are common, the entrepreneurs investment decision turns on the question, ... "does the reduction in costs attributable to the new machine compensate for the replacement of a tool which is still physically productive."[45]

This alternative conceptualization of the problem looks at innovation as but one ingredient in the 'total productivity-mix' : the efficiency of machine tool manufacturers, reflected through the prices of their products, now assumes primary importance. It is a global approach having reference to all facets of the problem of improving productive efficiency in the machine tool industry.

However, complications arise with this analysis because since independence successive Indian governments have interpreted, indeed couched, the development of the machine tool industry not only in terms of an implicit (profit-maximising) efficiency criterion but on a whole matrix of national aspirations. Figure 4 shows, schematically, the goals set for the industry by the central authorities. It may be observed that improving efficiency has had to vie with two other major objectives namely, growth and self-sufficiency. The machine tool industry was, early on, recognised as a key sector at the heart of India's development programme. Thus, rapid improvements in standards of living and employment were to be achieved through the industrialization and technological development of the economy. This was to be financed by the surplus from the agricultural sector (which would itself benefit from increasing mechanization); the foreign exchange savings; and, it was anticipated, foreign aid. A fourth objective impinged on India's military defence capability through the mechanization of the armed forces.[46]

It could be argued that the attempt by the machine tool industry to simultaneously achieve maximum levels of growth, diversification and efficiency in production was counter-productive. Certainly, the drive for self-sufficiency in the supply of most types of tools would have conflicted with the other two goals. Moreover, although government policies were formulated to assist the growth objective, in truth, they had more of an impact on the operational efficiency of the sector; deleterious though it was. Thus, with the forces of competition constrained and with the relatively low levels of demand inhibiting the division of labour, the conditions necessary for the proper functioning of the Brown-Rosenberg paradigm were absent. Hence, as Table 7 has shown, innovation did not take place.

Figure 4 : The Role of the Machine Tool Industry in Indian Economic Development



In view of the machine tool industry's lack of innovative flair, the question is broached : did the sector follow the most appropriate path for its development? With the advantage of hindsight the argument could be advanced that it did not. Perhaps the development of the Indian machine tool industry in the fifties and sixties would have been better served if it had emulated the archetypal Soviet model of the thirties? On a comparative basis, not only did the Soviet model of machine tool production have to operate according to the similar planning goals of growth etc., as its more contemporary Indian counterpart, but, in addition, the economic conditions of the two countries during their respective periods of industrialization may also have been fairly close, i.e., capital scarcity, shortage of skilled personnel, potentially vast internal market, and so forth. Furthermore, the fact that both industries were fostered under a regime of industrial autarchy is also of considerable relevance.

It should be emphasised, however, that temporal comparisons of this kind can be little more than generalised approximations. Most importantly, it is impossible to be dogmatic about the relative levels of industrialization in the Soviet Union of the 1930s in comparison with that of India in the 1950s. Emphasis on similarities as against divergences between the two countries in the respective time periods should be carefully avoided, especially in : the degree of autarchy imposed; the buoyancy of agricultural output; the extent of the skill and technological base; and the basic infrastructural characteristics of each economy. Given the above qualifications, there is, nevertheless, a good case for considering whether a Soviet machine tool manufacturing strategy during India's industrialization effort might have been a more appropriate course of action for the authorities to have followed.

A major aim of this study, then, is to examine the relevancy of the Soviet machine tool production model under the economic conditions of India in the 1950/60s. To do this rigorously the following approach of using contrasting hypotheses will be used:

(i) that India's machine tool sector should have pursued the Soviet model of machine tool manufacture whatever the economic conditions were. Here, the advantages to be derived from large scale, serialised production would have risen above the other constraining influences in the economy;

against the alternative stance:

(ii) that the Soviet model would have been inappropriate to the Indian machine tool industry, not least because of possible divergences in the conditions and circumstances of the Soviet Union in the 1930s with India in the 1950/60s, but also due to the various inefficiencies that were introduced into India's industrial environment from the import substitution policies that were followed at that time.

It has been postulated that a major element of the Western approach to machine tool production has been the emphasis given to product-innovation; this has been represented by the construction of the Brown-Rosenberg paradigm. From this it has been shown that the paradigm has broken down in India's tool sector as evidenced by the paucity of patent registrations. There is a complication here, however, in that patent registrations may not adequately reflect the degree of technical change that has taken place in the industry. There is the belief that in developing countries incremental learning curves might provide a more accurate measure of productive improvement. This line of thought will be more fully examined in Chapter 5. Suffice to say at this point that it perhaps may be more fruitful to view innovation as encompassing all those influences which have a positive affect on 'total factor productivity'. Attention is thus shifted away from solely innovation to the global efforts at reducing the costs of machine tool production : a form of 'capital-saving' which has been much neglected by economists concerned with economic development. Rosenberg was the first to recognise this when he wrote in his pathbreaking article, 'Capital Goods, Technology and Economic Growth', ...

> "What is important is not just the development of capital-saving innovation - although this is certainly very important. What is also important is improving the efficiency with which the existing types of capital goods are produced. Underdeveloped countries have been deficient on both accounts but the latter deficiency has received practically no attention. They have, therefore, missed a major source of capital-saving for the economy as a whole."[47]

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33. It should be pointed out that Rosenberg's analysis does not go as far as the discussion contained in the text; the present author's extension of Rosenberg's reasoning is, however, both consistent and logical with his argument.

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36. Quoted in Karmien and Schwartz : 'Potential Rivalry, Monopoly Profits and the Pace of Inventive Activity', Review of Economic Studies, Vol.XLV(3) No.141, (Oct.1978) p.547. The authors expand on Schumpeter's argument by adding ... "An innovation is introduction of a new product or process superceding an existing one. This means a monopoly" - and, therefore, monopoly profits required to motivate the entrepreneur to innovate - "may be of limited tenure and hence vunerable. The firm does not identify a particular source of innovative rivalry but instead regards rival innovation as a probalistic event." (p.547).

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46. It is of interest that a very large public sector company, Praga Ltd., is controlled by the Indian Ministry of Defence. In (20) the authors also make the telling point that one of the key proposals in the post World War II plans for the 'demilitarization' of Germany was the imposition of severe restrictions upon its output of machine tools.

47. N. Rosenberg : 'Capital Goods, Technology and Economic Growth', Oxford Economic Papers, Vol.15, (Nov.1936) p.222.

Chapter 3

Development of the Machine Tool Branch : The Goal(1) of Growth

Machine tool manufacture was of negligible importance at the time of India's independence in 1947. However, with the government's formulation of an economic strategy, as expressed in the country's rigorous planning regime since 1951, the importance of the sector has elevated considerably. In essence, this is merely a reflection of the rationale of Indian economic development in respect of its two-fold linkage between the production of indigenous technological capacity and the drive towards self-sustaining economic growth. In similarity to the Soviet experience of the 1930s, the Indian policy-makers assumed the two concepts to be highly interrelated; moreover, the performance of the latter aim was held to depend on the successful implementation of the former. Thus it was, that economic growth : the most fully articulated objective of Indian planning, and also regarded by many as the most important, hinged on the development of the heavy machinery building industries.

The point to be emphasised is that India, at the commencement of its Five-Year Plans, was an extremely poor country. Any attempt to raise real income per head through distribution was, therefore, unrealistic. The only logical alternative was to substantially increase the level of output in the economy thereby generating the expansion in employment and income necessary for higher consumption to be achieved. But this begs the question as to why aggregate output was low in the first place? In the planners' view, the chief limiting factor was the low level of capital stocks of the economy and the chief imperative was to increase the capital stock through a high rate of investment.[1] This, in general terms, was the genesis to India's two-sector growth model : the

'Mahalanobis Strategy'. Output capacity in the economy was adjudged to be constrained by the low level of capital formation and, in consequence, the production of capital goods was to be given priority in the allocation of investment resources. The appropriateness of such a policy is highlighted when it is considered that the Indian economy of the time was to all extents and purposes 'closed' because of the paucity of foreign exchange holdings. In addition, by reference to Chapter One, it will be recalled that Mahalanobis recognised the important distinction between the two types of capital goods : (i) those that produce consumer goods, and (ii) those that produce other capital goods. As the objective of the authorities was the long-term maximization of growth then greater significance is necessarily attached to the production of those capital goods belonging to the second category : 'machines producing machines'. Under these circumstances, the scale of investment priority in the economy in descending order of importance would be : the machine tool industry; the machine building industry; and finally, the consumption good industries. In short, the growth in the productive capacity of the machine tool industry was the lynchpin to the Mahalanobis strategy because, in an essentially 'closed' economy, capital accumulation would not be possible in its absence.

In the light of this introductory statement, the aim of this chapter, given the parameter of growth as one of the machine tool industry's primary goals, is to examine and detail the major issues of its development up to and including the present time : to paint a statistical and institutional picture that will serve as a backdrop for the analysis of 'self-reliance' and 'efficiency' in later chapters. In order to achieve this aim the chapter is split into three sections. The first section considers the growth trends of the industry leading up to and during the period of planning. An attempt is also made to document the main conditioning factors believed to have had an important influence on growth performance since the introduction of centralized planning in India. In this context, two factors of particular significance are elucidated : the emergence of an omnipotent public sector, and a planning strategy which,perforce, had to be implemented within the context of a mixed economy. Section two opens with a concise appraisal of the concentration of industry in the machine tool sector. This is followed by an analysis of the present economic status of the industry in terms of its organization of production. Finally, the third section offers an insight into the role of foreign collaboration as a vehicle for the technological development of the industry, with particular attention being paid to the case of HMT.

Section 1 : Aspects in the Growth of Machine Tool Capacity

(i) Historical Origins

Machine tool manufacture is one of the newest branches of 'modern' industry in India; it is at the same time, however, also one of the smallest. The fact that even as late as 1960 machine tools accounted for only 0.3 per cent of manufacturing output value belies the important strategic nature of the machine tool industry : it is primigenial to the process of industrialization. Prior to the period of planned industrial development, indigenous machine tool manufacture was, indeed, severely limited. Nevertheless, it is significant to note that the beginnings of the industry go as far back as the latter part of the 19th century. A brief examination of the historical origins of machine tool production will therefore contribute to an understanding of the present status of the industry.

The earliest recorded production of machine tools in India was in 1890. A number of Workshops in the undivided Punjab had begun to manufacture machine tools to satisfy their own requirements. Consequently, none of these machines found their way onto the market; a pattern of development not dissimilar to the origins of machine tool manufacture in Britain and America. These Punjabi artisans pioneered the manufacture of basic machine tools such as : 'deep gap' cone pulley lathes and 'deep throat' drilling machines, which were then used for the fabrication of simple machines like chaff cutters, cone crushers, and oil expellers.[2] Although the numbers of these manufacturers were very small and their products poor in quality they can be recognized as the forefathers of the machine tool industry in India.

The commencement of the 1st World War induced a limited number of small firms to produce machine tools specifically for manufacturing shells; however, at war-end in 1919 this activity ceased. Thereafter, it was not until the late 1930s that the production of machine tools for non-military purposes began to make some sort of impact. Again, in repetition of the events in the 1890s, a small nucleus of the larger general engineering concerns began to manufacture basic, general purpose machine tools. In 1937 for instance, Cooper Ltd., commenced production of simple cone-pulley lathes and pillar-type drilling machines. In the following year, the same company introduced into its product-mix a shaping machine. Also, around this time, another company : Kirloskar Bros., began development work on centre lathes; the first being commercially produced in 1938. Although these beginnings were significant, they should, nevertheless, be kept in perspective : it has been quoted that up until the 2nd World War only one hundred machine tools were produced annually in India.[3] The Calcutta Institute of

Management has suggested three reasons for this apparent low level of output : firstly, that there was little metal-working activity in India at that time; that imported machine tools were freely available; and finally, that the major users - the railroads and larger engineering concerns - were mostly foreign owned and, in consequence, preferred imported machine tools.[4]

The start of the 2nd World War set in motion dramatic changes in what, up until that time, could only be flatteringly referred to as a machine tool industry. The war years were to witness not only a surge in the production of tools, intended primarily to assist in the war effort but also the imposition of a skeletal planning apparatus. It will be useful for later discussion to reflect on this period of change.

For the era preceding 1939, on account of the insignificant size of Indian production, the country's machine tool requirements were generally met by imports. In response to the outbreak of war (India was of course a Crown Colony of the British Empire and as such, was more or less committed to contributing toward the allied 'war machine'), Indian industry expanded capacity to manufacture defence equipment and products which could no longer be imported. These events resulted in a greatly increased demand for machine tools; a situation not eased by the difficulty of importing the same. The Indian government's reaction to the problem was to pass the 'machine tool control order' and appoint a machine tool controller to regulate what imports there were; to make a survey of the capacity available for machine tool manufacture; to improve the quality of Indian machine tools; and, to procure the best quality machine tools for the armed forces, ordnance factories and war industries.[5] With these aims in view, a system of licensing was introduced with licenses being granted to producers of machine tools who possessed the necessary plant and skilled technicians.

In the early stages, these licenses were granted freely, mainly with the intention of rapidly creating a reasonable capacity to serve the needs of a war orientated economy. It was felt that later, with the return of peace and normalcy in international trade, attempts could then be made to rationalize and reorganise the industry on more scientific lines.

The small amount of machine tool imports India had been receiving prior to 1943 disappeared altogether at the beginning of that year. Two factors were the basic cause of this import scarcity : the entry of Japan into the war, and the closing of the mediterranean route to shipping. Great reliance had been placed on these meagre imports to supplement indigenous machine tool manufacturing capacity; a direct consequence of their loss was that serious bottlenecks in the maintenance and replacement of machinery in India's industrial undertakings ensued. Domestic machine tool capacity was therefore expected to supply all the country's requirements and to facilitate this, various schemes were put into force to regulate and control still more strictly the manufacture and distribution of machine tools produced in the country. A number of general engineering concerns were encouraged to undertake the manufacture of quality tools to augment the production of those firms which were already established producers. In this respect, governmental intervention could be traced back to the decision made through the machine tool controller, to implement measures which would directly affect the expansion of machine tool production. The more important of these policies can be listed as follows:

(i) the future import of machine tools into the country was to be strictly controlled and import licenses issued only for high priority contracts, and for such machine tools as could not be manufactured in the country;

(ii) the government agreed to purchase the entire production of its leading manufacturers providing that certain defined quality standards had been reached;

(iii) the services of a team of technicians from the United Kingdom were to be obtained to provide assistance to local machine tool manufacturers; and finally,

(iv) the government offered the services of the machine tool (inspection) branch belonging to the Industries and Supplies Department, to test and inspect the machine tools manufactured in India, which were then to be classified as 'graded' or'non-graded' depending on the quality.[6]

During the six years of World War II, the machine tool industry's output increased at a phenomenal rate. With the cessation of hostilities in 1945 however, the high level of demand was not sustained; foreign machine tools again became freely available whilst the demand for indigenously produced tools correspondingly fell. As a direct consequence of the liberalization in foreign trade, machine tool production in India deteriorated from a peak of Rs. 11.2 million in 1945 to Rs. 2.9 in 1950.

The serious decline in the fortunes of the industry was recognised early on by the government which in 1945 set up a machine tool industrial panel to prepare a comprehensive plan for its future development. In addition, in 1947 the government, under pressure from the machine tool manufacturers, referred their case to the newly constituted Tariff Board which after consideration recommended protection.[7]

It seems clear, therefore, that the early post-war years carried the Indian government's encroachment into the market place still further. Indeed, the process markedly accelerated after independence and particularly so in the mid-fifties when the programmes of planned industrialization were formulated with emphasis given to the development of the capital-goods industries.

(ii) Overview of Growth Performance During the Planning Period

The production of machine tools in India has grown steadily since the early fifties. In 1942, the country's entire output amounted to only 273 tools at a nominal value of Rs.6 million. With the spread of hostilities to South-East Asia, however, production was to rise spectacularly to reach 3,669 tools by 1945, thereby increasing the value of output almost twenty-fold over the three year period. The return of peace to the region caused a decline in the demand for military hardware and hence, for the machinery by which it was produced. Naturally enough, this 'trickling-down' process eventually affected the demand for machine tools which also fell in pro rata proportions. Indeed, the machine tool industry did not regain its war-end level of output even by the final year of India's First Five Year Plan. Thereafter though, the situation changed dramatically. Table 8 traces the growth of indigenous production as also total consumption (including imports) throughout the 1941-75 period. From the table it is evident that the growth in machine tool production accelerated sharply with the implementation of the 'Mahalanobis strategy' in the Second Five Year Plan; but even this was shaded by the performance of the industry in the ensuing Third Plan when roughly twice as many machine tools were constructed than for the whole of the preceding twenty years.

From 1960-74, the rate of growth of the machine tool

Table 8 : Machine Tool Production and Consumption in India

	Imports		Indigenous		Total Consumption	
	Nos.	Value in Crores	Nos.	Value in Crores	Nos.	Value in Crores
1941		.58	n.a.	n.a.		.68
1942		.57	272	.06		.63
1943		.54	1713	.64		1.18
1944		1.33	2170	.78		2.31
1945		1.82	3669	1.12		2.94
TAL 1941/45		5.14	7825	2.60		7.74
1946		1.83	4125	.91		2.74
1947		3.68		.46		4.14
1948		4.14		.55		4.69
1949		4.19		.47		4.66
1950		2.49		.29		2.78
TAL 1946/50		16.33		2.68		19.01
1951	1826	2.50	1143	.47	2969	2.97
1952	1614	2.21	1070	.44	2684	2.65
1953	2287	3.13	1070	.44	3357	3.57
1954	2813	3.85	1216	.50	4029	4.35
1955	4485	5.29	2003	.74	6488	6.03
TAL 1951/55	13025	16.98	6502	2.59	19527	19.57
1956	7352	8.37	2943	1.20	10295	9.57
1957	15339	11.32	3015	2.51	18354	13.83
1958	11953	12.21	3868	3.76	15841	13.97
1959	9072	11.61	4071	4.39	13143	16.00
1960	8225	13.21	5332	6.18	13557	19.39
TAL 1956/60	51941	56.71	19249	18.04	71190	74.76
1961	11920	17.89	8511	7.76	20431	25.65
1962	10706	18.95	10293	10.88	20999	29.83
1963	10399	31.51	11058	15.44	21457	46.95
1964	7650	33.53	13370	18.90	21020	52.43
1965	9642	32.32	15423	22.26	25065	54.58
OTAL 1961/65	50317	134.20	58855	75.24	108972	209.44
1966	7409	41.04	14931	25.78	22340	66.82
1967	6311	36.43	12330	21.58	18641	58.01
1968	4877	36.25	7879	17.14	12756	53.39
1969	2056	15.12	10445	21.92	12501	37.04
1970	1818	14.65	11654	28.94	13482	43.59
OTAL 1966/70	22481	143.49	57239	115.36	79720	258.85
1971	2940	17.75	11447	37.11	14387	54.86
1972	2298	19.29	8750	34.47	11048	53.76
1973	1884	17.35	10178	44.16	12062	61.51
1974	2105	22.92	13549	64.53	15654	87.45
1975	1780	33.18	12191	77.88	13971	113.06
OTAL 1971/75	11007	110.49	56115	258.15	67122	370.64

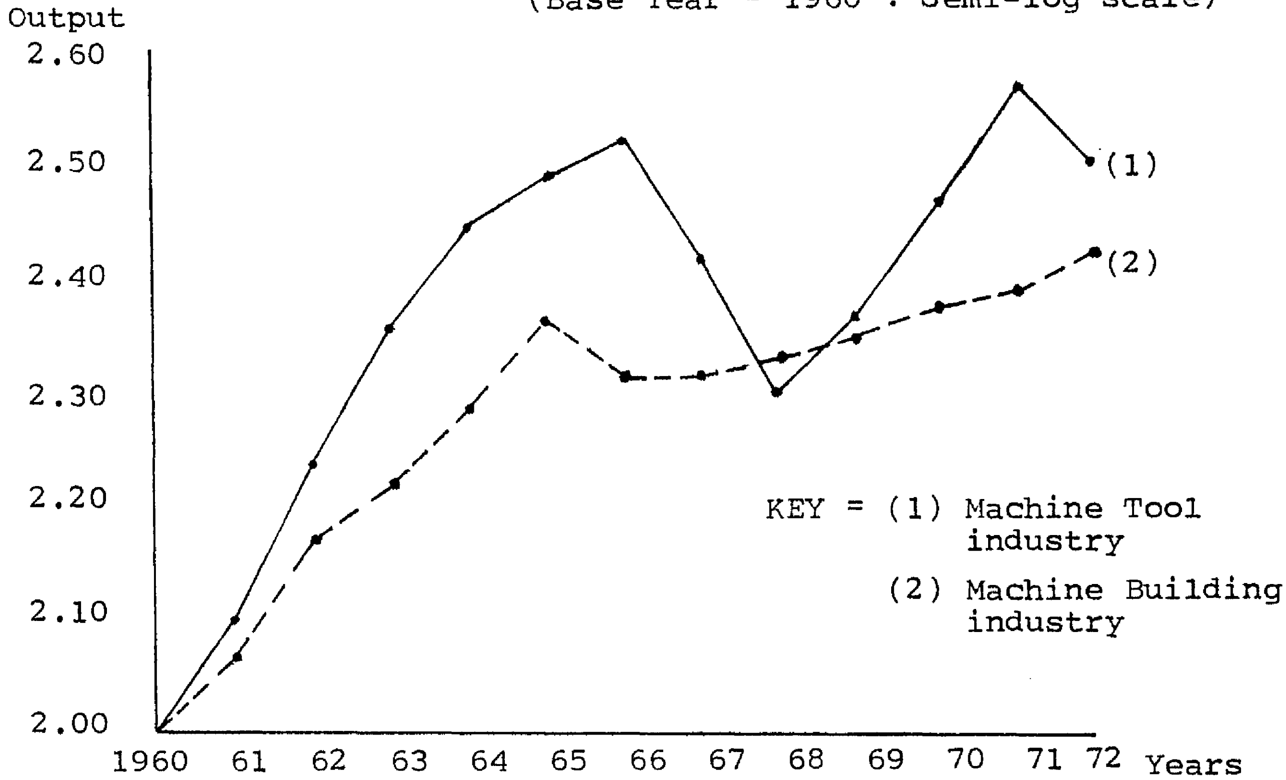
Source : D.S. Mulla & Co.
Files, Bombay.

industry was 10.8 per cent as against 6.7 per cent for all industrial production. The trend of output value, in constant prices, rose continually only until 1967 when growth was arrested; thereafter it oscillated for 5 years as the Indian economy struggled against a severe recession. The connection between a country's economic climate and the rate of growth of machine tool production is well established, and it is therefore obvious that the lull in the demand for machine tools during the years 1967-72 directly resulted from the recession in the Indian economy over the same period. By definition, a recession implies a sharp decline in industrial investment and, thus it was, that in India between 1966/67 and 1972/73 net domestic capital formation (as a percentage of N.N.P. at factor cost) fell from 17 per cent to 13.7 per cent.[7]

The mode of analysis can be cast in more specific terms by referring back to the methodology of this study as outlined in Chapter two. Of particular importance was the discussion concerning the relations of the machine tool branch to the machine building industry. It will be informative to explore this relationship further by comparing the respective growth trends of each sector. Figure 5 depicts the comparative growth of the two sectors through the medium of production indexes. It is interesting to note the parallel trends that both the machine tool and the machine building industry appear to take. The belief regarding the linkage between the two sectors is reinforced by observation of the time-lag between the fall in the machine building industries output in 1966 and the induced decline in machine tool manufacture one year later. Thereafter, the divergent paths that each industry follows appears to indicate that the machine building industry increased its production by utilizing more intensively the existing machinery rather than through its replacement or expansion. Moreover, the dependency of the machine tool branch on the fortunes of its customers : the machine building and associated metal-using industries, is further revealed by the similarity in the annual average rates of growth of the two sectors at 10.0 and 10.3 per cent respectively.

Figure 5 : Index Numbers of Production For Machine Tool and Machine Building Industries 1960-72

(Base Year = 1960 : Semi-log scale)



Source : (1) Appendix 1, Table A.

(2) 'Handbook of Statistics 1973', AIER, Calcutta, (1974) p.9. Constituent members of the machine building industry weighted by their share in total machine building output.

Examination of the Indian machine tool industry's growth in production indicates, both absolutely and in relation to industry as a whole, that the period since the Second Five Year Plan has experienced a rapid increase in output value. However, such a conclusion should be of no great surprise when it is considered that the pursuance of the objective of establishing and developing indigenous technological capacity necessitates the rapid build-up of a machine tool manufacturing base. Growth is, in any case, a function of production levels already achieved and the fact that India ranked 11th in world machine tool production in 1966 slipped to 16th in 1975 below countries such as : Brazil, Poland and Spain, seems to suggest that other newly industrializing countries are experiencing relatively faster growth in machine tool output.

(iii) Hindustan Machine Tools (HMT)

The emergence of a 'public sector' in the Indian machine tool industry can be ascribed to four separate factors. Firstly, at the time of independence in 1947, the new administration found itself with around Rs.4000 million worth of surplus war materials which included considerable numbers of machine tools. The 'War Disposals Utilization Committee', set up in 1948 to advise the government on the best way of using these stores, suggested among other things, the establishment of a machine tool factory.[8] Secondly, the partition of the Punjab as an agreed condition of independence meant that, at a stroke, eight important machine tool units were lost to India. Hence, at the commencement of the country's First Five Year Plan in 1951, there existed just 14 producers of 'graded' machine tools, possessing an aggregate annual capacity of only 3000 machines. In fact, for that year alone : out of a total requirement of Rs.29.7 million of machine tools, the indigenous industry was able to supply only Rs.4.7 millions worth; the remainder, amounting to almost 85 per cent was imported. A third reason for the creation of a public sector in the tool industry was advanced by the authorities during the early years of independence and called attention to the growing demand for more sophisticated, precision tools; a demand not being satisfied by the private sector units. It was proposed that a government owned undertaking should be established to cater exclusively for this type of demand whilst leaving the range of less expensive tools entirely to the private sector. Finally, the Kashmir war heightened the awareness of the Indian government to the fact that machine tools were not only requisite for industrialization but also for the manufacture of military hardware.

The decision to build a public sector machine tool plant was officially confirmed in 1949. At the same time, it was announced that the project would be undertaken in collaboration with a Swiss firm : Messrs. Oerlikon Machine Tool Works. Oerlikon had been preferred to Czechoslavakian participation because the company had already assisted in the establishment of a number of ordnance factories in the country. Four years were to elapse before, in the February of 1953, the factory was formally registered and christened Hindustan Machine Tools Ltd. A further three years were to go by before the first batch of five 'H-22 lathes' were produced in the May of 1956.

Right from the initial years of this collaboration little consensus existed between the Indian and Swiss managements as to the appropriate industrial strategy to be pursued. The Indian management, which had originally wanted to produce at least four varieties of machine tools, eventually gave ground and the Swiss policy : specializing in the production of a single machine, the H-22 lathe, in batches of 400 per year, was approved. However, this early skirmish between the protagonists for specialization and those against, was to spill-over into full scale confrontation several months later when, with a new Managing Director, HMT decided to buy out Oerlikon's 10 per cent share holdings in the company and embark upon a major programme of diversification. This policy was achieved through a whole series of foreign technical collaborations; a process which is described in some detail in Section three.

At the twilight of India's Second Five Year Plan with its emphasis on the promotion of capital goods industries HMT, with government agreement, decided to expand productive capacity. From Table 9 it can be seen that HMT's output value had grown rapidly between 1956-61 from Rs.3.09 million to Rs.42.47 million. Indeed, the company

Table 9 : H.M.T. Machine Tools Production 1956-75

(Rs. millions)

Year	Production	HMT's production to country production (%)
1956	3.09	26
1957	11.92	47
1958	17.67	47
1959	19.62	45
1960	31.02	50
1961	42.47	55
1962	55.29	51
1963	86.69	56
1964	93.43	49
1965	111.91	50
1966	122.10	47
1967	93.10	43
1968	97.50	57
1969	123.80	56
1970	151.20	52
1971	209.90	57
1972	193.40	56
1973	229.80	52
1974	315.90	49
1975	422.40	54

Source : S.M. Patil : 'Indian Machine Tool Industry and Growth', Op.cit., Table 1

now accounted for 55 per cent of India's total production of machine tools. To meet the growth in demand, HMT commissioned the construction of a second plant in Bangalore which came 'on tap' in the May of 1961. Over the same period an industrial estate was built around HMT I and HMT II with approximately fifty small scale units spread across an area of some 20 acres. To serve the continuing demand of Indian industry which during the first three Five Year Plans grew at a rate approaching 9 per cent per year, HMT III at Pinjore (in the then Punjab) began producing in the October of 1963; HMT IV at Kalamassery (Kerala) followed in 1965; and, HMT V at Hyderabad (Andrya Pradesh) in 1967. HMT VI, the erstwhile Machine Tool Corporation of India Limited based at Agmer (Rajasthan) was absorbed into the company much later in 1975.

HMT, after experiencing continuous growth since its inception suffered a serious reverse in fortunes during the years 1967-8. This was a period of severe recession in India's industry which dramatically affected capital goods investment - notoriously a major casualty when general economic activity is depressed. A decline in the level of public expenditure coupled with the formal declaration of a 'Plan holiday' in April 1967 compounded the problems facing the company. It was under these circumstances that the management of HMT decided to adopt a strategy of aggressively diversifying <u>out</u> of machine tool production. The aim was seemingly to hedge against the volatility of demand in the market for machine tools.

In fact, HMT during these recessionary years owed its continued viability to the profitability of a watch factory established in Bangalore in 1961. The venture was initiated with the collaboration of the Citizen Watch Company of Japan with an original capacity of 360,000 watches per year. Further expansion in the production of horological equipment took place during 1972-3 when a second watch-making unit in Bangalore was set up to manufacture automatic watches; a third unit in Srinagar was added during 1973-4 for producing hand-wound watches. In 1969, HMT IV at Kalamassery began to manufacture printing machinery with the assistance of an Italian collaboration. Also in the same year, an agreement was concluded with a Swiss concern for the manufacture of cold chamber die casting machines; this was to take place in a division attached to HMT I and II in Bangalore. In 1971, HMT III at Pinjore became the home for the production of tractors in collaboration with a Czechoslavakian company. Finally, in 1973 in collaboration with a Hungarian firm, HMT V at Hyderabad established a facility for producing glass, lamp components, and lamp-making machinery. However, although the list of HMT's 'supplementary' activities ceases at this point, various other lines for future production have been mentioned, namely : coal-mining machinery, automobiles, and power generation equipment.[9]

Concomitant with the expanding gamut of industrial activities taking place within the company was the growth in the services it could provide to other enterprises both in India and abroad. Under the auspices of its 'project consultancy wing' HMT has offered assistance ranging from a techno-economic feasibility study of a proposed machine tool accessories plant for the state government of Maharastra (in similar vein, the consultancy wing is at present involved in the preparation of feasibility reports for Tanzania, Kenya and Nigeria) to a complete 'turn-key' project for the establishment of a machine tool plant in the Philippines.

In terms of the growth of output value, the performance of HMT has been phenomenal. From 1960 when production stood at Rs.31.02 million, the company's output value increased at an annual average rate of growth of 11 per cent (based on constant prices) to reach Rs.422.4 million by 1975. However, these figures tend to conceal two important developments that have taken place within the company, especially since 1970 :

(i) Firstly, as Table 10 illustrates, although the value of production from 1969 to 1976 has grown annually at 13.5 per cent, the numbers of machine tools produced over the same period have registered only a modest 2.4 per cent rate of growth; the growth in the numbers of machine tools sold actually declined by 1.5 per cent. These trends appear to suggest that HMT's production strategy since the late sixties has been to concentrate on the sophisticated end of the technological spectrum. Indeed, the production of special purpose machinery and transfer lines since the seventies is by itself a reflection of the changing composition of output.

Table 10 : HMT's Production and Sales of Machine Tools 1969-76+

Year	Production (Nos.)	Sales (Nos.)	Production* (current prices)	Production (constant prices)
1969	2334	2275	127.6	134.9
1976	2757	2042	571.0	326.6
A.A.G.(%)	2.4	-1.5	-	13.5

Source : HMT Annual Company Accounts

Note : + relates to accounting years 1969/70 - 1976/77
* Rs. millions

(ii) Secondly, the relative share of HMT's productive operation has progressively changed : in 1960-61, the manufacture of machine tools represented 100 per cent of output value. The contrasting figure for the year 1977-78 was 40 per cent which clearly indicates the shifting operational priorities of the company.

(iv) The Apparatus of Industrial Planning

The fact that the development of the Indian machine tool industry took place in an environment characterized by a high degree of planning is indeed of some significance.

Naturally, as a capital-goods producing industry both public and private enterprises were, from a strategic perspective, ear-marked for preferential treatment; but in addition to this, the industry was nurtured under a regulatory framework that was designed to protect it from, amongst other things, the extremes of foreign competition during its period of infancy. Thus, leaving aside the question of foreign trade policy until Chapter 4, the intention at this stage is to present an apercu of the industrial controls and regulations which have been especially important to the business of machine tool manufacture in the country.

Throughout the course of planned industrialization in India, investment in the public sector of the machine tool industry has been subjected to direct measures designed to influence the nature and pattern of manufacture in the organized sector. Although investment in the private sector has also not been exempt from the physical controls of the planners. On reflection, the government's assault on the prerogatives of private sector enterprise in the machine tool sector was not surprising in view of the orientation given in successive plan documents towards 'a socialist pattern of society'. As such,it prescribed the institutional context in which development would occur; the emphasis being on the public sector as the pre-eminent agency of industrial development.

It is instructive to establish the very important point that unlike the U.S.S.R. which is a centrally planned state, India is a mixed economy possessing a centrally co-ordinated planning apparatus. There is a crucial difference, and it lies in the fact that the Indian government has 'direct' control only over that part of the economy constituting the public sector. The impact of the government on decision-making in the private sector units hinges, to a large extent, on a system which offers 'economic carrots' as a means of inducing compliance with the dictates of the plans. But, as Chaudhuri argues: "while it [the government] can devise alternative systems of incentives and disincentives, it cannot determine the degree to which allocative decisions in the private sector would respond to any such systems."[10] In consideration of this deficiency, it is necessary to make a distinction between government policies which act on the total level of demand for resources and those that impinge on the allocation of resources without directly affecting the level of demand. Basically, the former relates to activities within the agricultural and intermediary industries, e.g. rationing of food grains and energy distribution; and as such fall outside the purview of this discussion. It is the second type of policies, e.g. licenses and directives that are of concern here.

These types of controls were devised by the Planning Commission in the formulation of the Five Year Plans and were to operate primarily through the twin strategy of target-setting and an exhaustive system of licensing. Specifically, these mechanisms of control were designed to influence and determine : (i) the pattern of investment down to product level; and (ii) the choice of technology.[11] The relevance that this discourse, on the apparatus of industrial planning, has on the development of the machine tool industry, thus becomes clear : the planning system bears not only on the basic fabric of the tool industry, in terms of both process and product technology but also on the efficiency of the productive structure which ensues.

Though not wishing to spend too much time on a discussion of the government's target-setting policy its importance, nevertheless, should be noted as the process of license-issuance took place underneath its umbrella. Bhagwati and Desai point to two major failings regarding the target-setting policy. Firstly, the targets were not treated as approximate orders of magnitude but were rigorously interpreted as full-scale objectives, lapses from which were considered to be 'failures of planning'. Secondly, there is the criticism regarding the lack of any economic criteria in establishing the targets or, alternatively, of their having been revised in any systematic fashion to meet contingencies such as shortfalls in foreign exchange.[12] These complaints may have been justified during the first three Five Year Plans but the authorities recognizing the difficulties, subsequently made strenuous efforts to rectify the situation. The actions of the government, in this context, are reviewed later, after the role of industrial licensing has been assessed.

The instrument of control that has probably had the most impact on the development of the machine tool industry is the system of licensing, introduced under the Industries (Development and Regulation) Act 1951. The Act provided the armoury of controls required to implement the Industrial Policy Resolution of 1948 and the later Resolution of 1956. Broadly stated, the objectives of the resolutions were : the control of growth and the industrial composition of output capacity; the saving of foreign exchange; the control of monopoly and encouragement of smaller industrial units; and finally, the control over the location of industry. The Industrial Policy Resolution of 1956 laid down three classifications of industry according to their strategic value to the overall plan. In essence, these divisions bore close resemblance to the previous classification in the 1948 Resolution save that now, they were more sharply defined and less ambiguous regarding the role of the state. The 1956 categorization of industries was as follows:

(i) Schedule A : those which were to be the exclusive responsibility of the state;

(ii) Schedule B : those which were to be progressively state-owned, and in which the state would generally set up new enterprises but where private enterprises would be expected only to supplement the efforts of the state; and

(iii) Schedule C : all the remaining industries and their future development would, in general, be left to the initiative and enterprise of the private sector.[13]

In spite of the apparently definitive nature of these industrial groupings, history has shown that they were not water-tight compartments : depending on the exigencies of the time, industries could change status and qualify to produce a product in a different category.

Investment, in an 'ex ante' sense and above a certain limit[14], had to be licensed. In the main, this related to the expansion of capacity or the creation of new capacity. The government, through the 1956 Industrial Policy Resolution, established an industrial licensing Committee for machine tools; termed the 'Machine Tool Committee' its function was to act as arbiter on the whole question of capacity for the industry. Unless a license was granted by the committee, every machine tool producer in the organized sector was permitted to manufacture only those types and sizes of machines assigned to it. In addition to this, a 'Development Council for Machine Tools' was created by the authorities in 1958. Its duties included assessing the demand for machine tools and recommending the types to be manufactured in India.

Implementation of the recommendation of the 'Committee' and the 'Development Council', in effect, gave each firm a virtual monopoly on the types of machine tools assigned to it for manufacture. Quite the reverse, from the point of view of economic efficiency, of what the Indian government had supposedly intended from its intervention in the market. The strategy behind such moves was presumably to reduce the potential excess capacity that competing manufacturers would have induced under the conditions prevailing in the Indian economy during the period in question. However, a by-product of this policy was the creation of an artificial pricing system based on monopoly power; the fact that the entry of new firms into the markets for particular machine tools was not permitted must naturally have suppressed competition with the obvious deleterious repercussions on efficiency. Moreover, because the process of licensing became a highly centralized procedure it appeared to provide larger firms with the leverage to increase their monopoly power. The large enterprises possessed both the administrative resources and the economic muscle to undertake the necessary 'chivying' for their applications to proceed to a successful conclusion. It has also been suggested,[15] that large firms have regularly used subsidiaries to obtain licenses, which they have not taken up, in order to foreclose lines of manufacture to new entrants. Finally, in combination with the long delays involved in the process of approving or rejecting applications and so compounding the uncertainty over investment opportunities, there has been the absence, when the application has reached the stage of evaluation, of any explicit guidelines or consistent criteria of social profitability against which projects could be measured. Some of the principal delays were caused by the copious amounts of paper work necessitated by the application having to pass through various stages of clearance. Dependant on whether it involved foreign exchange for imports; a collaboration with a foreign company; and, the need to raise domestic capital, the application would then have to pass through each of the corresponding stages : the Import Licensing Committee; the Foreign Collaboration Committee; and, the Capital Issues Committee. Notwithstanding the pronouncement of the Import Licensing Committee, the D.G.T.D. would still have to clear the proposed project from the 'indigenous angle';

that is, certification was required that the imported materials were not available from domestic suppliers.

In 1967, the Indian government received the Hazari Report[16] which subjected some of the more glaring inefficiencies of the industrial planning strategy to close scrutiny and found that : "industrial licensing which was supposed to act as an instrument of industrial development... [had become] ... an impediment."[17] As a result of the publication of this Report, the government appointed a Committee to examine the working of the licensing system over the previous ten years; it was to be under the chairmanship of a Mr. S. Dutt. The Dutt Committee submitted its report in 1969.[18] The report was, in effect, a massive condemnation of the licensing system; it lead to the growth of monopoly and economic concentration in the hands of a few large business houses. The recommendations of the Committee attempted to reconcile the objectives of the planners with a mixed economy framework; a greater emphasis, indeed urgency, being given to the promotion of economic efficiency. A major plank in this new approach was the delineation of a 'core' sector consisting of industries defined to be not only of critical and strategic importance to the economy but also possessing the greatest linkages with the other sectors of industry. Further, the concept of the 'joint sector' was advanced; its purpose was to develop undertakings where both the public and private sector could act as partners in any given project. This recommendation of the Dutt Committee assailed the principle established in the formulation of the 1956 Industrial Policy Resolution regarding the reservation of industries of basic and strategic importance solely for the public sector.

In the February of 1970 the government, on the basis of the Dutt Committee's findings, responded by announcing a new initiative on industrial licensing policy. The government accepted that there should be a list of 'core' industries which were to be classified into eight separate groups; the sixth group was termed as 'heavy industrial machinery' which presumably included machine tools. In addition to the core sector, all new investment over Rs.5 crores was deemed to be in what was termed the 'heavy investment sector' : leaving aside industries which were specified to be the exclusive monopoly of the state (industries in the 'core' list as are included in Schedule A of the Industrial Policy Resolution of 1956) the large industrial units were now permitted to apply for projects in the 'core' and 'heavy investment' sectors. The principal aim of this directive was to check the proliferation of large 'industrial houses' in a disparate number of products and industries by instead concentrating them in a few areas of lumpy investment. Finally, the exemption limit from licensing provisions, including the introduction of new capacity as well as the extension of existing enterprises, was to be raised from Rs.25 lakhs to Rs.1 crore of fixed assets (land, buildings and machinery).

An amendment to the industrial licensing regime was announced in the February of 1973. The statement modified the 1970 Policy Resolution by widening its scope to include those industries which hold direct linkages with the core industries as also those industries which have consistently demonstrated high export potential. The machine tool industry was now explicitly defined in group seven of the revised list. Liberalization of licensing procedures was also promised to some of the larger private sector concerns on the premise that it would assist the units to utilize their capacities more fully (based on the assumption that it had been the restrictive licensing programme that had acted as the major constraining force on the utilization of capacity); and, from a paternalistic perspective, it would allow companies which had ignored the licensing regulations to legitimize their 'illegal' activities and thus, return to the fold.

A further policy amendment of 1975, increased the liberalization of industry; it de-licensed 21 industries (mainly consumption orientated) and permitted the unlimited expansion beyond licensed capacities to foreign companies and large industrial houses in 30 other industries (including heavy industrial and chemical equipment).

To summarize: the major and ongoing objective of industrial licensing has been to assist in the rapid development of the Indian economy through the concentration of resources in those sectors considered to be of the greatest strategic value. Although this was the primary aim, there was also the additional motive of controlling the growth of monopoly power. Substantial difficulties, however, have been experienced, in the implementation of industrial licensing through the need to link the above aims with the efficient operation of industry. In respect of the machine tool industry, it is fair to say that such a marriage has not been easy.

Section 2 : Present Economic State of the Industry

(i) Structural Characteristics of the Machine Tool Branch

Structurally, the machine tool industry is dominated by HMT which with two other major units in the public sector contributed more than 50 per cent of total output value in 1976. Currently, there are approximately 120 firms in the organized sector with the public sector and a further five private companies accounting for roughly 85 per cent of output value. A multitude of firms produce the remaining 15 per cent of output; mostly small enterprises concerned with the manufacture of basic, general purpose machinery.[19]

Although this study has confined itself to analysing the organized segment of the machine tool industry it should be noted, in passing, that the 'informal' (un-enumerated) sector consists of many hundreds of machine tool shops, each employing perhaps no more than 10 to 15 workers and serving primarily the local market. Many of these units will be family businesses, and two-thirds or more will be found in the Punjab.[20] The survival of these firms depends solely on the prices of their products (the quality of which is generally held to be quite low), sometimes undercutting comparable tools in the organized sector by as much as 50 per cent. A case in point refers to a company surveyed in Ludhiana, in the Punjab. It began life in the late fifties originally as a manufacturer of textile machinery. At an early stage the need arose for a broaching machine. HMT was then the only manufacturer of such machines and quoted a price of Rs.7.5 lakhs plus a delivery time of one year. Due to the lack of finance, the firm in Ludhiana decided to manufacture the tool itself (as a small-scale firm it was thus outside the government's licensing regulations); it was finished in a period of three to four months at an estimated cost of only Rs.4 lakhs.

In terms of international comparisons, the concentrated structure of India's machine tool industry is in sharp contrast to its counterparts in the West, or the 'East.' In the United States in 1958, there were 505 establishments having 10 or more employees engaged in the production of machine tools. But although these were large concerns, unlike India's HMT, none dominated the production of all or most of the major categories of machine tool; instead, each displayed a high degree of specialization in its particular field. This is witnessed by the fact that in the same year : three firms were pre-eminent in the field of gear-making machinery; three firms made most of the milling machines; and two firms produced most of the internal grinders.[21]

In the Soviet Union a somewhat similar specialization obtains, although at a much higher scale of operation. Of the 170 plants that comprised the Soviet machine tool industry in the early 1960s, sixty were specialized producers. Almost all of the gear machinery was made in three plants; most of the milling machines were made at Gor'kiy and Dimitrov; and, almost all radial drills were produced at a plant in Odessa.[22]

The above sketch of the structure of India's machine tool branch acts as a prelude to an examination of the industry's organisation of production. Prior to this, however, a brief mention should be made concerning the structure of output. It is pertinent to note that apart from the purely quantitative increase in the industry's output since the late fifties, there has also been considerable diversification in the composition of the same. Besides the manufacture of a broad variety of general purpose machine tools, the machine tool industry also produces such specialized machinery as : single-and multi-spindle automatics, drum turrets, copying lathes, horizontal boring machines, vertical boring mills, bed-type milling machines, gear hobbers, gear shapers, unit heads, special purpose machines, transfer lines, hydraulic and mechanical heavy duty presses, and so forth.[23] Clearly, there has been considerable improvement over the twenty year period in the sophistication of machine tool output. Although, from visiting most of the major machine tool enterprises in India, it is unmistakeable to the author that the technological transformation[24] of the product-mix occurred only in the few large firms of the public and private sectors. Nevertheless, due to the concentrated structure of the industry, it is a segment which accounts for the greater proportion of total output value.

(ii) Organization of Production

The goal of growth within the overall development of the machine tool industry cannot satisfactorily be analysed by studying only the changes in the quantity and quality of the output. Equally important to an evaluation of the progress the branch has made towards industrial 'maturity' is an assessment of the organization of its production.

The 'Western' model, characterizing the development of machine tool capacity in the capitalist countries over a century ago, revealed a number of distinct trends. Rosenberg[25] writing on the evolution of the American machine tool industry emphasized the linkage between the growth of all manufacturing industries and the derived demand for machine tools. The emergence and development of the machinery producing sector caused what the same author has termed 'technological convergence' where production processes of apparently unrelated industries with differing products, became common. The 'fons et origo' of the machine tool sector was, therefore, due to a market of minimum economic size being established for its products. Just as the division of labour into machine tool manufacture had initially come about through the increasing demand from the growth of the machinery building industries, so it was that the technological development of the tool industry was itself fuelled by the demand nexus forged with its customers. As the machine building industries advanced so they ... "became needful of ever more sophisticated and specialized capital equipment, they coached and compelled machine tool builders to advance along with them."[26] Gradually then, over time, the process of industrialization began increasingly to connote 'intensive' as opposed to 'extensive' development. In this way, other forms of technological specialization became feasible in activities such as : casting, forging, welding, heat treatment, electro-plating, and assembling. As a result of ...[this] ... intensive division of operations, serialization of parts and components followed.[27]

The precocious development of the Soviet machine tool industry, in the thirties, offers an alternative model; and for the countries in which it is viable, precludes the requirement that the final stage of serialization and standardization be reached through evolution. Despite the relative backwardness of their economy in the pre-planning era, the Soviets in a very short period of time managed, through a capital-goods led growth strategy and imports of selected technology, to 'evolve' a machine tool branch normally only developed during the latter stages of industrialization.

Conventionally, one of the reasons for believing that India holds a potential comparative advantage in the manufacture of machine tools is that economies of scale are of limited significance. After all, the putative model of machine tool production, even in the advanced countries, is characterized by the relatively small batches and volumes of output. Accordingly, if consulted, most economic theorists would not express surprise that India's authorities at the onset of planning gave scant consideration to the question of scale in machine tool production. Moreover, for India, the conventional approach was additionally attractive because it fitted in with the conditions of economic life at that time : a low level of capital accumulation due to the small size of the market for producer goods; and the depressed purchasing power of the machine building and metal-using industries which comprised that market.

It might be argued that such a

viewpoint was both myopic and paradoxical. Myopic, because in a country like India with a high elasticity of demand for industrial products, one factor should have overriding importance as the country strived to lay a mechanized base to its economy and that is not diversification; not customer specification of final output; possibly not even high levels of quality, but rather cost and price reductions of basic capital-goods. Price, in this sense will not only be a prime determinant of the 'extent of the market' but would also have instrumental value in the overall conservation of capital. If this principle had been followed, then the heretical Soviet model based on economies of scale might have provided the appropriate industrial organization on which India could have moulded its machine tool manufacturing practices. Furthermore, the Indian strategy may also have been paradoxical because a capital-goods led growth theory hinges squarely on the supply of producer goods being the crucial bottleneck to economic growth. Unlike the Soviet Union though, where all enterprize resided within the public sector, India at the start of industrialization possessed a predominantly private sector economy and was, therefore, unable 'directly' to create demand pressures through governmental decree. Consequently, although the pursuance of a two-sector growth model can provide an answer to the question regarding the supply of scarce capital-goods, it is insufficient by itself to solve the equally pressing problem concerning the wherewithal of the purchasers of these capital-goods in a low income economy.

The ramifications that lead from the aforesaid have serious import on the efficacy of the Indian tool industry's organizational structure. Of pragmatic significance is the interlocking relationship of the various elements in production organization; and, at the interface between input and output is found perhaps the most important : the installed technology, the nature of which characterizes the structure of production in the industry. The Soviet machine tool industry of the thirties acquired the majority of its fixed machinery from Western countries. This was done in order to facilitate flow-line production through the use of automatic, special purpose machine tools. In the context of this study, three factors are interpreted as being expressive of the technological level of installed equipment in the machine tool plants of India : the origin of the machines; their age; and, to some extent, their type.

Table 11 below illustrates, according to the size of firm, the survey results concerning the source of the installed machinery, i.e. indigenous or imported. It is interesting to note that some 95 per cent of all firms in the sample obtained up to 80 per cent of their fixed equipment from domestic sources. This is consistent with the evidence on the machine tool using industries in general, as shown by the machine tool census of 1968:[28] Specifically, of the 382,000 machine tools installed, 64 per cent were of indigenous origin.[29]

Table 11 : Domestic Origin of Installed Machinery

Indian Origin (%)	Companies: Small (nos)	(%)*	Medium (nos)	(%)*	Large (nos)	(%)*	Row Totals (nos)	(%)+
0	-	-	-	-	-	-	-	-
10	-	-	-	-	2	18.2	2	5.4
20	-	-	-	-	-	-	-	-
30	2	8.7	-	-	3	27.3	5	16.2
40	2	8.7	1	33.3	2	18.2	5	13.5
50	1	4.3	1	33.3	1	9.1	3	5.4
60	-	-	-	-	1	9.1	1	2.7
70	1	4.3	-	-	-	-	1	2.7
80	2	8.7	-	-	2	18.2	4	10.8
90	5	21.7	-	-	-	-	5	13.5
100	10	43.5	1	33.3	-	-	11	29.7
Valid Cases:	23	100.0	3	100.0	11	100.0	37	100.0
Missing Cases:	1		1		1		3	
Sample	24		4		12		40	

Source: The Indian Machine Tool Industry Survey (1978)

Note : * based on the total of valid cases in the firm size column
+ based on the total of valid cases of all the firm sizes.

(Firm size based on capital-investment : small scale below Rs.7.5 lakhs; medium scale between Rs.7.5 and Rs.25 lakhs; large scale above Rs.25 lakhs).

A feature of the Table is that the majority of large undertakings possessed proportionately more foreign technology than that of small firms. Again, the 1968 census data for all machine tool using industries provides corroboration of the survey's results; it concurs that in large scale concerns a greater portion of the machine tool stock (53 per cent) was of foreign origin; in the small scale sector the proportion was much lower (14 per cent).

But it is difficult to draw firm conclusions on the significance of these findings because, although firm size and scale are unquestionably in positive correlation to each other, there exist additional factors, equally important, which influence a company's choice of technique. The preference shown by foreign collaborators for large Indian concerns is one obvious example; the differing financial abilities as between the small machine tool companies and their large counterparts is another.

It will prove helpful to explore one aspect of this last factor a little more closely : credit. Tables 12 a, b, and c, denote the major destinations of credit obtained for the year 1978. Irrespective of firm size, credit for the purposes of fixed capital investment was clearly of negligible importance. However, the position of working capital is somewhat different. Here, all firms utilized their credit to a much greater degree. In the case of small firms, some 55 per cent of the total, employed 100 per cent of their credit solely to satisfy the needs of variable capital. Low profitability was the probable cause for the poor flow of internal funds. Finally, credit for the purposes of research and development was of only marginal consideration to all companies.

One side-issue regarding credit has to do with the impact of foreign collaboration during the early period of the industry's development. Due to the paucity of local

Table 12 : Major Destinations of Credit Obtained for 1978

(a) For the Purposes of Fixed Capital

Credit (%)	Small (nos)	Small (%)	Medium (nos)	Medium (%)	Large (nos)	Large (%)	Row Totals (nos)	Row Totals (%)
0	13	65	3	75	6	60	22	65
1-24	3	15	-	-	2	20	5	14.7
25-49	2	10	1	25	2	20	5	14.7
50-74	1	5	-	-	-	-	-	-
75-99	-	-	-	-	-	-	-	-
100	1	5	-	-	-	-	1	3
Valid Cases:	20	100	4	100	10	100	34	100
Missing Cases:	4		-		2		6	
Sample	24		4		12		40	

(b) For the Purposes of Variable Capital

Credit (%)	Small (nos)	Small (%)	Medium (nos)	Medium (%)	Large (nos)	Large (%)	Row Totals (nos)	Row Totals (%)
0	2	10	-	-	1	10	3	8.8
1-24	-	-	-	-	-	-	-	-
25-49	1	5	-	-	-	-	1	3.0
50-74	3	15	1	25	2	20	6	18.0
75-99	3	15	-	-	4	40	7	21.0
100	11	55	3	75	3	30	17	50.0
Valid Cases:	20	100	4	100	10	100	34	100
Missing Cases:	4		-		2		6	
Sample	24		4		12		40	

(c) For the Purposes of Research and Development

Credit (%)	Small (nos)	Small (%)	Medium (nos)	Medium (%)	Large (nos)	Large (%)	Row Totals (nos)	Row Totals (%)
0	17	85	4	100	7	70	28	82
1-24	3	15	-	-	3	30	6	18
25-49	-	-	-	-	-	-	-	-
50-74	-	-	-	-	-	-	-	-
75-99	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-
Valid Cases:	20	100	4	100	10	100	34	100
Missing Cases:	4		-		2		6	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey sources of credit, machine tool units had to accept any line that presented itself; this was magnified when rupee credit was involved. What this meant, of course, was that to thwart the probability that the potential collaborator might not make the credit available at a later, more suitable time, machine tool firms were prepared to saddle themselves with excess capacity by investing in machinery that was not currently required. The result of this practice is that in India it is possible to visit different machine tool factories or even separate plants in the same enterprize and observe a whole array of installed machinery from one particular country. An example of this phenomenon relates to the numerous enterprizes possessing equipment of predominantly Soviet or East European origin which were imported during the rupee credit era of the late fifties and early sixties. The implications from such dealings are serious : the choice of installed machinery reflecting the ease of obtaining the credit rather than its technological efficiency.

At the present time, the credit source tends generally to be the banking system although state finance corporations are a strong secondary source of funds. The cost of credit is reasonably high with interest rates averaging around 15-16 per cent. Small companies though, do enjoy the privilege of a concessionary rate some two to three per cent below this range.

An important characteristic of the technical level of the installed machinery is its age. Reference to the 1968 machine tool census shows that only 36 per cent of all machine tools installed were over 10 years old - the age at which machine tools are generally considered obsolete, and 16 per cent were over 20 years.[30] The census further indicated that in practically all types of general purpose machinery, Indian-made machine tools predominated. For the particular case of the machine tool branch, the evidence on these points as obtained from the survey is documented in Table 13. Unfortunately, it has not been possible to seggregate the more advanced technology from that of the universal, labour-intensive type of equipment.

Table 13 : Percentage of Installed Equipment, According to Age, in the Indian Machine Tool Industry

Metal Cutting Equipment	Percentage of Machines by Age (Yrs.) 1-5	6-10	11-15	16-20	21+
(1)Lathes	21.7	23.2	45.0	6.2	3.9
(2)Milling Machines	22.9	13.3	58.0	3.7	2.1
(3)Grinding, Polishing and Finishing Machines	13.9	10.6	63.2	8.3	4.0
(4)Planing, Slotting and Broaching Machines	21.6	17.2	48.3	7.3	5.6
(5)Drilling and Boring Machines	17.9	13.7	59.4	5.7	3.3
(6)Gear and Thread Cutting Machines	13.5	13.5	60.8	5.4	6.8
(7)Cutting-off Machines	14.0	26.7	48.8	4.7	5.8
Percentage of all tools	19.1	17.2	53.5	6.2	4.0

Valid Cases : 34
Missing Cases : 6
Sample : 40

Source: The Indian Machine Tool Industry Survey (1978)

However, from observations made during the survey, automatic machinery appears to figure prominently in the capital stock of the larger organisations although for the industry as a whole, the numerical superiority of general-purpose machines remains unassailable. The really interesting fact to emerge from the table is the deterioration in capital replacement since the census of 1968, as it relates to the machine tool industry :

63.7 per cent of all metal-cutting equipment in 1978 now having an age greater than 10 years. But, it would be incorrect to describe the age structure of the installed capital as critical, because 53.5 per cent of the machine tools lie in the 11-15 years age band. Nevertheless, the danger signals are there : unless the pace of capital replacement is speeded up, the Indian machine tool industry will find itself with an antiquated capital stock composed of what are already 'second-best' techniques of production. The difficulty with this argument, however, is that as excess capacity is a significant factor in the industry, there is consequently little incentive for entrepreneurs to engage in capital replacement.

Thus, it is speculated that the underlying reason for this low level of capital replacement is that the machine tool industry suffers from a demand constraint. The large public sector firms survive because of government patronage and, in the case of HMT, through the rapid diversification out of machine tool production. Moreover, this trend is not confined solely to the public sector but permeates throughout the entire industry. In the private sector, one medium size firm in Maharastra engaged its workforce almost permanently on the manufacture of components for a local scooter factory. Although this practice was initially to compensate for the slack in machine tool production, it was progressively becoming a more important element in the company's production make-up. Such secondary operations were observed at a number of machine tool concerns of varying size : a small firm in Bangalore, for instance, was found to be engaged in pressing out watch cases for HMT's horological business; and while the entrepreneur had ambitious plans for the expansion of this side of his company's operations, he could only express pessimism for machine tool production. In fact, the foremost problem worrying the industry today is the gradual decline in the rate of inflow of new orders and enquiries even though the recent recessionary tendencies appear to have receded.[31] But, it has become axiomatic to state that the machine tool industry is the first to suffer and the last to recover in the event of economic recession. For this reason, private capital has always been shy in so far as the machine tool industry is concerned. It is noteworthy that during the last 15 years not a single machine tool factory worth its name has been established in the private sector.[32] The Indian government has recognised the problem by recently making moves to widen the scope of the existing investment allowance to include various engineering industries which constitute a very important segment of the machine tool industry's customers.[33] Whatever improvement this will have on machine tool demand may be negated, however, by another government proposal to allow the freer import of foreign machine tools into the country. The objective of the measure is to increase competition in the domestic production of machine tools and force firms to produce more efficiently. Additionally, so it is argued, it will beneficially expose India's indigenous manufacturers to the latest developments in machine tool design; this would allow them to keep abreast of the rapid progress being made in machine tool technology abroad. The danger is, though, that it could depress demand still further.

The view that there is widespread sub-utilization of capacity in India's machine tool units is examined in detail in Chapter 5; however, it is not an argument which should arouse undue controversy. A report published in the early 1970s, stated that : "under conditions of normal demand, Indian machine tool manufacturers would be producing at rates of 10 to 40 units (counting all variants) of each model per month for the standard machine tools like lathes, milling machines etc. In the developed countries, collaborators and competitors commonly produce the same machines at rates of ten times this or more."[34] Returns from this study's survey appear to suggest, however, that even these figures are on the high side. Of course, the scale of production depends on the types of machine tool being manufactured; their technical configuration; the demand profile; and many other considerations. But, excluding HMT, the average batch size of firms in the survey ranged from 5 to 20 machines per month. For many of the smaller companies even batch methods of production are inappropriate; the manufacture of machine tools being carried out on a one-off basis. Production in these firms proceeds on a financial knife-edge : with no stocking taking place, manufacture is precariously dependent on the receipt of the next order arriving on time. Life is also tough at the top : HMT's extremely diversified production range, coupled with the division of production among six different locations (due mainly to the government's policy of regional balance), results in the duplication of functional facilities. Thus, despite the large size of the company, only limited economies of scale are possible.

Due to the lower volume of production in India, and hence smaller batch sizes,the set-up times are spread over fewer units; this will have a negative effect on the costs of production. In this context, a U.N. study on machine tool manufacture in developing countries once stated : "economies associated with the length of production run arise partly from the time and expense involved in switching the operations of a shop from one product to another. The changeover requires laborious tooling : a changing of auxiliary production equipment such as moulds and dies for casting and forging, jigs and fixtures designed to hold particular workpieces in place during machining etc. There is also the fact that the efficiency of a production department gradually improves as the same tasks are repeated and that every change causes a temporary decrease in efficiency. From limited evidence, it would appear that the elasticity of labour and capital costs with regard to the length of production run - the percentage change in these costs as the production run is changed by 1 per cent - is about 0.75."[35]

Without obtaining economies of scale in production then, the machine tool industry of India has been at a serious disadvantage concerning the ability to induce increases in demand through cost and price reductions. In these circumstances, the tenet that the capacity for productive capital formation is determined by the volume of demand implied in Adam Smith's adage : the 'division of labour is limited by the extent of the market', is a truism which still holds today. On this aspect, it will be both instructive and relevant to refer again to the article by Professor Amsden who wrote on the development of the Taiwanese machine tool industry. She argued that : "the achievement in poor countries of ... cost and price reductions may paradoxically necessitate a return to an earlier Western technology, embodying a less refined division of labour, and the production of a final product familiar in appearance and performance to Western consumers of a half a century ago."[36] The Indian and Taiwanese machine building and metal-using industries were both,at the start of industrialization, composed of low-income consuming units. However, in terms of absolute numbers, the Indian market more closely resembled the early period of Soviet industrialization while the Taiwanese market might legitimately be compared with that of the Japanese during the 1920s. In a potentially large market such as India possesses, a more elaborate division of labour should not be incompatible with cost and price reductions provided that economies of scale more than offset the rise in capital costs that would be involved, i.e. at high levels of output, modern technology would have lower unit costs of production. As in the Soviet case, such cheapening in the manufacture of basic, all purpose machine tools could well have been sufficient to attract the necessary level of demand required to make this strategy effective.

Standardization of components assist in reducing the costs of production. The need at this point then, is to assess the evidence on the progress the tool industry has made towards standardization. It is usual in the literature to view scale and the standardization and interchangeability of parts as concepts that are inseparably linked. But, in truth, this need not be the case; standardization etc., per se, being a corollary of improved production organization. Two types of standardization can be distinguished : firstly, the interchangeability and uniformity of tolerances, threads, and gauges of such basic components as nuts, bolts and bearings;[37] and secondly, the interchange of the more major parts and components used in the fabrication of similar types of machinery. In respect of the former, the Indian regulatory authorities have been able, since the introduction of the Five Year Plans, to impose a high degree of consistency in national standards.[38] However, except for HMT, which has been greatly involved in work connected with the interchangeability of components in its product range, there has been little systematic advance towards the second type of standardization amongst the large concerns in the industry. This is probably a reflection of the manifold collaboration agreements that have taken place with foreign firms of both East and Western origin. The fact that the associated licensed machinery emanates from differing engineering cultures; exhibits varying standards of accuracy and performance, hardly makes for the standardization of parts and components in India's machine tool plants.

Also valuable in helping to promote efficiency in the productive operations of enterprizes is the need to rationalize stocks of inventory, and input-variety in general. A number of the cost problems which tend to be associated with batch production techniques can be traced to the high variety of components manufactured. Therefore, one question put to India's tool-makers was whether any attempts had been made to reduce manufacturing costs through input rationalization? The replies received are detailed in Table 14. From the table it is evident that the importance of input rationalization is recognized by all firms, thereby transcending size classifications.

Table 14 : Experience of Input Rationalization in Machine Tool Production

	Companies							
Response	Small		Medium		Large		Row Totals	
	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Yes	11	45.8	1	25	9	75	21	52.5
No	7	29.2	1	25	3	25	11	27.5
Planned	6	25.0	2	50	-	-	8	20.0
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

It can be observed that 75 per cent of large firms have at some time formulated policies to reduce the variety and near-duplication of production materials; an equally high percentage applies to small enterprizes. One example of the progress that can be made through rationalization is shown in Table 15. The table depicts the results of a variety reduction study conducted by HMT in 1966. In passing, it should be noted that the same study also included under its terms of reference, the rationalization of tools and equipment resulting in the deletion of some 55 items from the inventory. As a general statement though, there is, in India's machine tool industry, a proliferation in input materials and also a lack of standardization of components which lowers the efficiency of the production organization and adversely affects the cost structure of the industry's products.

Table 15 : Results of HMT's Rationalization Study (1966)

Material	Before Rational-ization	After Rational-ization	no.of deleted varieties	% of deleted varieties
Cast Iron	43	17	26	60
Mild Steel	139	47	92	61
Construction Steel	288	198	90	31
Tool Steel	50	19	31	62
High Speed Steel	58	22	36	62
Aluminium Alloys	55	37	18	32
Copper	21	9	12	57
Bronze	43	10	33	76
Brass	38	10	28	74
Totals	735	369	366	50

Source : HMT News Digest, Vol.1, No.9 (Jan. 1967)

One of the less satisfactory characteristics concerning the development of the Soviet machine tool industry was the extremely high level of verticalization in the production processes of their factories. The Soviets did not believe that internalizing many of the ancillary functions of machine tool manufacture was a virtuous objective but, in the beginning without the existence of support industries, very little else was considered feasible. Of course, not only is this the easier path to follow thereby avoiding the difficulties implicit in the simultaneous creation of both principal and sub-contracting plants but it is also fairly typical of the majority of newly industrializing nations in the establishment of manufacturing industries. The rationale behind this pattern of development concerns the weakness of the supply and distribution system, including those feeder industries that do exist; this causes severe bottlenecks to occur in the principal industry's manufacturing operations. In addition, there is also the very important issue regarding the quality of the ancillary industries output. If this is sub-standard then another reason emerges for the integration of production processes : the ability to control the quality of input in production. The evidence of vertical integration in the Indian machine tool industry is somewhat assorted. Irrespective of size, many companies are engaged in activities, such as welding and metal-hardening treatment, that would normally be sub-contracted out to ancillary industries in a 'mature' machine tool industry. The inter-play of market forces (as described in detail in the methodology chapter of this study) leading to the vertical disintegration of production is the culmination of an evolutionary process. The motivating force behind this gradual re-structuring of industrial organization derives from the increasing specialization of particular activities within the total production spectrum. The expansion in the division of labour, of which the ancillary industries are one aspect, is a factor of profound significance : connoting amelioration in industrial efficiency. Thus, while verticalization is meritorious by ensuring the continuity in the output of an enterprize, it will, at the same time, have deleterious repercussions on the progress of the sector as a whole. In stating this fact, it is difficult to justify the logic which prompted many of the Indian machine tool manufacturers to comment with pride on the integrated nature of their particular organizations. The buying-out of items is almost seen as an undesirable objective. The speculative reason for this perverse industrial philosophy could lie in the developing countries perception of economic strength as being synonomous with self-sufficiency. Ultimately, however this must be harmful to economic development. As Harry G. Johnson once argued :

... "if the sub-structure of efficient supplying firms is lacking, and the enterprize is instead obliged to go into the business of producing parts itself ... the costs of production can rise to incredible heights."[39]

An elucidation of the survey data on the possession of casting facilities will provide some representation of the measure of vertical integration in the machine tool industry. Castings are an important constituent of a machine tool, accounting for the major share of its total weight. Thus, the quality and durability of the casting components will have considerable bearing on the depreciation and life of the asset. Table 16 lists the evidence with regard to the possession of casting facilities by the machine tool plants covered in the survey.[40]

Table 16 : Possession of Casting Facilities by Machine Tool Firms

	Companies							
	Small		Medium		Large		Row Totals	
Response	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Yes	7	29.1	2	50	8	66.6	17	42.5
No	17	70.9	2	50	4	33.3	23	57.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

For small firms, 70 per cent of those interviewed intimated that castings were bought out. A possible reason for this might be the recognition on the part of the entrepreneur of the potentially low utilization of a foundry, due to insufficient demand, should it be installed. Medium sized firms, on the other hand, exhibited no tendencies either way : 50 per cent of the companies indicating they possess casting facilities; 50 per cent indicating they do not. What is really surprising is the data on large firms with twice as many enterprises having the facility to cast metal as those that buy out. But quality standards are obviously much more demanding for the larger organizations with foreign reputations to create or maintain, and in this sense, the possession of a foundry enables the quality of castings to be controlled, thus minimizing the incidence of blow holes and other defects.

In conjunction with the above, an attempt was also made to assess the average quality of the ancillary industries output; the details of which are contained in Table 17. Although the results of the table are inconclusive, it is encouraging to note that only 3.6 per cent of respondents defined their ancillary supplies as being of low quality. Naturally, the format of the question imposes a degree of subjective relativity as to the entrepreneurs interpretation of 'quality'. But the intention was not to straightjacket the entrepreneur by designating strict and exhaustive scales for his response, rather some general index of satisfaction was sought; and it is in this light that the findings should be gauged.

Table 17 : Assessment of the Quality of Ancillary Supplies to the Machine Tool Industry

	Companies							
	Small		Medium		Large		Row Totals	
Response	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Low Quality	-	-	-	-	1	10	1	3.6
Good Quality	12	80	3	100	9	90	24	85.7
Excellent Quality	3	20	-	-	-	-	3	10.8
Valid Cases	15	100	3	100	10	100	28	100
Missing Cases	9		1		2		12	
Sample	24		4		12		40	

Source: The Indian Machine Tool Industry Survey (1978)

To conclude the section, a mention should be made regarding the role of auxiliary elements in the industry's production system. In an important respect the functioning of the auxiliary services in India's machine tool plants is duplicative of the Soviet experience during the early part of its industrialization. The requirement in the Soviet industry was to economize on the use of capital; a dimension back-stopping not only the technological development of the direct production processes but that of the internalized auxiliary operations also. Integral to the 'model' was a dualistic structure of industrial organization : capital-intensive production processes co-existing with labour-intensive techniques in the auxiliary activities. The primary aim of this policy was to keep the K/O ratio as low as possible. As far as the production processes were concerned the problem was approached via the investment into specialized machinery and the achievement of high levels of output. For the indirect processes however, this strategy was not feasible; instead, the alternative approach was pursued of keeping the K/O ratio as low as possible through the substitution of labour for capital.[41] In consonance with the Soviet policy regarding the organization of its auxiliary processes, most Indian machine tool units perceived these operations as a predominantly labour-intensive form of activity. The evidence contained in Table 18 consolidates this point. In some cases, involving the smaller Indian companies, a number of the auxiliary processes have been hived out to other organizations : one firm in Ludhiana, for instance, had the inspection of its products performed by an organ of the small scale industries service; it is not uncommon either, for the smaller units to have machinery repair and even maintenance carried out by other small, independent firms (though the owners of these concerns are usually members of the same family).

Table 18 : The Labour-Intensive Nature of Auxiliary Operations

	Companies							
	Small		Medium		Large		Row Totals	
Response	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Yes	19	82.6	2	50	8	66.7	29	74
No	4	17.4	2	50	4	33.3	10	26
Valid Cases	23	100.0	4	100.0	12	100.0	39	100.0
Missing Cases	1		-		-		1	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

The resemblance between the early production organization of the Soviet machine tool industry and that of India's ends here, however, as the internal technological dualism that characterized the former case is totally absent in the latter, where direct as well as indirect production processes are distinguished by the role incumbent on labour as the major factor of production. Table 19 illustrates the evidence to support this assertion. Clearly, the disturbing feature of the data is the lack of commitment to the adoption of modern techniques of production by all sizes of firm.

Table 19 : Company Strategy on the Acquisition of Best-Practice Production Technology

	Companies							
	Small		Medium		Large		Row Totals	
Response	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
In all Cases	5	20.8	-	-	3	30	8	21.0
Usually	12	50.0	4	100.0	7	70	23	60.5
Never	7	29.2	-	-	-	-	7	18.5
Valid Cases	24	100.0	4	100.0	10	100.0	38	100.0
Missing Cases	-		-		2		2	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

In summary, the aim of this section has been to add some empirical meat to the skeletal theoretical framework propounded in Chapter two. In particular, the analysis has attempted to lay bare the more striking divergences in the comparative patterns of development between India's machine tool industry and the earlier industrial organization of the Soviet model. The validity of such a comparison is based on the belief that India is one of the few developing countries which, at the start of industrialization, possessed similar economic conditions to that of the Soviet Union at the beginning of its development push. For this reason, it is hypothesised that the genre of Soviet machine tool manufacture may have been the appropriate one for India to have followed.

A two-sector growth strategy implies that capital goods are in short supply. Notwithstanding this fact, a central theme of the preceding discussion has been the emphasis given to the contraposing-force of demand, or rather, to the effects of its deficiency on the machine tool industry's organizational structure in production. Support for this type of approach can be found from Jack Baranson who once wrote in similar fashion on the problems of manufacturing in India, thus : "Contrary to widely held beliefs among development economists about capital deficiencies, the evidence seems to indicate that the basic difficulties lie in limitations imposed by the scale of local markets and overall deficiencies in supplier capabilities."[42] These two elements : low demand and ancillary services have received particular attention in the text but it is in relation to the whole that they are important. Other issues of equal significance relate to such facets of organization as specialization and the standardization and interchangeability of components. Also, production organization is inseparably linked with the composition of equipment and with types of technology employed.[43] The economic status of these associated factors have therefore been appraised in an attempt to gain a greater understanding of machine tool manufacture in India.

The cornerstone to the debate has been the conviction that cost and price minimization should have been conceived, from the start, as the guiding principle in the development of the industry. But, instead of treading the Soviet path, India allowed its machine tool sector to develop in a more or less 'ad hoc' Western manner. Consequently, this pattern, in combination with the industrial control aspects of government policy discussed in Section one, led to a situation being created where the machine tool industry never acquired the 'capital-saving' mentality that was characteristic of the Soviet approach. In fact, it is only recently that the subject of cost has received the attention with which it merits. Observe, as an example, the following (under) statement made at an engineering conference in 1977 : "One of the complaints which has been made against indigenous machine tool industry and engineering industry, is the high cost of its products ... With the complete protection in the last two decades, there has possibly been a certain neglect on the cost and price aspect."[44] Symptomatic of this neglect is the 'cost-plus' mechanism by which the final price is arrived at : the addition of a standard margin on costs. In this way, very little incentive exists for the manufacturer to improve performance. Indeed, when prices are set on a cost-plus basis, cost reduction and efficiency are not the primary goals of production.[45]

The degree of vertical integration of an industry is an important aspect in the determination of efficiency : a high level of vertical integration raises production costs. The critical nature of the concept has been acknowledged by the inclusion in the section of a discussion on its scope and prevalence in the industry. The analysis concluded with a brief sketch on the role of auxiliary processes in machine tool manufacture. Here again, a comparison was made with the Soviet experience in which labour was utilized as the 'cheapest non-linear servo-mechanism'[46] for the installed production technology.

Thus, cost reductions were achieved in the Soviet machine tool industry through high levels of : scale, specialization, and standardization. Of no less importance though, was the technological dualism that was displayed in the plants. Here capital-intensive production processes were assisted by labour-intensive auxiliary services in the manufacture of labour-intensive products. By contrast, the impression gained from the discussion hereto is that the Indian machine tool industry possesses predominantly labour-intensive techniques in both the direct and indirect areas of production; and the final product of the larger concerns which accounts for the major share of the market is capital-intensive relative to the needs of the machine building industries in India. It is also held to be costly, and whatever else can be said : a high-cost producer-goods industry is unlikely to be conducive to economic development.

Section 3 : The Role of Foreign Collaboration in the Machine Tool Industry

(i) Foreign Collaboration : The Vehicle for Technological Progress

The question could be asked : why did India of the early fifties having recognised the possibilities of the Soviet Planning System, as reflected by its adoption of a capital-goods growth model in 1956, gravitate towards a traditional 'Western' conceptualization of machine tool manufacture? In particular, what was it that galvanised the Indian authorities to pursue the rapid and massive diversification of its machine tool industry's output which, through the necessity of employing batch methods of production, dissipated the opportunities to be gained from economies in both specialization and scale? Or was it that the situation just developed by default, i.e. no politico-economic consensus having existed on the subject? A tentative reply to these questions might be formulated by assessing the comparative roles played by foreign collaboration during the early period of industrialization in the Soviet Union and India.

For the first decade or so after 1930, the Soviets concentrated on the mass production of simple, standardized machine tools and although there was some collaboration with foreign companies, it was generally of minimal significance.[47] Admittedly, most of the designs of these basic tools were copies of foreign models, however, almost invariably such 'technological transfers' involved selectivity in the model chosen for manufacture : conforming to the overall capital-saving approach pursued by the Soviets. Moreover, in the initial stages of industrialization the Soviet machine tool industry limited itself to the production of a small nucleus of models; a policy implicitly based on a 'walk before you can run' philosophy. Machine tool imports were only allowed if advanced machinery was required to supplement indigenous production; this sophisticated equipment was, as a matter of policy, not manufactured in domestic plants. As such, imports of pre-selected machine tools were integrally incorporated into the development strategy of the industry. An obvious example of this type of import was the requirement of automatic machinery for the Soviets' system of flow-line production.

By contrast, the development of the Indian machine tool industry has been characterized by the heavy emphasis given to technical collaboration with foreign companies. From the very beginnings of the Second Plan period with the establishment of HMT, foreign collaboration has been interpreted as the vehicle for technological development in machine tool design. HMT, which was begun in 1956 with Swiss collaboration, epitomizes this view. Between 1966 and 1970 a further ten agreements were signed. Of these agreements, four alone were concluded during February/March 1966 with the following firms, viz :

(i) Messrs. Gildemeister and Co. A.G. West Germany, for the manufacture of multi-spindle bar and chucking automatics;

(ii) Messrs. Manurhin of France for the manufacture of single spindle automatics;

(iii) Messrs. Ernault Somna of France to manufacture 'S' and 'U' pilot lathes; and

(iv) Messrs. Jones and Lawson, U.S.A. to manufacture shell turning 'FAY' automatics.[48]

The process of collaboration has continued to the present time with HMT currently involved in six collaborations with foreign machine tool concerns; the most recent being in 1975/76 with The Cross Co., U.S.A. for the manufacture of very sophisticated transfer line machinery. However, foreign collaboration has not been confined solely to the public sector : Bharat Fritz Werner Ltd., Ex-Cell-O India Ltd., Mysore Kirloskar Ltd., Traub India Ltd., and Cooper Ltd., are just a few of the more prominent private companies involved in this form of international arrangement. In retrospect, India could be accused of being naively indiscriminate in the technology that it permitted its machine tool units to manufacture under license. Could there really be sound economic justification in terms of long-run demand potential, for HMT to have acquired the manufacturing capability of over 70 different types of machine tools? Moreover, a progressively rising proportion of the product range is highly capital-intensive in nature, which is yet another divergence from the early Soviet pattern of production. Thus the Indian machine tool industry, possibly due to the influences of national prestige, allowed an 'international demonstration effect' of considerable proportion to pervade its product range.

In essence, the polemical debate to which the role of foreign technology in the development of the Soviet and Indian machine tool industries gives rise, centres on its industrial destination: whether the technology be process or product orientated. If the problem is addressed in this manner then the comparative approaches might be viewed from the different but perhaps more revealing perspective regarding the Soviet preference for the more arduous task of 'skipping stages' in technological organization as against the Indian predilection for the relatively easier task of 'skipping stages' in the product-mix produced.

(ii) Features of the Collaboration Process

This section provides a brief discussion of the nature and problems of foreign collaboration in India's machine tool industry. The analysis is qualitative in character, with information being drawn from three basic sources : (1) a 1971 study by J. Mitra[49] who examined the industrial circumstances of 18 machine tool units in India having foreign collaboration agreements; (2) the present study's survey of Indian machine tool manufacturers; and (3) a supplementary survey carried out by the author of a small number of British machine tool concerns which have, or have had in the past, collaboration agreements with Indian companies. The discussion will proceed from three particular standpoints : Firstly, the rationale behind the Indian units choice of partner. Secondly, the working relationship once the agreement has been signed; and finally, the technical state of the tools made under license.

The general impression to be gained from all data sources is that machine tool manufacturers in India have very little room for manoeuvre in their choice of foreign collaborator. In fact, from conversations held with Indian manufacturers in the survey to this study, it became clear that a greater onus was on the Indian enterprise to persuade foreign companies to invest in the Indian market rather than the other way around. Mitra in her study, reported that at least 6 of the 18 machine tool manufacturers she had interviewed, had considered no alternatives at all. Their choice of collaborator having been made on several grounds : the prior friendship of the parties concerned; the Indian partner had previously been engaged as the selling agent of the foreign company; the brand name of the model to be produced under license; and finally, solely on the fact that the foreign company was willing to invest.

From the scattered information available on the subject, it is apparent that very little scientific basis existed for the Indian companies' choice of collaborator or, indeed, the technology to be produced under license. This view is corroborated by Mitra who emphasises the meagre attention paid by the Indian enterprises to either the foreign machines selling potential or the appropriateness of its performance in the Indian market. To quote : "The major drawback in collaboration agreements has been the limited market forecast work carried out by the manufacturers before entering into collaboration. Government and private industrial aims must mesh in formulating and effecting a 'know-how' import policy on the basis of a proper evaluation which distinguishes between the types of machines we need to produce : whether the machine is rugged, simple and aims at the low budget user; whether the machine is the first of its kind to be produced in India; whether the machine embodies a new design in a line of machine tools already established in India; whether the machine is a very sophisticated general-purpose or special-purpose machine tool and the range of applicability of such a machine; and finally, whether the design is based on numerical control systems and the scope for its use ... The Licensing Committee and the Foreign Investment Board seem instead to follow the procedure of first-come-first-served and allow the first applicant to pre-empt capacity and then to sit pretty if he is so inclined. In the machine tool field, one often hears complaints from private sector producers that public sector applications are always 'more equal' than others - they are always processed first and accepted first."[50] This final point is borne out by the comments of a spokesman for a British machine tool enterprise which until quite recently has held a collaboration agreement with a prominent public sector company in India. He suggested that it was because his company's partner had been a public enterprise that little difficulty was experienced in the issuance of licenses for initial production and also for the subsequent import of materials and components. Moreover, as the company was also under the jurisdiction of the Ministry of Defence, a visit to Delhi and the Minister concerned was all that was required for the process to be expedited.

Once the collaboration agreement has been concluded what, in theory, are the benefits available to the foreign concern? The following advantages can be established: In the first instance, there are the purely financial aspects regarding the payment of royalty and licensing fees. Unfortunately, no evidence is readily available to indicate the extent of either type of remittance in the Indian machine tool industry. The survey fared no better in this respect; it seems that remittances paid to foreign collaborators is a subject of some sensitivity. What is known, as can be garnered from the government's policy on collaboration, is that the normal maximum for royalty payments is 5 per cent of net sales. Now, given that Indian output levels are generally quite low and couple this with the fact that some 50 per cent of the royalty will, in any case, be taxed away by the Indian authorities then it may be surmised that the sums involved are not of 'earth shattering' significance. In fact, it can readily be conceived that the initial teething stages of the collaboration may actually involve a loss to the foreign partner due to the increasing transfer of resources and expertize to 'iron out the faults'.

The possible small size of lump-sum or royalty payments may cause the foreign collaborator to harbour misgivings over the project but a secondary form of potential income provides some measure of recompense; it has regard to the export of proprietory items, components and materials to the Indian partner. The problem with royalty payments is the need for the Indian company to attain sufficiently high levels of output to make the remittances a worthwhile revenue source to the foreign collaborator. Difficulties arise if satisfactory levels of output are not reached and in this situation one of the ways in which foreign concerns might be encouraged to mitigate for shortfalls in income returns is through over-pricing on the capital equipment components and raw materials supplied to the foreign partners.[51]

A second factor, motivating foreign companies to enter into collaboration with Indian machine tool units relates to a non-pecuniary consideration : foreign manufacturers are aware that once a particular machine tool model is produced in India its import is usually banned - hence, in order to retain a foot-hold in the Indian market it seems reasonable to opt for a licensing agreement especially if it is for a machine model which is on its way out in the developed world.[52] Indeed, market interests may hold even greater importance to the foreign partner than questions concerning the size of remittances. Support for this, comes from several British machine tool manufacturers who gave their reasons for collaboration as : overcoming Indian import regulations; protecting their existing market position; and taking advantage of the potential market size.

It will be convenient at this juncture to pick-up on the point regarding the modernity of the technology transferred. The general conclusion of Mitra's findings is that : "the foreign collaborator rarely parts with his latest designs, even under license."[53] Although this view is in unison with current academic thinking on technological transfer, it nevertheless runs counter to the evidence collected from this study's surveys, both in India and Britain.

Looking at the Indian situation first, Table 20 details the number of collaboration agreements, machine tool units held with both foreign and Indian companies during 1977/78. It can be observed that out of the 40 respondents only 6 units were involved in collaboration agreements with foreign companies. However, it should be stressed that most of these 6 firms collaborated with more than one foreign company.

Table 20 : Collaboration Agreements in the Indian Machine Tool Industry

Collaborations	Companies (nos)	(%) of total firms
None	33	82.5
Indian	1	2.5
Foreign	6	15.0
Valid Cases	40	100.0
Missing Cases	-	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

Table 21 below, takes the analysis a step further by documenting the replies given by these 6 Indian concerns to the question of whether they regarded the tools manufactured under license as models now obsolete in the industrialized countries. The findings are apocalyptic in character : 83 per cent of firms indicating that they do not regard the foreign technology being manufactured under license as obsolete. The validity of these results is reinforced by noting that the survey encompassed nearly all the Indian manufacturers currently holding collaboration agreements with foreign machine tool concerns.

Table 21 : The Technical State of Machine Tools Manufactured Under License

Obsolete	Companies (nos)	(%)
Yes	1	17
No	5	83
Valid Cases	6	100.0
Missing Cases	-	
Sample	6	

Source : The Indian Machine Tool Industry Survey (1978)

The British manufacturers were asked a similar question in relation to the nature of the technology they were imparting to their Indian partners. The replies received further strengthen the credibility of the Indian findings : of the 4 British firms responding to the question, 3 stated that the technology was not obsolete whilst the fourth, although not answering in a positive fashion, is a world leader in numerically controlled machinery and clearly not in the business of manufacturing dated technology. More illuminating is the fact that 3 out of these 4 companies were still producing the transferred technology at the time the collaboration was entered into.

Before concluding the section, it is important to briefly mention the influence that foreign collaboration has had on the price and quality of Indian output. A good starting point for the discussion is the not entirely unexpected preference shown by the overseas manufacturers for large Indian partners. Table 22 illustrates the evidence on this point by showing that 5 out of the 6 Indian manufacturers holding collaboration agreements are classified as large firms.

Table 22 : Collaboration Agreements in the Indian Machine Tool Industry, According to Size of Firm

	Companies							
	Small		Medium		Large		Row Totals	
Collaboration	(nos)	(%)	(nos)	(%)	(nos)	(%)	(nos)	(%)
Foreign	1	100	-	-	5	83.3	6	85.7
Indian	-	-	-	-	1	16.7	1	14.3
Valid Cases	1	100.0	-	-	6	100.0	7	100.0
Missing Cases	-		-		-		-	
Sample	1		-		6		7	

Source : The Indian Machine Tool Industry Survey (1978)

Large firms are an attractive proposition because, due to their higher output levels, not only are remittances for royalty and proprietory items enhanced but, in addition, the payment streams are more likely to be stabilized. Furthermore, it has been a consistent theme of this study that scale is an important determinant of efficiency. However, although foreign companies prefer large Indian manufacturers it is not certain that considerations concerning the cost-structure of the company play an important role. For instance, one British firm of international repute in the field of drilling machines admitted that in 1976 its foreign collaborator was selling the licensed machines in India at higher prices than those itself charged for the same machine in Britain. Further empirical confirmation of such price differentials is again provided by Baranson in his epic study of the collaboration agreement between Cummins Ltd. - a world reknown manufacturer of diesel engines - and Kirloskar of India. From his analysis which covered the period 1964-69, Baranson found that : "depending upon the method of comparison, Indian costs ran anywhere from 3.5 to 4.1 times U.S. costs."[54] The problem is that many foreign collaborators seem to have viewed the Indian economy as a seller's market and, as a consequence, have given limited attention to the question of cost and price reductions. In many respects, the very act of collaboration may itself prove to be counter-productive in improving industrial efficiency. The standardization of components reduces costs but this is not helped where designs originate from many different countries and where the foreign firms' agencies have assumed responsibility for export and servicing abroad.[55]

References and Notes

1. Pramit Chaudhuri : 'The Indian Economy - Poverty and Development', Vikas Publishing Ho. (1978) p.217.

2. 'A Survey of India's Export Potential of Machine Tools', Indian Institute of Management, Calcutta, Vol.II (1969) p.135.

3. S.M. Patil : 'A Study of Indian Machine Tool Industry', UNIDO-HMT Workshop on Machine Tools, Bangalore (Nov/Dec 1975) p.4.

4. 'A Survey of India's Export Potential of Machine Tools', Op.cit. pp.136-39.

5. See Government of India - Ministry of Commerce : Report of the Indian Tariff Board on the Machine Tool Industry (1947) p.3.

6. Government of India etc., ibid., pp.3-5.

7. K. Lateef : 'China and India : Economic Performance and Prospects', I.D.S., Uni. of Sussex (1976) p.25.

8. S.M. Patil : 'A Quarter Century of HMT' Company leaflet, (1978) p.15.

9. P.S. Jha : 'HMT - Two Decades of Growth', Company leaflet, (1977) p.23

10. Pramit Chaudhuri : Op.cit. p.234. There may be dispute as to whether industrial and import licenses invalidate this argument. Through private correspondence with Chaudhuri, he contends that they do not. He reasons that two points should be borne in mind : "Firstly, that licensing of either sort only covered the activities of a part of the private sector, i.e. the organised manufacturing sector, and within it mainly those of the larger firms. There were large areas of the private sector that were not covered by the system. Secondly, and this is the important point, licensing systems are essentially negative forms of control, they can try to stop people from doing things, but they cannot compel them to do so."

11. J. Bhagwati and P. Desai : 'India : Planning For Industrialization', Oxford Uni. Press (1972)p.231.

12. See J. Bhagwati and P. Desai : ibid., p.241.

13. See R. Datt and K.P. Sundharam : 'Indian Economy', S. Chand & Co. N. Delhi (1977) p.134.

14. See Datt et al ibid., for definitions of these investment levels.

15. Pramit Chaudhuri : Op.cit., p.243.

16. R.K. Hazari:'Industrial Planning and Licensing Policy', Final Report (1967).

17. R. Datt : Op.cit. p.137.

18. Government of India : 'Report of the Industrial Licensing Policy Inquiry Comm.' (1969).

19. The peculiarity of industrial structure in India lies in the fact that there is a high concentration of both small factories or household enterprises at one end of the scale and large undertakings at the other. Medium size factories have not developed in India. The colonization of the economy is usually forwarded as being the principal reason for this : foreign firms owned by big business implanted amongst the large number of indigenous small firms.

20. See Bhagwan Prasad : 'Machine Tool Industry in The Small Sector of the Punjab', Small Industry Extension Training Unit, Hyderabad (1971).

21. See A.J. Daukas : 'Machine Tool Production in the United States and U.S.S.R.', in Dimensions of Soviet Economic Power, Government Printing Office, Washington D.C. (1962) pp.163-80.

22. A.J. Daukas : ibid., pp.163-80.

23. S.M. Patil : 'Indian Machine Tool Industry and its Future Growth', private mimeo (1978),p.6.

24. The term, in the sense that it is applied here, relates to either 'capital-quickening' or 'capital-deepening' where both lead to an increase in capacity by increasing productivity. See R.M. Solow, 'Fixed Investment and Economic Growth', in W.H. Heller, (edit) Perspectives on Economic Growth. Random Ho. N.Y. (1968) pp.213-15.

25. See N. Rosenberg : 'Technological Change in the Machine Tool Industry, 1840-1910', Journal of Economic History, Vol.XXIII : 4 (Dec.1963).

26. A.H. Amsden : 'The Division of Labour is Limited by the Type of Market : The Case of the Taiwanese Machine Tool Industry', World Development Vol.5, No.3, (1977) p.221.

27. Chu-Yuan Cheng : 'The Machine Building Industry in Communist China', Edinburgh Uni. Press (1972) p.130.

28. Directorate General of Technical Development : 'Census of Machine Tools' (1968).

29. Although it should be said that many of these machine tools would have originated from the hundreds of small firms in the industry.

30. 'Handbook of Statistics 1973', Association of Indian Engineering Industry, Calcutta (1974) p.54.

    N.B. However, the age pattern of the Indian machine tool stock some 12 years after the start of industrialization is not so spectacular when compared with that of the Soviet Union's in 1940, after an equivalent lapse of time since its growth campaign began.

    Age Pattern of the Soviet Machine Tool Stock at Machine Tool Census - 1940 (as %)

Age in Yrs.	Under 10	10-20	Over 20
%	71	13	16

    Taken from M.J. Berry : 'Research, Development and Innovation in the Soviet Machine Tool Industry, Unpublished study, Uni. of Birmingham, (1974)p.50.

31. Editorial : Economic Times (16th Aug. 1977) India.

32. Economic Times (27th July 1977) p.V. On this point, according to survey returns, 12 firms have entered the industry since 1965, but all of these have been small size concerns.

33. 'Industry Happy Over Government Concessions', Commerce (23rd July 1977) p.19.

34. Indian Institute of Management : Op.cit., p.159.

35. 'Industrialization of Developing Countries', Monograph No.4, Engineering Industry (1969) p.25.

36. A.H. Amsden : Op.cit., p.219.

37. A.H. Amsden : ibid., p.222.

38. In fact, according to the 'Indian Institute of Management' (pp.136-9), a system based on Dr. Schlesinger's standards was introduced during the 2nd World War.

39. Harry G. Johnson in the introduction to, J. Baranson's : 'Manufacturing Problems in India - The Cummins' Diesel Experience', Syracuse Uni. Press (1968) p.ix.

40. Soviet pride in the mass production methods used in the machine tool industry is matched by official displeasure with the high degree of vertical integration of the industry in the U.S.S.R. Captive foundries in 1960 satisfied 85 per cent of the industry's requirements for castings, and almost all the plants produced their own stampings and forgings. In the U.S. in 1958 only 2.9 per cent of the metal-cutting machine tool plants had their own foundries, 0.2 per cent had forging shops and 2.7 per cent carried out stamping, blanking and forming operations'. Taken from A.J. Daukas : Op.cit.,p.176.

41. See D. Granick : 'Organization and Technology in Soviet Metal-Working : Some Conditioning Factors', AEB, Vol.47, (May 1957) p.640.

42. J. Baranson : Op.cit., p.1.

43. D. Granick : 'Economic Development and Productivity Analysis : The Case of Soviet Metal-Working', Quarterly Journal of Economics, Vol.71, (1957) p.206.

44. 'Status of Indian Machine Tool Industry', in Status of Indian Capital Goods Industry Workshop proceedings, Association of Indian Engineering Industry, Calcutta (1977) p.44. Moreover, it is interesting to see that in the foreword to this publication is the statement : "The feeling has been that the cost of Indian capital goods was much higher than the imported ones of comparable standards.

The indigenous capital goods industry is, however, of the opinion that the cost could be brought down substantially if there was adequate demand"...

45. Chu-Yuan Cheng : Op.cit., p.153.

46. E. Ames and N. Rosenberg : 'The Progressive Division and Specialization of Industries', Journal of Development Studies, Vol.1, (July 1965) p.369.

47. One such instance ... "is the Krasny Proletariat plant in Moscow, an expanded Tsarist plant previously known as Bromley Brothers, making small diesels with German technical assistance in the late 1920s, and then lathes. The first lathe models produced in 1929-30 were cone pulley types, replaced in 1932 by the new Soviet standard lathe which followed very closely the design of the German standard machine ... By 1937, the plant employed some 7,500 workers [and was] still producing lathes." From A. Sutton : 'Western Technology and Soviet Economic Development 1930-45', Hoover Institute Press (1971) Vol.II p.141.

48. S.M. Patil : 'A Quarter Century of HMT', Op.cit., pp.24-5.

49. J. Mitra : 'Some Aspects of Foreign Collaboration in Indian Industry', Commerce (April 22nd and 29th, 1972).

50. J. Mitra : ibid., pp.22-3.

51. On this point, "a study by Vaitos in Colombia has shown empirically that a very large proportion of the return to a direct investment or license agreement may be got by overpricing intermediate inputs." Taken from C. Cooper : 'Science, Technology and Production in the Underdeveloped Countries', p.12.

52. J. Mitra : Op.cit., p.5

53. J. Mitra : ibid.,

54. J. Baranson : Op.cit., p.82.

55. J. Mitra : Op.cit., p.22.

Chapter 4

International Trade : The Goal(2) of Technological Self-Sufficiency

In the previous chapter, demand considerations, i.e. the low level of absorption of machine tools in the Indian market, was adjudged to be a major retarding influence on the development of both the machine tool industry and the economy. In the early 1950s, however, it was the obverse of this situation : a limited machine tool productive capacity, that was held to be the constraint to capital formation; and capital formation, moreover, was viewed as the crucial growth-determining factor. Underdevelopment in this context is characterized by a structural incapacity to produce the capital goods required for growth : a problem of supply. In relation to this state of affairs, Celso Furtado once wrote : "development is not the endogenous transformation of a pre-industrial economy, but the implementation of an accelerated growth process through the adoption of foreign techniques."[1] These techniques are embodied in physical capital goods which cannot be produced domestically.[2] This situation is usually described as technological dependence;[3] and one of the reasons that India decided to build up, amongst other heavy goods industries, a machine tool sector, was to avoid such dependency.

The objective of this chapter is to assess the importance of India's machine tool industry in the light of the country's pursuit of technological self-sufficiency. In order that the analysis proceeds in logical fashion, it is appropriate that discussion opens with a section that traces the historical thinking on the interrelationship between economic development and international trade. This begins with the primarily Marxian approach of sectorizing the economy into producer - and consumer goods industries. The analysis is expanded, however, to allow 'exports' to substitute for the indigenous producer goods sector which during the early stages of economic development is invariably absent. In many respects the structural characteristics of this form of theorizing are akin to the classical principle of comparative advantage according to which development is promoted by specialization. In cognizance of this fact, the first part of the section reviews the main tenets of the comparative advantage doctrine through the medium of the typical commodities involved and the factors which encourage or impinge on their exchange via trade. Discussion is centred around the established criticisms made by Prebisch regarding the efficiency of the present international division of labour; however, in line with the two-sector approach emphasised in this study, analysis of the Prebisch thesis is developed through a modified Marxian framework. The penultimate part of this opening section examines the alternative theoretical approach as advanced by the critics of the comparative advantage doctrine. These protagonists of 'growth theory' perceive development from a dynamic perspective; they tend to ignore the potential of trade save for the strategic purpose of stimulating the growth of particular sectors - on the export side, and the international transfer of advanced foreign technology - on the import side. Finally, other approaches to foreign trade are briefly reviewed.

The theoretical basis that an appraisal of these 'trade models' provides brings the discussion around to the second section of the chapter. Here, an attempt is made to assess empirically the importance of foreign trade as a source of supply of machine tools during the first twenty years of Indian industrialization. Using government policy as a springboard, the development of the machine tool industry will be gauged by reference to India's quotient of self-sufficiency in meeting the needs of its machine building community. Such an approach is deemed valid because, for the machine tool industry in particular, the emphasis of government policy has been on economic independence; a goal to be achieved at almost any cost.

Section 1 : Doctrinal Conflict

(i) The Structural Relationship Between Exports and Growth in an Underdeveloped Country[4]

Invariably, when an underdeveloped country begins to seriously consider promoting the development of its economy, no indigenous capital goods capacity exists. In such circumstances, a perfectly rational approach to the problem would be to sectorize the economy along the lines followed in Chapter 1, into a consumption goods sector and a capital goods sector; to begin though, the introduction of foreign trade requires that the model be refined to conceive of the former group of industries as the domestic sector and the latter group as the export sector. The idea being that the export sector provides the capital goods needed for growth to take place via the foreign exchange it earns, whilst the domestic sector supplies the consumption goods needed for both sectors.[5] Before giving serious consideration to this revised conceptual framework, it will be valuable to lead into the discussion with a recapitulation of the main features of the Marxian model on which this theorizing is based. In particular, it will provide clarification of the differing technical and functional characteristics between each of the sectors in the circular flow of the economy.

The basic analytical construct in Marxian analysis is the well-known static, closed economy model :

Capital goods Sector (dept.I) : $O_I = K_I + V_I + S_I$

Consumption goods Sector (dept.II) : $O_{II} = K_{II} + V_{II} + S_{II}$

Where O is output, K is constant capital (or fixed costs), V is variable capital (or the wage bill), and S is the entrepreneurial surplus (or profits), all per period of time. In the stationary state there is no net investment, so that all profits are consumed. The equilibrium condition is that the supply of capital goods must equal the demand for them that comes from the replacement of the capital goods used up in both sectors in the process of production. Similarly, the supply of consumption goods must equal the demand arising from the income of workers and entrepreneurs in both sectors :

Supply		Demand
$K_I + V_I + S_I$	=	$K_I + K_{II}$
$K_{II} + V_{II} + S_{II}$	=	$V_I + S_I + V_{II} + S_{II}$

each of these equations reduces to :

$$K_{II} = V_I + S_I$$

The dynamic derivation of this analysis is the model of equilibrium growth (or, in Marxian terminology : the schema of expanded reproduction); the major modification to the static approach being the introduction of savings and investment under the assumption that all capital accumulation comes out of profits. The difference by comparison with the stationary model is that the surplus is now broken down into its constituent parts according to the purposes to which they are applied. The dynamic model then takes the following form :

$$(\text{dept.I})\ O_I = K_I + V_I + SC_I + \Delta SK_I + \Delta SV_I + \Delta SC_I$$

$$(\text{dept.II})\ O_{II} = K_{II} + V_{II} + SC_{II} + \Delta SK_{II} + \Delta SV_{II} + \Delta SC_{II}$$

Here, the total surplus (S), of the stationary model is now divided into (SC), the stationary amount of entrepreneurial consumption; (ΔSK) the increment to constant capital; (ΔSV) the increase in the wage bill; and (ΔSC), the addition to the entrepreneurs own consumption. The equilibrium condition is as before : by equating the supply of dept.I, with the demand for its output that arises in both sectors from replacement and (now also) from net investment, and the supply of dept.II., With the demand for consumers goods that comes from the income going into consumption in both sectors, the equilibrium equation is obtained :

$$\left[K_{II}\right] + \Delta SK_{II} = \left[V_I + SC_I\right] + \Delta SV_I + \Delta SC_I$$

in which the stationary terms have been put in brackets. An important feature of this model, is that each sector is dependent on the other for part of its requirements, but produces more than it needs for its own output. Only these surpluses enter into the exchange between each sector. The two sectors must, therefore, stand in a specific quantitative relationship to each other. In the stationary state, this proportionality depends only on the capital output ratios; that is, technology, and additionally, in the dynamic model, on the savings ratio. Under the assumptions of this model, the capital-output ratio and the savings ratio are roughly given by the relative shares of profits and wages. The proposition is that this proportionality between the two sectors holds only when they are in the same market for their entire 'surplus' output, otherwise, as Merhav argues : "there is no more reason why they should be proportional to each other, than there is for the product of two countries to stand in a fixed ratio to one another."[6] The reasoning behind this is that any disturbance to the equilibrium can only be a temporary phenomenon in a closed economy : if one of the two sectors should expand more than is warranted by the demand created by the other, its prices and profits would fall and, in the long-run, capital and labour would migrate to the other sector until the proportionality between them is restored.

In the 'open' model where an export sector acts as a proxy for indigenous capital goods capacity there need be no such requirement for proportionality. The expansion of the export sector depends on foreign demand and on its own accumulation. The latter is the strategic variable with respect to the sectors impact on domestic growth; for the profitability of expansion in the export sector is affected only indirectly and partially by the domestic sector. Moreover, the export sector depends on the domestic sector only for the supply of wage goods. This fact may be illustrated if the terms that represent the stationary flows are withdrawn from the last equation. The incremental equilibrium equation that results is thus :

$$\underset{\text{(Domestic Sector)}}{\triangle SK_{II}} \quad = \quad \underset{\text{(Export Sector)}}{\triangle SV_I + \triangle SC_I}$$

Clearly indicating that investment in the domestic sector depends entirely on the increase in the demand for consumption goods generated by the growth of the export sector.

Evidently then, the growth of the export sector is the prime source for stimulating the development of the domestic economy. But because various factors militate against its efficient operation, the foregoing model unfortunately cannot be regarded as the key to spring third world countries from the 'low level equilibrium trap'[7] of economic underdevelopment. Merhav dwells at length on three issues which have pervasive influence over the character and tempo of the growth of the export sector; it is worthwhile listing these below :

(i) On the assumption that foreign demand is perfectly elastic, the export sector will expand until the supply schedule of its domestic factors rises against it and attains some equilibrium level. Beyond that level, the accumulating profits will not necessarily migrate into investment in the domestic sector because under conditions of technological dependence this investment will not create its own demand.

(ii) Even an expanding export sector does not necessarily induce growth in the domestic sector; there are, in fact, strong forces working against such an outcome. Merhav makes it clear that he is not talking about the widely observed phenomenon of export sectors being regarded as outposts of other economies in the countries where the exports are produced, so that accumulating profits are repatriated and reinvested wherever the anticipated return is highest - (which may or may not be the place where these profits originated). Even in the ideal case where the export sector is indigenous; it is on the demand side completely independent of the domestic economy and, suitability of factors may also make it, to some extent, independent of the demand for labour : it is often in the economy, but not of it.

(iii) Such an export sector provides the economy with a given capacity to import and to that extent removes the technical bottleneck that results from the absence of a domestic capital goods industry. It will not, however, substitute for the latter in terms of automatically widening the domestic market through the investment outlays that expand the export sector. On the contrary, the larger the volume of imports it permits, the more will the import competing industries at home be depressed unless they are protected by a conscious development policy.

The growth of the export sector determines, through the volume of imports it makes possible, the boundaries within which the domestic sector can expand. If it were the case that no constraints on the expansion of the export sector existed then there would be no limits to the growth potential of the domestic economy. However, the problem with underdeveloped countries as Merhav succinetly states : arises precisely because their exports fail to expand sufficiently, both in terms of the import capacity they provide and the markets they create, by generating income and employment.[8] International specialization through the accident of possessing rich natural resources or the aftermath of a colonial economy may make it somewhat easier, once development is initiated, to effect the necessary changes for domestic savings to be converted into foreign exchange for the import of capital goods. But in general, the level of exports is not enough to satisfy the import requirements created by domestic development, nor adequate to raise income and employment sufficiently to compensate for a slow rate of growth in the domestic sector.

This brief examination of the main principles of the structural relationship between the export sector and economic development sets the stage to enquire whether the growth of the export sector is so constrained as to not make it a viable alternative to indigenous capital goods capacity. In attempting this task, the nature of the commodities involved and the factors that affect their expansion in international trade will be examined against the rules of economic exchange on which the system is to all extents and purposes governed : the theory of comparative advantage.

(ii) <u>The Theory of Comparative Advantage</u>

The present international division of labour has evolved, whether by design or fate, in such a way as to preclude the majority of developing countries (the newly emerging countries being notable exceptions) from actively engaging in the export of products with a high technological content. The reasons for the exclusion of these countries from this particular area of trade are straightforward; that is, if you happen to be a classicist. Theirs is a two-pronged argument : firstly, reasoning on the basis that specialization raises efficiency, the theory of international trade states that countries are better off with trade than without it. More recently, neo-classical thinking has brought forth a second reason in terms of the Heckscher-Ohlin version of the comparative advantage doctrine : countries further benefiting by trade if they manufacture commodities that use more of their relatively abundant factors of production. The appropriate trading strategy would then be to export these commodities whilst importing others which use more of their comparatively scarce factors. This pattern of exchange continuing until ultimately the world market is in equilibrium; a situation which, in the classical theory and the Heckscher-Ohlin treatment of the same, is determined from a comparison of the opportunity costs of producing a given commodity with the price at which the commodity can be imported or exported. Thus, in equilibrium, no commodity is produced which could be imported at lower cost; and exports are expanded until marginal revenue equals marginal cost.

The purely classical exposition of the theorem operates under the assumption of full employment and perfect competition. Therefore, if the opportunity cost of a commodity is equal to its market value, market prices of factors and commodities can be used to determine comparative advantage under competitive conditions.[9] By contrast, the Heckscher-Ohlin modification of the basic theory has, as its major feature, the fact that perfect competition and initial equilibrium are not mandatory elements in the determination of comparative advantage. Instead, the critical assumptions here are that factors of production are comparable amongst countries and also that production functions are the same.[10]

There is voluminous economic literature regarding the equity of the contemporary international division of labour - which is, of course, based on the principle of comparative advantage. It would be fair to say that the majority of these writings, from an empirical platform, weigh heavily against the validation of the theory with respect to the underdeveloped group of countries : both in terms of raising their levels of real income and reducing the degree of technological dependence on the more advanced countries. The former issue is examined over the next few pages whilst consideration of technological dependence is delayed until the next part of the section.

In the context of the first of the above issues : increasing the growth of real income in the third world countries, the economist whose name is most associated with criticizing the comparative advantage doctrine is that of Raul Prebisch, the former Secretary-General of UNCTAD.[11] Prebisch questions the global 'gains - from - trade' conclusions of classical trade theory on both analytical and empirical grounds; however, the controversy that he raised with his criticisms was not so much concerned with the mechanics of trade theory but rather with :

(a) the conditions under which these gains can be realized; and,

(b) who will gain more and who less.

In many instances, much of the criticism on the subject has a tendency to mirror Prebisch's original arguments. Thus, the main points of his attack against present international trading patterns are briefly reviewed.

Prebisch analyses the development of the world market in terms of countries representing the 'centre' (the advanced group of nations) and those that represent the 'periphery' (the underdeveloped set of nations). Historically, the international division of labour has been marked by this latter group specializing in the production of food-stuffs and raw materials which are then sold to the centre usually in exchange for manufactured goods, and especially technology. In direct conflict with the pre-supposed gains from specialization, Prebisch argues that growth in real income has not materialized in the periphery. To assist in the evaluation of Prebisch's criticism, it will be helpful to recall the Marxian methodology expounded earlier. Although now, the role of agriculture will be made explicit. The use of the Marxian model as an auxiliary instrument in the presentation of these economic processes is not made solely on the grounds of exposition but also to maintain consistency in the argument underpinning this thesis : the importance of indigenous capital goods capacity in the pursuit of economic development.

Naturally enough, the Marxist simple reproduction model acts as the starting point for the analysis. It will be remembered that the relationship of department I to department II gives the following equation :

$$K_{II} = V_I + S_I$$

The assumption that $V_I + S_I$ be equated with the export sector is no longer maintained; instead, it reverts to its more formal interpretation of being equivalent to capital goods. But some modification of this relation is required to make it compatible with the Prebischian conceptualization of those countries belonging to the periphery.

The pattern of production pertaining to these pre-industrialized nations relates firstly, to an agricultural sector where the subsistence of the producers is completely consumed by them; where the agricultural surplus is not re-invested but transferred to the urban sector or exported abroad; and finally, where agricultural production remains more or less constant excepting climatic variations. The point of significance here is that the removal of the surplus leaves the agricultural sector in a situation of comparative stagnation.

A second feature of the periphery's productive structure has regard to the phenomenon of the dynamic sector being comprised of two sub-sectors operating in total isolation to each other. On the one hand, they are composed of local industrial branches which, as a rule, produce consumer goods and can, therefore, be regarded as department II. On the other, the sector comprises the usually foreign dominated enterprises, i.e. in mining or in the plantations, which as a rule produce the raw materials and can be considered as department I. Moreover, here,.."in contrast to the agricultural sector, the reproduction process is extended. That means the surplus value is always transformed into additional capital (i.e. constant and variable capital)."[12]

The above scenerio applicable to the situation extant in the non-industrialized countries bears little relation to the Marxian theoretical framework which is based on conditions as would exist in a 'mature' industrialized economy where capitalism has taken hold of both agriculture and industry. Under these assumptions, Marx included agricultural activities with the other consumption items in the department II category. This cannot be the case in the economies of the peripheral countries because there, agriculture is a stagnating sector which co-exists with the other dynamic sectors of their economies. In such circumstances, the concept of 'economic dualism' adequately describes the economic process : "the Marxist bi-sectoral reproduction pattern is applicable to the capitalist dynamic sector; the stagnating non-capitalist sector viz. agriculture stays outside the pattern."[13] The essence of the distinction between each sector is a reflection of the different reproduction processes involved. Thus, the focus of attention should not be directed at the relation of agriculture to industry as equally dynamic elements in the mature capitalism of the original Marxian conception, but rather at the respective role of each sector in the process of capital accumulation.

Besides this fundamental difference, there also exists another significant divergence between Marx's original model and the present version applicable to the countries of the periphery; it has regard to the location of departments I and II. In the centre, both departments are located in the same society; in the periphery, department I consists predominantly of foreign dominated enterprises engaged in activities such as mining and plantations. As such, it might be argued that department I in the periphery has no connection to department II : there is no organic relation between them. In fact, department I is more likely to be a component part of the reproduction process in the advanced nations : "The different locations of departments I and II results in the fact that turnover between both departments can be effected only through the importation of ... $V_I + S_I$ ... and the exportation of ... K_{II}."[14]

On the acceptance of the above logic, it is clear that foreign trade has an essential role to play in the acquisition of capital goods. The problem, however, and this is the mainspring of Prebisch's attack on international trade theory, is that the nature of the commodities in which the export sector of the periphery must specialize, and the factors that affect their expansion in foreign trade, are inherently disadvantageous to the growth of real income in these countries. Prebisch cites two main causes for the failure of the periphery to gain from trade and, with the aid of Marx's modified theoretical apparatus, both are documented below :

<u>1st Criticism</u> : Firstly, there is the fact : "that the countries at the centre are their own largest customers for their products, so that cost and price movements emanating from their internal markets become transmitted to their external markets. This would remain true even if there was price discrimination between the two markets. Since the countries at the centre have a scarcity of labour, and wages are inflexible downwards, the wage increases which occur during the upward turn of the business cycle have a ratchet effect, and there is, therefore, a secular trend for the prices of export goods

from the centre to rise ... the gains in productivity which the advanced countries have achieved have, in other words, been distributed in the form of higher incomes and prices rather than through stable money incomes and falling prices."[15] By contrast, the periphery have great difficulty marketing their department II products in the centre. In any case : "the products of department II are above all sold in the home market ... hence, the developing countries have only one possibility of exchanging the products of department II with another sector viz. agriculture."[16] This implies that the agricultural surplus (S_o) be exchanged for the K_{II} items of department II, thereby allowing primary commodities to act as the major export goods of the periphery and, moreover, the medium of exchange for the import of capital goods ($V_I + S_I$) for both department I and department II.

This pattern of trade for the developing countries imposed constraints on the growth of real income. In particular, Prebisch notes that the existance of an elastic labour supply keeps the costs of labour constant in the export sector, geared, as it is, to the specialization in primary products chiefly through the use of peasant labour. The upshot of this whole process is not only that the centre fails to pass on to the periphery the gains from its own productivity increases, in so far as they are expressed in prices, but the periphery is unable to retain the benefits of its own increases in productivity. These are passed on to their customers in the centre in the form of lower prices. Therefore, Prebisch argued, there is a long-run trend for the net barter terms of trade of the peripheral countries to fall.

There are, in addition, structural factors pertaining to the <u>internal exchange</u> between S_o and K_{II}, which work against the growth of real income in the developing countries. As S_o is exchanged for $V_I + S_I$ from the centre, the role of the agrarian surplus can readily be conceived as acting as a catalyst in the process of international trade. This reproduction process can only be effective, however, if the owners of S_o are in a position to absorb the products of K_{II}. For illustrative purposes, let S_o be sub-divided into its three component parts :

$$S_o = S_r + S_v + S_{exp}$$

where :

S_r = raw materials for dept.II (part of K_{II}),

S_v = foodstuffs for the working people in dept.II (V_{II}),

S_{exp} = surplus for export, as required for the importation of ($V_I + S_I$).

Thus S_o, provides through internal exchange V_{II} and K_{II} : foodstuffs and raw materials for department II and additionally, via S_{exp}, the means of production. Therefore, in the extreme case (without S_{exp} supplying capital goods from abroad) :

$$S_o = V_{II} + K_{II}$$

But while S_o operates under the conditions of a stagnating agricultural sector, $V_{II} + K_{II}$ by contrast continues to grow, 'egged-on' by the stimulus of the extended reproduction process taking place in the dynamic sector of the department II industries. The effect of this divergent growth path between the two sectors has serious consequences on the economic development of the periphery. The growing department II will demand ever greater S_r and S_v. Eventually though, an export sector will have to develop, to 'supply' the capital goods necessary to satisfy the increases in capacity which an expanding department II calls forth. Part of S_o will then have to be apportioned to S_{exp}, and it will need to grow in unison with the rate of expansion of department II. However, with a constant S_o due to stagnating agriculture, the requirements of S_r and S_v can only be met at the expense of reducing the S_{exp} part of the agricultural surplus. So that :

$$(\downarrow)\ S_{exp} = S_o - (\uparrow)\ (S_r + S_v)$$

Consequently, the agricultural surplus available for export will quantitatively decline even under the conditions of stagnating agriculture. It is this asymmetrical nature of the process of internal exchange in developing countries that severely affects their ability to import producer goods and, in turn, to achieve increases in real national income.

2nd Criticism : The second principal reason, according to Prebisch's thesis, why the peripheral countries are unable to increase their capacity to import through participation in international trade, has to do with the low income elasticity of demand for agricultural products.[17] Through the operation of Engel's law of aggregate consumption, the advanced countries will exhibit a declining income elasticity of demand for importing foodstuffs and raw materials. This situation is the antithesis of that holding for the developing countries where the income elasticity of demand for manufactured goods is rising. In any case, the cost structure of many of the emerging nations' primary, especially agricultural, products remains comparatively constant. This is mainly attributable to the employment of out-moded technology and the maintenance of inefficient practices which, by extension, lead to the sectors non-involvement in the reproduction process. Again, the foregoing situation contrasts sharply with the agricultural sector of the centre countries which operate in the dynamic environment of department II; a feature reflected in the relatively declining prices of the sector. The importance of this distinction derives from the fact that here, agricultural products are not sold at their costs of production on the world market but at the prevailing world price.

These characteristics of the foreign trade of the peripheral countries provide a broad outline to the problem at hand : S_{exp} will supply a fund for imports, the value of which over time, will grow less and less. As a consequence, the pace of the reproduction process will be constrained because of the financial inability to import capital goods. However, the issue is compounded for the developing countries due to the progressive post-war substitution of synthetic raw materials for those of natural origin. Combine with this, the tremendous technological development of industry in the centre which further reduces the import of raw materials necessary for a given unit of production, then it is clear that the adverse terms of trade that determine the peripheral countries capacity to import : the balance between S_O and $(V_I + S_I)$, sorely affects their potential for economic development.

(iii) Growth Theory : An Escape from the Impasse?

The chief focus of attack, thus far, has been directed at the specialization by the periphery in the production and export of primary commodities. Problems arise here, because the terms of trade for these types of goods relative to the predominantly manufactured exports of the centre are declining. Such a process will naturally impinge upon the achievement of adequate growth because export revenue stagnates and is never sufficient to keep pace with the import requirements of the dynamic industrial sector. Hence growth in real income remains an elusive goal.

Table 23 shows the results of an empirical investigation to test Prebisch's criticism concerning the adverse terms of trade of developing countries and its effect on their ability to purchase technology from abroad. The basic method used to calculate the net

Table 23 : Indexes[18] of the Net Barter Terms of Trade, Income Terms of Trade, and Export Quantum, for all trade between the Developing and the Developed Countries 1954-77 (1970 = 100)

Year	Barter Terms Of Trade			Income Terms Of Trade			Quantum of Exports	
	T_1	T_2	T_3	I_1	I_2	I_3	Q_1	Q_2
1954	119	116	137	48	57	67	40	49
1955	117	115	135	49	59	69	42	51
1956	116	110	128	52	59	69	45	54
1957	110	103	119	49	56	64	45	54
1958	107	99	109	49	53	59	46	54
1959	103	97	105	51	56	61	50	58
1960	103	98	105	54	59	63	52	60
1961	99	95	106	53	58	65	54	61
1962	97	92	96	56	60	62	58	65
1963	99	96	101	61	65	69	62	68
1964	99	99	106	65	69	74	66	70
1965	99	99	107	68	70	73	69	71
1966	100	99	102	73	74	76	73	75
1967	98	97	97	75	75	75	77	77
1968	99	97	99	84	81	83	85	84
1969	102	102	107	93	93	97	91	91
1970	100	100	100	100	100	100	100	100
1971	101	91	86	103	92	87	102	101
1972	99	90	84	112	102	95	113	113
1973	109	97	94	139	117	114	128	121
1974	178	102	113	222	122	136	125	120
1975	155	86	88	175	100	102	113	116
1976	163	92	89	217	126	122	133	137
1977	173	102	95	228	138	128	132	135
Coefficient of Regression :	1.78	-0.59	-1.53	7.16	3.39	2.84	4.38	3.87
Standard Error :*	22.33	5.88	9.14	29.86	9.72	11.18	7.27	7.41
R^2 :	0.25	0.35	0.59	0.75	0.86	0.77	0.95	0.93

Source : United Nations Monthly Bulletin of Statistics, Nov.1966, June 1977, 1978 and 1979.

Notation : T_1 Barter Terms of Trade, all commodities
T_2 Barter Terms of Trade, excluding exports of fuel
T_3 Barter Terms of Trade, exports less fuel Vs machinery
I_1, I_2, I_3 Income Terms of Trade, corresponding to T_1, T_2, T_3
Q_1 Quantum Indices of Exports from LDCs, all exports
Q_2 Quantum Indices of Exports from LDCs, exports less fuels

* Due to the high standard errors, little credibility should be given to the absolute values of the coefficients; relative magnitudes and trends are, in any case, what are being sought.

barter terms of trade for the developing countries was the ratio of the export price index to that of the import price index which was then related to the same for the developed countries. Accordingly, a relatively greater rise in the terms of trade of the developing countries shows itself as a rise in the T indexes. The income terms of trade, on the other hand, is a concept that takes account of the volume of exports of a country as well as its export and import prices : it is designed to show changes in a country's capacity to import in exchange for exports. A rise in the value of the 'I' indexes then, indicates that the developing countries can obtain a relatively larger volume of imports than before from the sale of exports. Their capacity to import in comparison with the advanced countries has increased. The quantum indexes of exports are self-explanatory.

As can be noticed from Table 23, for the period 1954-77, the net barter terms of trade, for all trade between the developing and the developed countries have shown a small upward trend of about 1.78 unit points per annum. However, when exports of fuels are excluded, the net barter terms of trade exhibit a declining trend of 0.59 unit points clearly indicating the significance, since 1973, of the increasing price of oil. Furthermore, when the price indexes of exports less fuels are compared with the price indices of machinery : "the crucial growth-determining class of imports",[19] the growth in the terms of trade deteriorates still further to a negative 1.53 unit points. A similar pattern exists in respect of the developing countries capacity to import. Since 1954, the trend for all trade has grown at 7.16 unit points per annum; taking out fuels reduces this to 3.39 unit points; and finally, their capacity to import machinery shows only a modest growth rate of 2.84 unit points. The illuminating conclusion to emerge from the analysis is that even though the quantum of exports has increased over the 24 year period by 4.38 unit points and without fuels by 3.87 unit points, the deteriorating terms of trade of the mass of the developing countries without fuel has meant that their capacity to import technology has only risen by some two or three points.

It will be recalled, however, that the 'real income' issue only constitutes a first part of the criticism (and apparent demise) of the static comparative advantage theory; there is, of course, the further question regarding the developing countries technological dependence on the centre. The seeds to this reliance are common to both the Ricardian and Heckscher-Ohlin formulation of comparative advantage and have regard to the essentially static nature of the concept. As Johnson argues : "the gains from trade are the result of taking advantage of comparative cost differences by specialization and international exchange, as in classical analysis. But instead of being firmly grounded in stable and enduring characteristics of national economies - inherent cost differences, as in the Ricardian model, or differences in factor endowments, as in the Heckscher-Ohlin model - comparative advantage is the evolving consequence of the dynamics of technical progress, capital accumulation, and population increase, and their diffusion through the world economy."[20] From this dynamic derivation of comparative advantage, has emerged a political consensus in most of the developing countries that government should assist the drive toward industrialization. It may not be feasible to leave the process of development entirely in the hands of the private sector as the time-scale involved may be inordinately long relative to the aspirations of these peoples. The importance of government intervention is critical : it, to a large extent, ignores present comparative advantages with the attendant implications on foreign trade and instead attempts to manipulate development by creating potential growth sectors. A state of affairs which is little more than an expression that the static comparative advantage doctrine has nothing to say on the technology element in the growth process of capital scarce countries.

The above considerations are interwoven into the dialectic fabric of the 'comparative advantage versus growth' conundrum. The development strategy chosen will ultimately depend upon the objectives of the respective countries belonging to the periphery. If it is the maximization of static efficiency, then the comparative advantage model will provide the appropriate allocation of resources. On the other hand, if the objective is held to be growth, then the investment criteria will be totally different with trade being superceded in importance by the emphasis given to rapid increases in production. Seen in this light, the dilemma can be reduced to a more fundamental choice-set : the relative valuation of present versus future output and consumption. Efficiency in resource allocation will maximize present output and consumption from a given amount of resources, but may impair future growth. Striving for growth will lower present consumption but will provide greater output in the future.[21]

A further strand to the discussion on whether to maximize present or future welfare has now been implicitly revealed : the choice of technique. In fact, the choice of technology strikes at the heart of the problem regarding the dependence on imported investment goods. This is because without the possession of an indigenous capital goods industry, the choice of machinery must necessarily conform to the configuration of technology that is characteristic of the advanced nations. In so doing, the range of choice will be confined to the sophisticated end of the technology spectrum which may not be appropriate to the factor endowment or market-scale of the periphery.

The large volume of statistical information that has now become available on the developing countries import-dependence of technology clearly indicates the serious nature of the limitations it imposes on choice. Leontief, for instance, in 1963, compared the industrial structures of several developing countries with the structure of the United States and showed that the shortfall of self-sufficiency (i.e. domestic production of requirements) of the developing countries is greatest in the sectors of machinery and basic producers' goods.[22] The share of metal products and basic metals in total manufacturing industry in the underdeveloped countries is generally not over 10 to 15 per cent compared with 30 to 40 per cent in the advanced countries.[23] One measure of the developing countries dependence on imports for the acquisition of technology can be found by the ratio of imported capital goods to gross domestic fixed investment. Table 24 illustrates the position of developing countries with respect to this factor. It is evident that for many of these nations in the late sixties, there existed a high degree of dependence, some as high as 50 per cent, on imported capital goods.

The degree of dependence on the import of technology from the centre has disquieting repercussions on the expansion of economic activity in the developing countries. Difficulties arise because the higher are these imports, the greater will be the employment - output leakages from the system. This will always be the case irrespective of the level of exports because the domestic content of fixed investment will diminish in proportion to the share of imports in total investment expenditure : the investment multiplier contracts as a direct consequence of these seepages.

Table 24 : The Share of Imports of Capital Goods in Gross Domestic Fixed Investment in Selected Developing Countries (1960-62 and 1966-68)

Country	1960-62 (%)	1966-68 (%)
Thailand	41.1	38.0
Singapore	76.4	81.7
Taiwan	36.8	42.8
Nicaragua	29.6	40.8
Philippines	31.4	27.9
Uganda	24.9	21.8
Bolivia	41.0	53.5
Tanzania	25.9	23.0
Sierra Leone	13.7	23.8
Peru	37.3	42.7
Ethiopia	19.9	21.7
Venezuela	21.8	23.8
Mexico	23.5	21.6
Pakistan	26.3	21.1
India	20.9	17.5
Malaysia (West)	51.7	57.9
Kenya	25.8	32.8
Hong Kong	62.6	54.5
Iraq	32.1	55.3

Source : U.N. World Economic Survey 1968-70, Table 35, pp.87-8.

(iv) More Recent Thinking on Trade Theory

A crucial question to emerge from the previous discussion, is whether the conflict between the gains from trade and the gains from growth can be resolved so that benefits from both can assist in the development of an economy. In this respect, recent writing on the subject has tended to emphasise the important causal link that trade may hold in the propulsion of a country's economy to a higher stage of growth. Just as trade was seen as the engine of growth for the backward countries under colonialism, so, too, today, following several decades of inward-oriented import substitution, trade is championed as a means to increase output and employment, and thereby improve the income distribution, in the still poor countries of the world.[24]

Present debate has begun to move away from the confines of the primary-good exports of the developing world and now focuses on manufactured products. Quite simply, this is because the trade paths for primary products are given, being determined by natural forces, with consumption patterns being dependent on income levels.

The neo-classical approach to international trade, represented by the Heckscher-Ohlin theory described earlier in the chapter, alluded to the fact that ... "trade will be most likely between unlike economies, and that the gains from trade will be greater where conditions are most dissimilar."[25] There are problems, however, with categorizing trade flows simply in terms of the exchange of factor-appropriate capital intensive goods from the developed to the developing world which in return exports factor-appropriate resource and/or labour intensive products back to them. On two points, this appreciation of the situation has shown to be ill-based. In the first instance, a recent study indicated that ... "There is no tendency for trade between countries with dissimilar factor endowments (North-South) to be greater than trade between similar countries. In fact the proportion of trade accounted for by North and South countries is very similar for both North and South, with a slight tendency for greater trade between 'similar' groups than dissimilar groups."[26] A second criticism that strikes at the very core of the Heckscher-Ohlin approach to trade theory was briefly touched on in Chapter 1, namely, the Leontief 'Paradox', which demonstrated that US exports were labour-intensive in comparison to the country's imports.[27]

A study by Myrdal[28] took a radical and pessimistic perspective of the development opportunities for less developed countries. Through a concept he referred to as 'cumulative causation' he asserted that the present efficiency of an economy is determined largely by its past history : thus, although initially competitive economies by developing cumulatively will become more efficient, the reverse will occur for underdeveloped countries whose competitive disadvantage will lead to cumulative contraction of efficiency. Under Myrdal's reasoning, problems loom large even if two countries are initially equally efficient in production, and one country later gains a competitive advantage; this is because the competitive 'edge' grows cumulatively. Moreover, in a scenario where two countries begin industrial life from a position of unequal efficiency then cumulative causation may possess the alarming consequences of exacerbating the development chasm.

The results of Myrdal's study confirmed the difficulties that he hypothesised stem from the classical and neo-classical rationalization of trade. But as the author was unconcerned with the direction of that trade, it was left to Burenstam-Linder to tackle the problem. In his famous thesis of 1961[29] Linder argued that trade flows will tend to be greatest between 'like' countries and least between 'unlike' countries; this is, of course, the antithesis of classical predictions. The appearance of Linder's essay was the first in the formulation of useful empirical propositions about the pattern of international trade in marginally differentiated products of the same type. The pervasive expansion of intra-industry trade shows that much of the enlargement of international commerce takes the form of increasingly fine division of labour within industries, rather than the sectoral specialization assumed in classical discussions of comparative advantage - this to the discomforture of international-trade economists weaned on models of pure competition.[30] Linder showed that a country like Sweden specialized in the production and export of 'quality' goods as are reflected by the demands of the income class possessing the largest numbers. The product qualities sought by the other income groups characterized by lower numbers will typically be imported from those countries where the appropriate income levels are enjoyed by the largest proportion of the population.

Drèze[31] elaborated on Linder's theorizing by distinguishing the 'style' and 'design' differences in products. He found that small countries with a population of ethnic and cultural diversity, such as Belgium, are unable to produce styles and designs of goods to meet the demands of their population at prices competitive with imports from abroad. Instead, Belgium imports style-specific products from its larger, neighbouring countries and specializes in the production of more standardized and functional variants in demand by a narrow section of the market in the rest of the world.[32]

Later works have tended to polarize on whether it might be changes in 'technology' that explain the patterns of international trade. As soon as an invention is applied - and this innovation does not necessarily come into being in the country where the invention evolved because the production mechanism and marketing organisation has to meet certain minimum requirements - the country concerned has a sort of monopoly, which furthermore goes hand in hand with a sellers' market. In this initial phase a large number of changes are made in production technique, and it is only in the following (growth phase), in which mass production is gradually commenced, that buyers become more price conscious. In this phase, the production technique is extended to other countries (e.g. by means of the sale of licenses and the establishment of subsidiaries). Imitation by other countries puts an end to the technological lead, and it may even happen that these countries through lower production costs or differentiation of their products, export to the country in which the innovation originated. In the last phase (maturity phase) there is a buyers' market; and indeed not many more improvements are made in the production process.[33] This is referred to in the literature as the product cycle model of trade.

There are a number of caveats to the validity of the product-cycle approach to international trade. Firstly, one must not lose sight of the fact that technological advance also benefits traditional products. Secondly, innovations have sometimes been known to counteract international trade instead of stimulating it. Cases which come to mind are when nylon to a large extent replaced silk and when the Haber process made possible the extraction of nitrogen from air and thus reduced dependence on natural deposits.[34] Finally, such a cycle does not necessarily occur. Great uncertainty still persists as to the combination of conditions which determines the optimum rate and direction of technological progress.[35] Thus, although the United States is the country whose experience is most apposite to the product-cycle model, with one of the highest per capita incomes in the world and also the lowest of capital/labour cost ratios, the theory is undermined by, again, Leontief's study, that US exports are more labour-intensive than are its imports.[36] Notwithstanding this, product cycle approaches imply that the abundance of skill as opposed to capital is the major determinant of US export performance; and this has been established by empirical study.[37] However, because of its size, wealth, military power, educational system and other attributes, the United States may still not validate the product-cycle theory.[38] It is an area where further empirical research is required and is, in fact, being undertaken.

Vernon's study of 1966, as also those of Posner,[39] Hufbauer,[40] and Stobaugh[41] have resulted in the specification of models capable of explaining international trade in new products in which the producing country has an initial comparative advantage, due to patent or copyright protection or the existence of dynamic economies of scale, but whose competitive-edge might be gradually eroded by the recognition and imitation of the innovations elsewhere. At the present stage of industrialization in the world, most 'new' products have close competitive substitutes, and therefore models of 'technological-gaps' and 'product-cycles' have direct regard to the previously mentioned theory on intra-industry trade.

approach to trade, it does not, in similarity to those of classical ilk, allow for the transfer of technology. More significantly, Linder ignores the investment of multinational companies. But, with production by firms outside their national boundaries now thought to account for 15 per cent of the world's output, this would, under present trading conditions, appear to be a serious omission. The links between direct investment and international trade in manufactured goods is further shown to be important by the evidence on trade which takes place 'within' multinational enterprizes.[42] The product-cycle theory, perhaps comes closest to explicitly recognizing the role of multinational enterprizes in this process. Although Hirsch[43] does admit to their significance. Other economists: Gruber, Mehta and Vernon (1967)[44] and Keesing (1966)[45] ... "have also observed the relationship between the production of knowledge, international investment and trade, and more recently Baldwin (1970)[46] has called for an explicit incorporation of trade in factor inputs into trade theory."[47]

With the introduction of direct investment into international trade, the product cycle theory will operate by relocating the production of 'mature' products overseas, thereby taking advantage of the lower labour costs in the developing countries. Innovation or 'new' products will continue to be induced in the developed countries by the competitiveness and economies of scale existing in these already industrialized areas. It clearly follows, as Frances Stewart has noted, that the ... "flow of trade will thus be North-South for new ('technological gap') products ... and South-North for mature products ..."[48] Concentration of innovation in the North is thus a major explanation of why Linder is wrong in believing that trade is greatest among similar countries - when those countries are the poor countries. However, this same concentration is also the main reason why South-South trade 'ought' to be developed, and North-South trade inhibited : in other words, Linder's thesis ought to be made true.[49] In consequence, there has recently emerged a new orthodoxy to the effect that (labour-intensive) manufactured exports, able to benefit from scale economies derived from sales to world markets

which were under-emphasised in the past, must be
encouraged with at least the same vigour with which import-substituting industry was encouraged in the past.[50]

To conclude this section, then, it must be accepted that present thinking indicates that the merging of the gains from trade with the gains from growth rests ultimately on the efficacy of the developing countries to initiate policy measures that produce sufficient economic change to make their economies more responsive to the stimulus from trade. But as India did, in fact, choose the growth strategy alternative, the intention of the next section is to appraise the progress that the country has made in its efforts to become self-sufficient in the manufacture of machine tools. However, to place the results of the empirical analysis in perspective, it will be helpful if the salient features of the import substitution policy are first described. The section begins, therefore, with a brief overview of the principal planning controls involved in India's trade regime.

Section 2 : The Case of Indian Technological Independence

(i) The Import Substitution Regime

The rationale of establishing domestic machine-making capacity : to remove the need to import a major proportion of a country's technological requirements, is a major aspect of a capital-goods growth strategy. The approach actively promotes the creation of indigenous industry to replace imported goods but the problem is that the machinery by which these goods are produced has itself to be imported.[51] Given, that the initial increase in the level of imports is an acknowledged cost of any country's thrust for self-reliance, the Draft Outline of India's Second Five-Year Plan stated : "if industrialization is to be rapid enough, the country must aim at developing basic industries, and industries which make machines to make the machines for further development."[52] Hand in hand with the growth of domestic industry came an increase in government interference in trading patterns : not only was the composition of imports changed, i.e. reducing the inflow of consumption goods to facilitate the rise in capital goods imports, but also foreign exchange ceilings were introduced to cover all categories of imports. Although Bhagwati and Desai trace the origins of import controls in India back to 1940 and the war years in general, it was not until 1947 they argue, with India's balance of payments becoming adverse, that the emphasis of import policy turned away from the purely descriptive restriction of imports to matters concerning the regulation of foreign exchange. It was at this time, they state, that India : ... "began the changeover from 'qualitative' to 'quantitative' licensing on the basis of specified exchange ceilings allotted for specific commodities and groups, designated by currency areas."[53] However, because of the strains on the country's foreign exchange reserves caused by the heavy industrial investment of the Second Five-Year Plan (1956-61), the various import controls were rigorously tightened up. For this reason, and also because 1956 was in effect the formal commencement of the import-substitution regime, it will provide a suitable point to begin the review of India's import control procedures.

It should be stressed from the start that the method by which India executed its import policy, especially after the 1956-57 exchange crisis, was by the direct control of foreign exchange expenditure. Generally speaking, neither tariffs nor the manipulation of the price mechanism were used by the Indian authorities in influencing the structure of demand in imports.

There was an important operational distinction between imports of raw materials, spares and components as against imports of capital goods and equipment.[54] The six-monthly government budget naturally gave priority for exchange-use to essential resources such as : food, petroleum, and fertilizers, after which the foreign exchange that remained could be distributed for the benefit of economic growth in accordance with the official criteria laid down. The allocation of this foreign exchange was made on the estimated requirements of the public sector undertakings; the Iron and Steel Controller; and the economic advisor, the Ministry of Finance, who would be responsible for the distribution of his portion of the foreign exchange for the various imports of the private sector.

As a first step to importing, it was necessary for all enterprises to apply to license-issuing authorities in order to obtain the clearance to import permissible items. Licenses for established importers were known as 'E.I.s'; for actual users 'A.U.s'; and for capital goods 'C.G.s'. There were numerous other licenses but the aforementioned could be said to be the most important. The rationale under which each category of license was vetted centred around the two main pillars of India's foreign exchange policy : 'essentiality' and indigenous 'non-availability'. It is difficult to better the description of these two principles than the one given by Bhagwati and Desai : "Thus, imports, in terms of both magnitude and composition, were to be permitted under each category only if some designated agency of the government had certified that they were 'essential' (as inputs or equipment for production). At the same time, some agency had to clear the imports from the viewpoint of indigenous availability : if it could be shown that there was domestic production of the imports demanded, then the imports were not permitted (regardless of cost and quality considerations). Thus, in addition to the license-issuing authority, there was a 'sponsoring' agency certifying 'essentiality' and a 'clearing' agency for 'indigenous clearance'." [55]

Although these measures would seem to have provided the Indian government with a definitive and encompassing regulatory framework, problems were encountered in practice because allocative decision making had to be projected past first stage priorities into the 'grey areas' of sub-priorities. In terms of A.U. licenses, difficulties must have been enormous simply due to the sheer numbers of industrial priorities that existed. Further, on what basis could there have been an evaluation of priority between say, a manufacturer of pneumatic pumps and a manufacturer of coal mining equipment? Seemingly, all such decisions would have to have been made eventually in relation to : industrial capacity, employment, and perhaps, past import allocations. If this was the situation in regard to industry-wise allocations of foreign exchange, little imagination would be required to see that problems would have been amplified when decisions were reduced to the question of unit allocations. Here again, in the final analysis arbitrary judgements would have had to have been made on the eligibility of competing firms for the utilization of foreign exchange. If Bhagwati and Desai's reflections are near the mark, then such decisions were inefficiently though perhaps inevitably based on : "the spreading-out evenly of a scarce resource on a 'fair' and 'equitable' basis."[56]

One of the objectives of the import-substitution regime was to restructure the composition of imports away from consumption commodities towards the more growth-orientated capital good items. One of the ways that the authorities successfully implemented this policy was through the reduction in the issue of E.I. licenses which covers a multiplicity of activities, in favour of the production-biased A.U. licenses. However, a noted characteristic of import-substitution strategy has regard to the encouragement that it implicitly gives to the domestic production of the displaced consumption good imports and India proved to be no exception to this process. The impact of this factor on India's economic growth is difficult to calculate but Hazari has worked out estimates which do provide some indirect indication of its importance through the maintenance imports needed to sustain domestic consumption : "for the years 1961-2 and 1963-4 he found that 7.6 and 8.5 per cent of total imports went to 'luxuries' and 28.7 and 32.9 per cent to 'necessities' (which included such items as : matches, thermos flasks, and electric fans)." [57]

Space does not permit extensive treatment of the numerous problems which hampered the effective implementation of India's import-substitution regime. Without elaboration, suffice to note the more important of these additional constraints : delays, administrative and other expenses, inflexibility, lack of co-ordination among different agencies, absence of competition, inherent bias in favour, ceteris paribus, of industries with imported, as distinct from domestically produced inputs, anticipatory and automatic protection afforded to industries regardless of costs, discrimination against exports, and finally, loss of revenue. [58]

To be fair, the Indian government was aware of many of the weaknesses involved in the import-substitution procedures and in conjunction with the pressures from the country's continuing balance of payments deficit made some attempts in the sixties and seventies to remedy the more obvious deficiencies. In 1962, the Import and Export Policy Committee headed by a Mr. Mudaliar advised that maintenance and developmental imports were both essential for a growing economy. The interesting feature of the committee's recommendations was, however, that the increased supply of these raw materials and components should not just be channelled to the priority capital goods industries but to any industries that were export-orientated.

This may be seen as a significant watershed for government trade policy : the economy was to be encouraged to break-out from the 'hot-house' of import substitution via the promotion of exports.

The import policy announced after the devaluation of 1966, was to provide added substance to the Committee's initiative by liberalizing the import of raw materials, components and spares for 59 priority industries.[59] This increasing liberalization of imports was extended in 1976 to allow manufacturers engaged in export production to use, if so desired, their entire import replenishment entitlement for the import of machinery required for modernization, replacement and research and development. Finally in 1977, the coming to power of a new government, the Janata Administration, took import-liberalization many steps further on; a fresh philosophy was introduced, that of giving impetus to the small scale sectors of the Indian economy. There was also a major dismantling of many of the license restrictions and, in an effort to create greater competition and efficiency within the 'key' sectors, there was to be a further significant liberalization of imports but, now especially, capital good imports.

The description of India's import substitution policy has set the stage to examine the progress that the country had made in its drive towards self-sufficiency in the manufacture of machine tools. This aim of the industry forms the basis of the next part of the section.

(ii) <u>Machine Tool Manufacture : Self-reliance and After</u>

As the numerous references that permeate the text testify, self-sufficiency has repeatedly been stressed in the planning documents of India as a goal to which great importance has been attached. This objective has applied a fortiori to the machine tool industry as it has consistently been accorded 'key' status in the planned development of the country.

Since 1955, the value of imports of machine tools has risen five-fold from Rs.52.9 million to Rs.266.4 million in 1975. Nevertheless, as Table 25 shows, the machine tool branch of India has progressed over the same period from a situation where it initially provided only 11 per cent of total consumption to one where twenty years later in 1975, it accounted for 78 per cent of the country's demand for machine tools. Thus, machine tool imports over the period have dropped to only 22 per cent of total supply consisting mainly of special types like gear shavers, very heavy duty types and high precision machines like jig boring machines, thread grinders, gear grinders, spiral bevel generating machines, etc.[60]

At this level of analysis, import substitution in the machine tool industry appears to have been very strong, and especially so during the 1970s. However, with the help of a statistical technique borrowed from Alfred Maizels[61], the examination of the industry's import-replacement performance can be taken a stage further by breaking-down the total change in imports of machine tools into two elements : import-substitution and demand expansion. If, as industrialization has proceeded over the twenty year period, the increase in the demand for machine tool imports can be separated from the total change in imports, then a more accurate picture of the import substitution effect can be obtained. This 'pure' measure of import-substitution is simply the calculation of the difference between the actual imports at the end of the period and what they would have been if the ratio of machine tool imports in total supply had remained constant as at the commencement of the period. Likewise, the expansion of demand is arrived at by the

Table 25 : Indian Machine Tool Production and Trade 1955 to 1975*

(Rs.million)

Year	Total Indigenous Production (1)	Total Imports (2)	Total Exports (3)	Supply of Tools to India Cols.(1+2)-(3) (4)	% Imports to Total Supply of Tools Cols.($\frac{2}{4}$ x 100%) (5)	Self-Sufficiency Rate (100-Col.5) (6)
1955	6.80	52.90	-	59.70	89	11
1956	10.60	83.50	-	94.10	89	11
1957	23.40	146.10	-	169.50	86	14
1958	34.00	143.90	-	177.90	81	19
1959	41.60	162.90	-	204.50	80	20
1960	58.60	209.40	-	268.00	78	22
1961	85.20	178.90	1.50	262.60	68	32
1962	120.10	189.50	1.50	308.10	62	38
1963	167.80	315.10	1.70	481.20	65	35
1964	209.70	344.40	2.60	551.50	62	38
1965	254.60	352.10	5.60	601.10	59	41
1966	284.80	430.00	6.60	708.20	61	39
1967	254.70	394.00	6.80	641.90	61	39
1968	206.30	335.10	18.80	522.60	64	36
1969	266.70	189.90	29.50	427.10	44	56
1970	374.50	183.00	27.90	529.60	35	65
1971	503.20	217.05	30.50	689.75	31	69
1972	494.57	236.42	29.80	701.19	34	66
1973	622.58	286.25	36.86	871.97	33	67
1974	884.50	294.60	72.00	1107.10	27	73
1975	1040.30	266.40	85.00	1221.70	22	78

Sources : (i)D.G.T.D. Government of India
(ii)Indian Machine Tool Manufacturers Association
(iii)American Machinist (Feb.1976)

N.B. * Relates to Group A Machine Tools only calculation of the difference between the total supply of machine tools in the initial year with the figure for the current year on the assumption that the import-proportion of total supply had remained constant throughout the period. Symbolically, the change in imports from a base to a current year can be written as :

$$\partial M = M_1 S_1 - M_o S_o$$

where M represents the import-proportion of machine tool supplies, S denotes total machine tool supplies, the subscripts o and 1 referring to the base and current periods, respectively.[62]

Table 26 shows the results of this analysis for the Indian machine tool industry during the period 1960-75. The contents of the table are striking in that import-substitution over the whole period was 85.3 per cent higher than the expansion in demand; a prolific performance by any standard. During the first period 1960-65, the effect of the import-substitution of machine tools was dramatically outweighed by the stimulation of expanding demand generated by the heavy government investment into capital goods industries. The subsequent five year period witnessed a sharp change in the impact of import substitution, being far and away the more positive influence in the change of imports. In large part, this must be attributed to the recession that occurred in the economy during the latter years of the 1960s. For the final period, spanning the first five years of the 1970s, the change in imports was minimal, amounting to Rs.23.4 million or only 13.5 per cent of the total change in imports of machine tools over the whole 16 year period. The 'pure' import-substitution effect in this last period was 33.5 per cent greater than the expansion in demand, thus continuing to outstrip the latter component by a considerable margin. For the entire period 1960-75, import-substitution accounted for Rs.376.5 million which, against the lower expansion in the demand for tools of Rs.203.2 million, caused a decline in imports of Rs.173.3 million. However, an obvious fact to emerge from the table relates to the progressively declining trend in the level of import-substitution; the share of each period in the total import-substitution over the 16 year period falling from 41.4 per cent during 1960-65, to 33.8 per cent during 1965-70, and finally, to 24.8 per cent during 1970-75. Although this is what would be expected in the normal course of events - the more you make yourself, the fewer are the possibilities of substitution - it is the repercussions of such a process that evoke concern.

Table 26 : Effect of Import-Substitution and Expansion in Demand on Imports of Machine Tools (1960-75)

(Rs.millions)

Period (o) (1)	Aggregate* Supply (S_o)	(S_1)	Imports (M_o)	(M_1)	Change In Imports (M_1-M_o)	Import Substitution $S_1\left(\frac{M_2}{S_1}-\frac{M_o}{S_o}\right)$	Expansion in Demand $\frac{M_o}{S_o}\left(S_1-S_o\right)$
1960-65	426.1	798.3	332.9	467.6	134.7	-156.0	290.7
1965-70	798.3	529.6	467.6	183.0	-284.6	-127.2	-157.4
1970-75	529.6	732.0	183.0	159.6	- 23.4	- 93.3	69.9
1960-75 :					-173.3	-376.5	203.2

Source : From Table 25

* Aggregate supply = (Domestic production + Imports)-(Exports).

All data reduced to constant prices using the U.N. implicit price deflator index of G.F.C.F. by manufacturing (1970 = 100).

India has followed the conventional path of most contemporary developing countries in respect of foreign trade : the replacement of primarily agricultural exports by an import-substitution regime charged with the objective of conserving scarce foreign exchange resources; but which, after a period of time has elapsed, gives over once again to an export-orientated type of economy. The problematical question concerning export-promotion, however, is whether the many years of operating in a sheltered market has left India's producers unable to compete in world markets. This has particular relevance to the machine tool industry which has been protected from foreign competition since its inception in 1956. It may be, that for many of the poorer countries, an import-substitution policy is a 'necessary evil' but it can perhaps be pushed too far to the neglect of productive efficiency and consequently cost effectiveness. On this point, it is pertinent to mention the contribution of Little, Scitorsky and Scott in their celebrated study on industry and trade in developing countries, thus :
"Too much import-substitution implies wide resort to capital-intensive processes. For a given value of industrial output more capital has to be used, which implies less investment in other sectors and therefore less employment there ... Although industry can grow much faster than the domestic demand for manufacturers while import-substitution is taking place and thus appear as a 'leading sector' in growth, this process can go on only for a limited period - perhaps about 15 years ... Thereafter, only exports can permit industry to grow faster than the internal demand for manufactures. But by then the country will have an industrial structure unsuited to export markets ... restricted by the high prices and inequalities associated with excessive emphasis on import-substitution."[63]

This statement by Little et al., seems to have been tailor-made to describe the predicament that the Indian machine tool industry finds itself at this time. It is a prime example of an industry, and especially the public sector thereof, that has been fostered under heavy government protection to the possible detriment of the rest of the mechanized economy. Thus, with India's import-substitution programme running out of steam, if the growth of the tool industry is to be maintained there will be a need, it might be argued, given the low levels of absorption of machine tools in India, for a rapid growth of exports to occur. It is to this question that the study now addresses itself.

Prior to 1961, there were no exports of machine tools from India. Even after that year, as table 25 illustrates, machine tool exports were of minimal significance throughout the remainder of the decade; the final year, 1969, was an exception though. In that year, the value of exports at Rs.29.5 million was higher than the aggregated export value for the entire period 1961-7. It was the recession in domestic industry, coupled with the introduction at about that time of sympathetic government measures to encourage exports that led to this sudden upsurge in the sales of machine tools abroad. The annual average rate of increase in export value from 1961 to 1975 amounted to a gargantuan 33.4 per cent. But, as this figure is distorted by the relatively small amount of exports in the base year, it may be more appropriate to gauge the rate of growth from 1969. Even here though, the value of exports up to 1975 registered a very high 19.3 per cent rate of growth. This rate of increase in the value of machine tool exports is indeed very high but it should be tempered, however, by the sobering fact that for 1975, the total volume of India's machine tool exports represented only 0.2 per cent of world exports; it was only 2.1 per cent of those of the United States; a mere 0.6 per cent of West Germany's; and, perhaps more worrying, was lower than Brazil's or even Taiwan's exports.[64]

Table 27 provides a further insight into the export performance of the machine tool branch by the disaggregation of total annual exports according to their regional destinations.

Table 27 : Export Performance of Indian Machine Tools

(Rs./Lakhs)

Region	1972-3	Year 1973-4	1974-5	1975-6	Reg. Totals
South East Asia	54	55	176	126	
West Asia	6	18	19	68	
Asia Total :	60	73	195	194	522
East Africa	13	22	36	32	
North and Central Africa	4	9	18	17	
West Africa	2	4	20	6	
Africa Total :	19	35	64	55	173
East Europe	2	79	23	28	
West Europe and EEC	37	46	96	100	
EFTA Countries	32	51	44	111	
Others	2	3	3	15	
Europe Total :	73	179	166	154	672
United States	26	38	82	146	
Canada	6	6	32	42	
North America Total :	32	44	114	188	378
Others	1	1	4	10	
Australia	12	23	118	80	
New Zealand	8	12	45	28	
Oceanic Islands	3	2	2	5	
West Indies	1	1	1	1	
Grand Total :	210	369	712	818	2109

Source : Indian Machine Tool Manufacturers' Association Annual Report 1975-76, Appendix III.

Although the table only depicts data for the period 1972-3 to 1975-6, this is probably the most important period, in the sense that exports expanded rapidly during this time. It can be seen that over the 4 year period, the combined Asia and Africa export totals amounted to Rs.695 lakhs which was Rs.355 lakhs less than for the combined Europe and North America totals. Moreover, notwithstanding the fact that the annual average growth of export value to the developing regions was very high at 27.5 per cent, it was still lower than the 28.8 per cent rate of growth of Indian machine tool exports to Europe and N. America.

These statistics require interpretation and two questions contained in the questionnaire of this study's survey were included for just that purpose. Firstly, it was thought important to ascertain the role exports play in the manufacturing activities of the units covered in the sample. Table 28 documents the evidence for the 3 year period 1974-76. The data clearly shows that the vast majority of firms were not involved in the export of their products to any great extent. It was usually the case that the larger companies and, HMT in particular, accounted for the lion's share of Indian machine tool exports.

Table 28 : Share of Companies' Output Destined for Export Market

Share of Output (%) to Exports	Companies by Year 1974 (nos)	1974 (%)	1975 (nos)	1975 (%)	1976 (nos)	1976 (%)
0	22	56.4	23	57.5	15	37.5
1-25	14	35.9	12	30.0	19	47.5
26-50	2	5.1	2	5.0	3	7.5
51-75	-	-	-	-	1	2.5
76-100	1	2.6	3	7.5	2	5.0
Valid Cases	39	100.0	40	100.0	40	100.0
Missing Cases	1		-		-	
Sample	40		40		40	

Source : The Indian Machine Tool Industry Survey (1978)

There is good reason to believe that this fact also accounts for the high proportion of exports destined for the more advanced markets of Europe and North America, rather than the other developing countries where the industrial environment would be expected to be somewhat similar.

On this point, note what the then Managing Director of HMT said in 1978 : "HMT successfully applied the first lesson of export promotion, the best way into the market is through the strongest and not the weakest buyers...", and commenting on the company's export performance to other developing countries he remarked : "sales in the developing countries were ... inhibited by the fact that the demand for sophisticated and precision machine tools of the type produced by HMT were limited to the few purchases being made mainly from aid-giving countries under their tied-aid programme."[65]

If attention is directed to Table 29 it will be observed that the growth of HMT's exports during the period 1962-75 averaged 23.4 per cent though during 1970-75, this is reduced by half, to 11.5 per cent.

Table 29 : Export Performance of HMT (1970-75)

	(1) HMT* Exports		(2) Industry Exports		(3) Industry - HMT Exports		(4)
Year	current prices	constant prices	current prices	constant prices	current prices	constant prices	(1) as a (%) of (2)
1962	1.5	2.3	1.5	2.3	-	-	100.0
1970	20.4	20.4	27.9	27.9	7.5	7.5	73.1
1975	60.5	35.2	81.8	47.6	21.3	12.4	73.9
AAG(%)							
(1962-75) :		23.4		26.2		-	
(1970-75) :		11.5		-		10.6	

Source : (i) HMT Company Annual Accounts
(ii) S.M. Patil : 'A Quarter Century of HMT', Leaflet (1978), p.43.
(iii) S.M. Patil : Study of the Indian Machine Tool Industry UNIDO-HMT (1975), p.5.

Notes : * HMT's figures relate to financial year (year ending 31st March)

Constant prices : (1970 = 100)

Furthermore, it appears that the company's export performance has proved only marginally more successful than for the industry as a whole as evidenced by the slightly lower growth rate of the latter over the 1970-75 period. This small difference in the trends is surprising given that the value pattern of HMT's exports would have been thought to have increased relatively more rapidly during this period. It may partly be explained by the diminishing importance of machine tools in the total production activities of the company; that is, the growth in the volume of exports has been less than the growth in export value.[66]

The second question concerning exports that was included in the questionnaire was intended to seek information on the possible existence in the industry of discriminatory pricing between domestic and foreign purchasers. The inclusion of this question was prompted by the results of the research conducted by M. Frankena in the late 1960s which indicated that : "the landed export prices of Indian engineering goods in 1967-70 were often substantially below those received for the same products and markets by competitors from advanced countries.[67] The evidence Frankena obtained seemed to justify his two conclusions : (i) Indian engineering goods other than commodity-like products were exported for hard currency only at prices below those received by competitors from West European countries, and (ii) the size of the price discount necessary to sell Indian goods was positively related to the marketing requirements of the product. In respect of machine tools,he found that a discount of between 20-30 per cent had been applied to an unspecified Indian machine tool manufacturer's product in comparison with a West German competitor.[68] Frankena suggested three reasons why export price discounts operated on Indian engineering goods, and they formed the basis of the question put to the machine tool units, covered by the survey, on the question of export pricing policy.

Table 30 details the responses received by the participating companies. From the 26 replies given by firms to this question, 15 stated that they had no discount policy.

Table 30 : Policy of Companies Regarding Discounts on the Export Price of Machine Tools

Type of Policy	Companies by Size							
(A) Discount Policy Because :	Small (nos)	Small (%)	Medium (nos)	Medium (%)	Large (nos)	Large (%)	Row Totals (nos)	Row Totals (%)
(i) Costs of breaking into the market	5	33.3	-	-	4	44.4	9	34.6
(ii) Increased profitability as the costs of marketing are greater than the costs of discounts	-	-	-	-	1	11.1	1	3.8
(iii) Smaller back-up services to distributors so reducing the private costs of exports	-	-	-	-	1	11.1	1	3.8
(B) No Discount Policy :	10	66.7	2	100.0	3	33.3	15	57.7
Valid Cases	15	100.0	2	100.0	9	100.0	26	100.0
Missing Cases	9		2		3		14	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

Of the firms that gave discounts : 9 units regarded it as the costs of breaking into new markets;[69] 1 unit, that it was cheaper than providing elaborate marketing arrangements; and 1 unit, which indicated that it was less expensive than the provision of back-up services. An interesting point, is that a higher percentage of small and medium sized firms had no discount policy as opposed to the large sized companies, although this probably reflects nothing more than the greater competitiveness of the 'Western' markets in which the larger concerns are involved.

The results contained in table 31 on the pricing policy of Indian machine tool exports are far too inconclusive to be interpreted as congruent with Frankena's findings on the issue.[70] The situation would in any case have changed since Frankena conducted his research because in the early 1970s, the Indian government introduced an export subsidy scheme which was available to all quality machine tool manufacturers; it being an explicit attempt by the authorities to encourage producers to export more of their output. As the export subsidy amounts to 25 per cent of saleable value; a figure suspiciously similar to that cited by Frankena in his study, it would seem that the government has now overtly taken over the role of artifically cheapening the price of India's machine tool exports, thus, assuming the financial burden that was previously borne by the manufacturers themselves. However, import substitution implemented through protection probably created in the intermediate goods industries a situation in which the costs of production were higher than international costs and prices. Obviously, under such conditions, the competitiveness of India's machine tool exports would deteriorate in direct relation to the increase in the costs of the intermediate goods the tool industry used and still uses as inputs. Inter-state and local excise duties would have tended to compound the issue. In these circumstances, it could be that the industry has had to use the relatively high cost domestically produced inputs as opposed to the cheaper input materials which could have been imported from abroad;[71] but, in order to ensure the competitiveness of exports, the Government attempted, indirectly, to make these inputs available to exporters at world prices.[72] Therefore, the Indian Government's export subsidy on machine tools could reflect more an attempt at neutralizing the high costs imposed by domestic inputs and taxes than the hypothesised need to compensate for inefficiencies incurred in production.

References and Notes

1. Celso Furtado :'Development and Underdevelopment', Uni. of California Press, L.A. (1964), p.142.

2. M. Merhav : 'Technological Dependence, Monopoly and Growth', Pergamon Press,(1969) p.30.

3. "Dependent economies are, usually rightly said to suffer from the use of excessively capital-intensive technologies" and "..there is no reason to doubt that LDC's as a group 'depend' for their industrial technology on advanced countries, in the sense simply of getting most of their technology from abroad." Sanjaya Lall : 'Is "Dependence" a Useful Concept', World Development, Vol.3, (Nov/Dec.1975) p.804.

4. The theoretical description of the structural relationship between exports and growth draws heavily from M. Merhav : ibid., Chapt.5, which has itself been based on P. Sweezy's, 'The Theory of Capitalist Development', Oxford Uni. Press N.Y., (1942) Chapt.10.

5. It is conventional to ignore the possibility of importing consumption goods.

6. M. Merhav : Op.cit., p.164.

7. This phrase is taken from : R. Nelson 'A Theory of the Low-level Equilibrium Trap', A.E.R. (Dec.1956), p.894.

8. M. Merhav : Op.cit., p.166.

9. H.B. Chenery : 'Comparative Advantage and Development Policy', A.E.R. Vol.4, No.1 (March 1961) p.19.

10. H.B. Chenery : ibid., (p.20) he goes on to say ..."these assumptions are not required by classical trade theory."

11. See Raul Prebisch : 'The Economic Development of Latin America and its Principal Problems', E.C.L.A., U.N., N.Y. (1950), and 'Commercial Policy in the Underdeveloped Countries', A.E.R. Papers and Proceedings (May 1959).

12. P. Khalatbari : 'Application of the Marxist Reproduction Model to the Developing Countries', in Mai Palmberg (Ed.) :'Problems of Socialist Orientation in Africa',Scandinavian Institute of African Studies, Uppsalu, Sweden (1978)p.105.

13. P. Khalatbari : ibid., p.105.

14. P. Khalatbari : ibid., p.106.

15. M. Merhav : Op.cit., p.170.

16. P. Khalatbari : Op.cit p.106.

17. From the World Economic Survey, U.N. (1968-70) p.58 the developed market economies coefficients of import elasticities were listed thus:

Commodity Class	Elasticity
Food, Beverages, Tobacco (SITC 0+1)	0.6
Crude Materials, Oils and Fats (SITC 2+4)	0.5
Fuels (SITC 3)	2.4
Manufactures (SITC 5-8)	1.9
Total, excluding fuels	0.8

18. Calculations : (i) T_1, T_2 and T_3 derived from the basic relation :

$$\frac{\text{Terms of Trade of the developing countries}}{\text{Terms of Trade of the developed countries}}$$

(ii) $I_1 = Q_1 \times T_1$, $I_2 = Q_2 \times T_2$, $I_3 = Q_2 \times T_3$

(iii) Q_1, and Q_2 are self-evident.

19. M. Merhav : Op.cit., p.174. This author conducted a similar analysis though only extending to 1965.

20. J. Baranson : 'Manufacturing Problems in India - The Cummins' Diesel Experience', Syracuse Uni. Press (1968) p.6.

21. A.P. Thirlwall : 'Growth and Development with Special Reference to Developing Countires', Macmillan (1974), p.151.

22. W. Leontief : 'The Structure of Development', Scientific American, 209 No.3 (Sept.1963) pp.162-3 quoted in Merhav : Op.cit., p.56.

23. M. Merhav : Op.cit., p.56.

24. A.H. Amsden : 'The Industry Characteristics of Intra-Third World Trade in Manufactures', Economic Development and Cultural Change, Vol.29, No.1 (Oct. 1980) p.1.

25. F. Stewart : 'The Direction of International Trade : Gains and Losses for the Third World', in G.K. Helleiner : A World Divided - The Less Developed Countries in the International Economy Cambridge Uni. Press (1977) p.94.

26. Ibid., p.94.

27. The 'paradox' being explained by the large human investment characteristic of US exports.

28. G. Myrdal : *Economic Theory and Underdeveloped Regions* London, Duckworth (1957).

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34. M. Van Meerhaeghe : *International Economics*, Longman, (1972) p.54.

35. 'A note on the New Delhi Session of the UNCTAD and Implications for International Trade of Changes in Technology and Industrial Structure', *Economic Bulletin For Europe*, No.1, (1968), p.58.

36. See W.W. Leontief : 'Factor Proportions and the Structure of American Trade', *Review of Economics and Statistics*, (Nov. 1956). See also, 'The Impact of National Characteristics and Technology, on the Commodity Composition of Trade in Manufactured Goods', in *The Technology Factor in International Trade*, NY, Columbia Uni. Press (1970).

37. See I.B. Kravis : 'Availability and other Influences on the Commodity Composition of Trade', *Journal of Political Economy*, April 1956; and L.T. Wells Jnr. 'Test of a Product Cycle Model of International Trade : US Export of Consumer Durables', *Quarterly Journal of Economics*, (Feb. 1969).

38. On this, see S. Hirsch :'The Product Cycle Model of International Trade - A Multi-Country Cross-Section Analysis', *Oxford Economic Bulletin of Economics and Statistics* (1975) p.305.

39. M. Posner : 'International Trade and Technical Change', *Oxford Economic Papers*, 13, (Oct. 1961) pp.323-41.

40. G.C. Hufbauer : *Synthetic Materials and the Theory of International Trade*, London, Duckworth (1966).

41. R.B. Stobaugh : 'Where in the World Should We Put That Plant', *Harvard Business Review*, (Jan/Feb 1968).

42. Exports to their overseas affiliates amounted to 52 per cent of total exports by 320 major US manufacturing firms in 1965; roughly one-third of these intra-firm exports were destined for further processing overseas. M.T. Bradshaw : 'US Exports to Foreign Affiliates of US Firms', *Survey of Current Business*, Vol.49, No.5, (May 1969) pp.34-51.

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48. F. Stewart : Op.cit., pp.96-7.

49. Ibid., p.98.

50. G.K. Helleiner : 'Manufactured Exports From Less-Developed Countries and Multi-national Firms', *Economic Journal*, 83, (March 1973) p.22.

51. Over the 10 year period 1947-48 to 1957-58, the import of capital goods into India rose from 22.3 per cent to 30 per cent of all imports. See Table 5.2 in D. Bhattacharya : Op.cit., p.210.

52. Government of India : Second Five Year Plan, p.25.

53. J. Bhagwati and P. Desai : Op.cit., p.282.

54. J. Bhagwati and T. Srinivasan : 'Foreign Trade Regimes and Economic Development : India', Oxford and IBH Publishing Co. N.Y. (1975), p.36.

55. J. Bhagwati and T. Srinivason : ibid., p.37.

56. J. Bhagwati and T. Srinivasan : ibid., p.38.

57. J. Bhagwati and P. Desai : Op.cit., p.307.

58. J. Bhagwati and T. Srinivasan : Op.cit., p.41.

59. R. Datt and K. Sundharam : Op.cit., p.590.

60. Dr. S. Patil : 'Indian Machine Tool Industry and its Future Growth', Unpublished paper (1978) p.6.

61. A. Maizels : 'Industrial Growth and World Trade', N.I.E.S.R., Cambridge Uni. Press (1963).

62. See A. Maizels : ibid., pp.150-51, and also C.Y. Cheng : 'The Machine Building Industry in Communist China', Edinburgh Uni. Press (1972), p.212.

63. Little, Scitorsky and Scott : 'Industry and Trade in Some Developing Countries - A Comparative Study', OECD, Oxford Uni. Press (1970), p.11.

64. Calculated from the Indian Machine Tool Manufacturers' Association Annual Report (1975-76) Appendix II, - original source 'American Machinist'.

65. Dr. S. Patil : 'A Quarter Century of HMT', pamphlet (1978), p.42.

66. Although no figures are available for exports, it is indicative that while total production value (in constant 1970 prices) grew at an annual average rate of 13.5 per cent from 1969-76, the corresponding growth of units produced over the same period managed only 2.4 per cent, and incredibly, the growth of sales actually declined by 1.5 per cent. (See Table 10 in Chapter 3).

67. M. Frankena : 'Marketing Characteristics and Prices of Exports of Engineering Goods From India', Oxford Economic Papers No.25 (1973), p.127.

68. M. Frankena : ibid., See Table 1 p.30.

69. According to Frankena, this was a temporary strategy used successfully by Japanese machine tool exporters, during the early 1960s, in the North American and Australian markets, ibid., p.132.

70. It should be noted that although Frankena makes no explicit mention of it in his article, the period 1967-70 was a time of acute recession in Indian industry and consequently, Indian exporters of machine tools may have been willing to sell their products at below cost with the sole objective being to obtain some contribution to fixed capital.

71. As a case in point, ... 'The price of Argentine sulphuric acid is three to four times the price on the international market, because a 100 per cent customs duty is charged on sulpher imports in order to permit a modest amount of domestic production (at high costs)'. M. Van Meerhaeghe : Op.cit., p.98.

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Chapter 5

Technical Development in the Production of Machine Tools : The Goal(3) of Efficiency

Unquestionably, there exists a relationship between capital accumulation and the process of development. It is clear that a growing capital stock enlarges a country's capacity to produce goods; but both Fel'dman's and Mahalanobis' conception of the role that capital has to play in a developing country ran deeper than this : their theoretical models explicitly took into account the growth inducing effects of 'reproducible' capital goods investment. However, there is a complication to this approach, in that merely increasing the size of the capital goods sector and thereby enlarging an economy's productive capacity, may not be 'far and away' the most important element in economic growth. Basically, the problem hinges on how capital is defined, and whether it incorporates technological development.

The problems concerning the definition of capital were dealt with fully in Chapter 1. There, capital was defined simply as : "those goods which expand the productive base of an economy". Obviously though, this classification is arbitrary and many goods and services commonly judged as being consumption-orientated could quite validly be included under the heading of capital items. Examples readily spring to mind : investment into education and social overhead capital for instance, both improve the potential for further productive investment. It is important, therefore, to be continually aware of such difficulties when analysing capital goods as a source of output growth.

Further to the problems concerning the impreciseness of the classification between capital goods and consumption goods, there is the controversy regarding the origins of technological advance : is it the case that growth is endogenously determined through factor input variables as classical and sector-biased growth and development theories have been primarily concerned to show, or alternatively, is growth exogenously determined as production functions assume? It must be emphasised, however, that this disagreement does not detract from the consensus that exists among economists[1] that the process of capital accumulation is a 'sine qua non' for technological development in an economy.

Irrespective of the contentiousness surrounding the definition of capital, two important factors which impinge on economic growth derive from the establishment of a domestic capital goods sector in the 'closed type' economies such as those of the Soviet Union and India : not only is industrial capacity to produce enlarged through the production of 'machine-making' machines but also, the rate of technological development in the sector will determine the price of capital relative to labour.

The latter aspect regarding the relative price of domestically produced technology is a consideration that has received only piecemeal attention in economic discussion; its importance to economic development, however, is crucial. The Soviet Union during its initial phase of development has been one of the few recently industrialised countries to give explicit recognition to both objectives : a policy of resource allocation directed mainly at extending basic capital goods capacity whilst at the same time, economizing, in the widest sense, on the use of capital wherever feasible.

The development path of the Soviet machine tool industry is a manifestation of this strategy. The Soviet planning authorities assigned the industry a 'leading sector' and allocated investment funds accordingly. As such, the situation reflected nothing more than the machine tool branch's critical role in the reproduction of capital. More significant perhaps, was the realization by the Soviets that efficiency in the manufacture of technology was equally as important as the efficiency embodied in the machines produced. This meant more than simply invention and innovation, it encompassed education and training facilities and many other considerations concerned with the organisation of production. Productive efficiency was the 'raison d'etre' of the Soviet machine tool industry's development strategy because clearly, the simple fact had been grasped that the price of a machine is the essential variable determining its marginal efficiency to would-be buyers; it influences not only the initial decision to purchase but also later plays a major part in the decision to replace. Therefore, via high levels of specialization, scale and standardization, a high degree of operational efficiency leading to low-cost production was achieved in the machine tool sector.

In addition, there is the fact that the technology produced was appropriate to the low capital-labour coefficient pertaining to the Soviet machine building industry of the 1930s. Even small accretions of capital to the workers in this sector would have had a substantially greater impact on output growth than would have occurred in countries where capital deepening had already been taking place for some considerable period of time.

When talking of a Soviet machine tool production strategy, it is necessary to emphasize the priority given to the manufacture of simple, general-purpose machine tools. This form of technology facilitated large production runs because of its amenability to the standardization of components and parts. In turn, the economies of specialization and scale that accrued would have reduced the price of the final product. It was via this somewhat circuitous route that a sufficient level of demand for machine tools, necessary to sustain the process, was generated from the machine building industry. Technological progress, in the sense of radically altering the mechanical means of production of the tools produced did not take place. Although the machine tool industry did make minor improvements to the product range, primarily for the purposes of 'scaling-up', in the main, production was based on selected imports of only standard and proven foreign machine tool designs. Product-innovation, therefore, took a 'back seat' in the Soviet machine tool industry's overall development strategy.

India's perception of the role technological progress should play in the manufacture of machine tools differed sharply from that of the Soviet approach. Based on the Western model of innovation : the 'Brown-Rosenberg' paradigm delineated in the methodology of this study, the Indian machine tool industry's product range was characterised by ever-increasing diversification and sophistication. Batch production methods predominated and, as a result, cost-price reductions due to scale and specialization did not materialize. Moreover, standardization of components was minimal which further impeded movement towards increased efficiency. Using foreign collaboration as the vehicle for technological change in the machine tool industry's product range, labour-saving innovation was introduced into India's metal-working economy. This form of technology was not only inappropriate but, for the reasons advanced above, it may also have been high-priced. In India, therefore, the traditional strategy of machine tool production based on innovation - induced - replacement broke down; the external motivations for innovation to take place in the tool industry were absent probably because the marginal efficiency of the technology the sector produced was far too low for machine builders to rationally contemplate purchasing. In a low income economy cost-price considerations must always predominate.

In pursuance of the Western model, India merely subscribed to the accepted proposition that capital accumulation is a necessary, some might say the sole condition, for the development of underdeveloped countries : the putative escape route from the 'vicious circle of poverty'. A major intention of the present study however, has been to suggest that capital accumulation may not, by itself, be a sufficient condition for development to take place. It is not enough for a country like India to be self-sufficient in the manufacture of machine tools or other capital goods, attention must also be paid to the efficiency with which the technology is produced.

An important element in this framework relates to demand. There are two key issues, specifically in relation to the production of machine tools in India, which can be delineated :

(i) For the technology to be appropriate to the machine building sector, it might at the same time have to be relatively low-priced; and

(ii) as in the Soviet schema, if the above pre-condition is satisfied, then aggregate demand should cease to be a constraining influence on the scale of machine tool output.

The contention is, that if the price of a tool can be reduced sufficiently then a rising demand schedule will automatically ensue; the process feeding on itself by creating the conditions necessary for scale economies to take place. In this reformulation of conventional industrial thinking, demand for machine tools in the initial stages of industrialization is held to follow rather than lead increased efficiency in the machine tool branch.

In support of this approach, it is worth noting a statement by Rosenberg : "in underdeveloped countries, the investment decision is likely to be heavily weighted by an unfavourable relative price structure which acts as a serious impediment to investment activity. The investment decision after all, involves computation of a prospective rate of return which is determined by the present price of capital goods and the anticipated future price of consumer goods. But it should be clear that the relative inefficiency of the capital goods industries in underdeveloped countries and therefore the high price of capital goods is responsible for yielding low or even negative rates of return on a wide range of prospective investments. A major handicap of underdeveloped countries then, is located in their inability to produce investment goods at prices sufficiently low to assure a reasonable rate of return on prospective investment."[2] For empirical validation of his thesis, Rosenberg draws on a study by Kuznets[3] who found that the marginal efficiency of the capital goods produced by the advanced countries' producer good industries was at a relatively higher level than their counterparts in the developing countries; this clearly indicates that the ratio of capital goods prices to consumer goods prices was substantially lower in the former than in the latter.

From what has been stated hereto, it would appear that technical progress is a concept having more than one interpretation : in the Western model of machine tool production, technical progress has essentially been characterised by innovation in the product-mix; in the Soviet model of the 1930s, on the other hand, it was a phenomenon that centred almost exclusively on the way in which machine tools were produced. The Indian machine tool industry during its developmental phase emulated Western practices and hence, rationalised technical progress accordingly. With the advantage of hindsight however, this may have been the wrong choice because, as was shown in Chapter 2, no indigenous innovation of an appropriate nature occurred in the technology manufactured by the tool industry.

It becomes the task of this chapter, therefore, to examine the data from the survey and from official sources, in an attempt to reach some conclusion on the technological development of the Indian machine tool industry's productive operations during its formative years. The analytic framework for the chapter is based on the three separate ways in which technological development can be viewed :

In Section 1, the term 'technical change' is used to describe the character of technical improvements; it commences with a discussion of the difference between technical and economic efficiency and proceeds to analyse various production coefficients of the machine tool industry. These single factor indexes of output per unit of input assist in providing information on how techniques have changed in response to factor price movement and are reflective therefore of endogenous technical change. Section 2 concerns itself with an exploratory analysis into the effects of changes in technology on the industry's development or, more specifically, on the role of technological change in the process of growth. This is defined as 'technical progress', and it is important that 'the concept should not be confused with technological change.'[4] Technological progress is applicable to the difference between planned and actual output as predicted by an aggregate production function; and as such, could be described as nothing more than a 'catch-all' residual, sometimes referred to as 'total factor productivity', including a diverse number of factors besides technical change, that contribute toward growth. Hence, technical progress is a concept which goes beyond factor-price efficiency : it is exogenously determined. The section finishes with an appraisal of various economic influences including, in particular, capacity utilization which are thought to be responsible for the efficiency levels obtained. Finally, in Section 3, technical development is defined more literally to refer to changes in technology itself where technology is viewed as useful knowledge pertaining to the art of production. The culminating section in this sense looks at the economic activities through which improvements in machine tool manufacture stem : industrial training, the process of 'learning by doing', and most of all, research, development and design facilities.

Section 1 : The Character of Technical Change in Productive Operations

(i) Taxonomy

Efficiency is a most difficult and nebulous concept. Due to this fact, the first part of the section is taxonomic in nature; the intention being to clarify the various concepts under discussion so that confusion in terminology does not destroy the analytical content of the chapter. Generally speaking, efficiency measures are used for the purposes of gauging the performance of units or sectors on either a temporal or cross-sectional plane. The basic objective is to evaluate relative resource usage in terms of the output generated. In this respect, the measurement of efficiency is simply the relation of input to output which, at a first level, is purely a technical problem. From this engineering perspective, the measurement of efficiency is expressed in terms of physical units; an efficiency rating of 100 per cent being theoretically feasible.

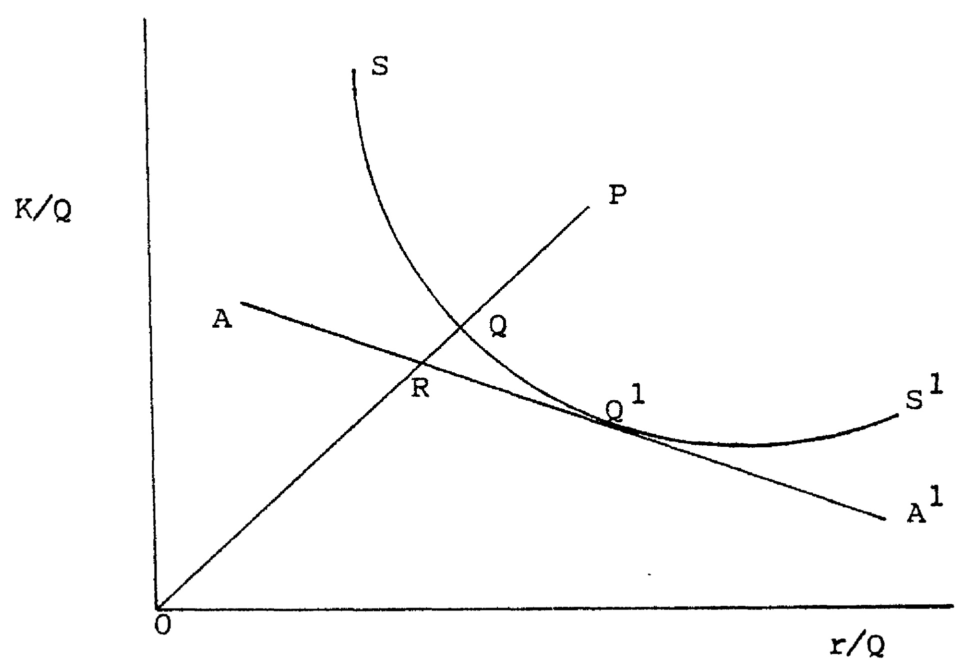
'Technical' efficiency is integral to the rationale of the new welfare economics. Here, efficiency has regard to the economy that produces at a point on its production possibility surface, for which there must be uniform factor prices for identical inputs with no price discrimination. Firms must all be cost minimizers with sufficient knowledge of their own production functions to enable them to reach the optimal position. If technical progress is allowed into the analysis, then the Paretian notion of efficiency in production is relevant, i.e. if a new process can produce the same output as the old but with less of one or more inputs, then the old process has become technically inefficient. However, if allowance is made for indivisibilities, finite time horizons and economies of scale, it is possible to be both rational (profit maximization) and inefficient. This is the case when indivisibilities give rise to increasing returns even though each process taken by itself shows constant returns to scale.[5]

In an engineering environment, technical efficiency is an appropriate measure of a factor's performance. There is a major drawback, however, in that comparisons can only logically be made where output and input are reasonably homogenous. Suppose x units of input produce a ton of steel in one firm and x + 1 units of input are required to produce a ton of steel in another. It is not known whether the first firm is as efficient as it might be but it would appear, prima facie, that it is more efficient than the second.[6] Even with a slight alteration to the final product of one firm, the comparative analysis of efficiency becomes invalid because 'like with like' is not being compared. Moreover, the question of input aggregation raises equally serious problems of measurement. This is because it is impossible to add together a heterogenous assortment of resources : ballbearings; the 'aging' of machinery, and man-hours, simply cannot be aggregated. In addition, as Salter has trenchantly observed : "The interpretive problems begin once we ask what such figures mean. They are not a measure of efficiency, for a high output per man-hour can be produced as inefficiently as a low one. Nobody attempts to maximise labour productivity, nor indeed should they. Businessmen - despite what they say at productivity congresses - are interested in prices, costs and profits, and to them increasing productivity is simply one means of reducing labour costs."[7] Clearly, the way around the problem, as Salter suggests, is to apply prices to the factors to be aggregated; and, as shall be seen later, to output also.

Thus, through the valuation of output and input the concept of 'economic' efficiency is arrived at. For reasons of practicality, economic efficiency is the criterion that has the most relevance. Under an engineering measurement of efficiency, a technically perfect machine tool would incorporate the ideal materials and would perform to tolerances of extreme precision. The difficulty is though, that the tool would be economically inefficient because costs of production would be so high that there would be no customers which could profitably pay the price that would cover them.

M.J. Farrell in a classic article[8] published in 1957, presented a diagrammatic representation of these efficiency concepts. As an aid to clarification, it will be useful to reproduce Farrell's analysis and this is done in Figure 6 below. Working under the assumptions of constant returns to scale and there being only two factors of production to produce output, the author was able to graphically depict : technical, economic, and also overall efficiency. The figure can relate to either a firm or an industry but as Farrell addressed his analysis to firms, this approach will be continued here.

Figure 6 - A Diagrammatic Representation of the Various Forms of Efficiency



The isoquant SS^1 represents the various combinations of the two factors that a perfectly efficient firm might use to produce unit output. Obviously, any firm producing to the right of the efficient production function is, in the Paretian sense, inefficient. Point P represents the ratio of capital and labour per unit of output that a firm is observed to use. In similar fashion, point Q represents a firm using composite input in the same proportion as P. Technical efficiency is defined, therefore, as :

$$\frac{OP - PQ}{OP} \left(= \frac{OQ}{OP} \right)$$

If AA^1 is a slope equal to the ratio of the prices of the two factors, then Q^1 and not Q becomes the most efficient method of production : Q is not now the optimal point on the boundary because the capital-labour ratio that was applicable to technical efficiency is inappropriate for economic efficiency. Evidently then, economic efficiency is :

$$\frac{OR}{OQ}$$

Finally, the firm would be perfectly efficient (both economically and technically) if the capital-labour ratio line OP intersected at the point of tangency between the price line AA^1 and the production frontier SS^1. Symbolically :

$$\frac{OR}{OQ} \cdot \frac{OQ}{OP} = \frac{OR}{OP}$$

(ii) Production Coefficient Analysis

The rapid growth in the output of the Indian machine tool industry has come about through the interaction of a number of factors. Besides the financial and technical assistance of foreign collaborators and the effects of technological progress there is also the additional aspect to be considered of changes in production technique.

Improvements in production technology not only dictate the absolute level of the contribution that capital and labour make to the process of growth but also the apportionment between them. In view of this, the second part of this opening section is concerned with examining the capital intensity of the machine tool industry; and to reinforce the conclusions to be derived from the analysis, the productivity of each factor will also be calculated. Capital intensity and factor productivity are related basically because of the complementarity of capital and labour in the process of production. These associations, as Cheng has cogently stated, are crystallized in the movement of the K/L trend : "when the rate of increase in capital stock surpasses the rate of increase in employment, capital stock per worker (K/L) increases. If the rate of utilization of capital does not decline, this must result in an increase in labour productivity."[9]

These relations, though simple in theory, are very much more difficult to put into practice. Output can be expressed in physical measures, such as tonnes, metres or numerical quantities but is is impossible or meaningless to add together quantities of dissimilar items as, for instance, machine tools. One way of overcoming this problem is to convert the machine tools produced during a given period into the man-hours or machine-hours that were consumed in their fabrication. Unfortunately, the difficulty with this method is that it does not take into account the value of the product to the purchaser or, for that matter, to the process of economic development. Thus, for the purposes of efficiency analysis, the most appropriate expression of output is in terms of its monetary value. Naturally, monetary values are distorted by inflation but this problem may, to a certain extent, be overcome by using a suitable price deflator. An additional merit of monetary measures besides being an expression of producer satisfaction[10] is that they also determine the rewards available to labour and capital.

The value of sales or gross output is the obvious though not necessarily the most satisfactory measure of output. In many respects a better measure would be the net output or added-value of production : the difference between the value of the goods produced and the cost of the materials used in their manufacture. Thus, net output discounts the effect of variations in material costs; it represents the value-added to the materials by the processes of production. In other words, the concept represents the wealth created by a unit whereas gross output includes the wealth created by other units. Net output is the sum available to cover all wages, salaries, dividends, interest, rent and retained profits. In the analysis of the efficiency of India's machine tool industry net output is, therefore, deemed the most relevant measure and when related to the inputs of labour and capital, the productivity indexes can hence be obtained.

But, like output, there is considerable dispute concerning the nature and measurement of inputs; these are all interconnected with the problems of aggregation and definition which were touched on earlier, especially in the context of capital. Moreover, there is the major criticism which can be applied equally to capital and labour regarding the inadequate treatment of changes in the quality of factor input both across, and at a point in time. The search for solutions to these problems that will appease all critics is not easy, and ultimately decisions will have to be taken on the arbitrary judgment of the individual constructing the production coefficient. Thus, the need here is simply to make the reader aware of the weaknesses inherent in production and productivity analysis and that these be taken into consideration in the interpretation of the research findings. In any case, little interest should be attached to the absolute numerical value of the ratios; it is the trends that are important.

In the construction of the machine tool industry's K/L index, labour data has been disaggregated to provide numbers[11] and costs of direct, i.e. 'productive', employment. However, the same has not been possible for capital. Consequently, the capital figures are global, in the sense that they include all categories of fixed assets.[12] Moreover, the values of fixed capital as reported in the A.S.I. represent the written down (book) values (where depreciation is calculated according to the rates allowed by the income tax authorities).[13] Most economists however, have generally favoured the gross stock measure over the net stock measure for the purposes of a production analysis. The reason, as sharply pointed out by Professor Leontief, is that the use of "depreciated coefficients implies that capital stocks decrease in efficiency in exact relation to the depreciation charge", whereas "most available evidence indicates that this is not a reliable assumption."[14] Although this assumption implicit in the use of net stock capital figures is clearly not free from criticism, it could nevertheless be argued that the use of gross stock figures is also biased on the extreme assumption of constant efficiency throughout the service life of fixed capital assets. Thus, this manner of constructing the K/L ratio precludes the possibility of using it as an approximation of the degree of mechanization : the ratio of equipment to production workers, excluding investment in buildings from the numerator and administrative personnel from the denominator. Nevertheless, fixed capital per direct worker is adequate to provide the underlying trend of capital intensity in the industry.

An index representing changes in the K/L ratio of the machine tool industry over time reveals an interesting pattern. Table 31 provides a temporal analysis of the K/L relation for the period 1960-74. Due to the lack of consensus among economists as to the most correct form of calculation for the index, the trends of both capital per wage $K/L_{(i)}$ and capital per man $K/L_{(ii)}$ are presented.

Table 31 - Capital-Labour (K/L) Ratios in the Machine Tool Industry

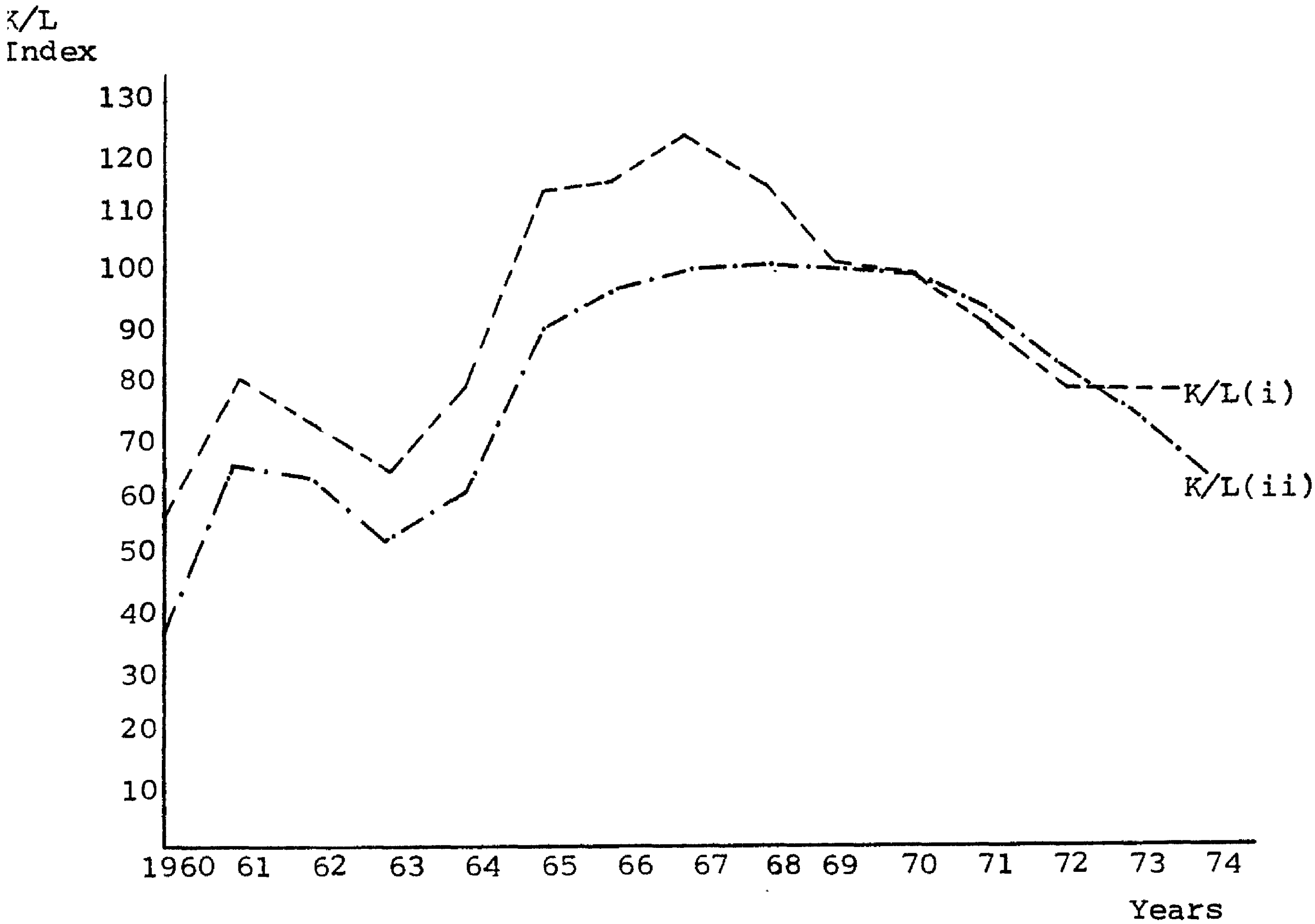
Year	Fixed Capital[15] (Constant Prices) (Rs.000s)	Labour (Nos)	Wages (Constant Prices) (Rs.000s)	$K/L_{(i)}$ (=(I)÷(3)) Rs. of K per unit Rs.of L (Yr) Ratio	$K/L_{(i)}$ Index	$K/L_{(ii)}$ (=(1)÷(2)) Rs.000s Per Man (Yr) Ratio	$K/L_{(ii)}$ Index
	(1)	(2)	(3)	(4)		(5)	
1960	78854	7372	17300	4.6	59.0	10.7	37.5
1961	145634	7481	22618	6.4	82.1	19.5	68.4
1962	185998	9789	31902	5.8	74.4	19.0	66.7
1963	207374	13178	39779	5.2	66.7	15.7	55.1
1964	261000	14444	41847	6.2	79.5	18.1	63.5
1965	458416	17490	51641	8.9	114.1	26.2	91.9
1966	497059	17850	54597	9.1	116.7	27.8	97.5
1967	510289	17716	51992	9.8	125.6	28.8	101.1
1968	513731	17582	56661	9.1	116.7	29.2	102.5
1969	525009	17996	64592	8.1	103.8	29.2	102.5
1970	525059	18409	67268	7.8	100.0	28.5	100.0
1971	535280	19582	72947	7.3	93.4	27.3	95.8
1972	475858	19270	73807	6.4	82.1	24.7	86.7
1973	423704	18957	66286	6.4	82.1	22.4	78.6
1974	364327	18921	56773	6.4	82.1	19.3	67.7
Annual Average Rate of Growth for the Period 1960-74 :					2.4		4.3

Source : Appendix 1, Table A

The rate of growth of the indexes was 2.4 per cent for $K/L_{(i)}$ and 4.3 per cent for $K/L_{(ii)}$. A possible explanation for the difference in the growth rates of the two ratios may be found in the disparity between the increase in the costs of remuneration and the expansion of productive employment. Thus, while in $K/L_{(i)}$ the wages of direct workers rose from Rs.173 lakhs in 1960 to Rs.567.7 lakhs in 1974, registering an annual average growth of 8.9 per cent, the comparative growth in the employment of direct workers in $K/L_{(ii)}$ over the same period was from 7372 to 18921, recording a somewhat lower rate of growth of 6.7 per cent.

For an industry which was built up through foreign collaboration, with the technology that accompanies such development, it is somewhat surprising that the growth in capital intensity has not been higher. Figure 7 diagrammatically traces the paths of $K/L_{(i)}$ and $K/L_{(ii)}$ for the period 1960-74. Clearly, up to 1967/68 there was a rapid growth in the relation of capital to labour : over the first 7 years of the decade the average growth rate of the K/L indexes approximated 13 per cent. Immediately following this period came the 3 years of the recession which seriously affected the rate of investment in the industry. The situation thereafter changed dramatically with the static or slightly falling K/L coefficients of the recessionary years giving way to continuous and progressive declines in the same during the 1970s.

Figure 7 - The Relative Changes in the K/L Indexes of the Machine Tool Industry for the Period 1960-74 (1970=100)



Source : Appendix 1, Table A.

The reasons for this decline in capital intensity are a matter for speculation although two factors can be suggested which may have been of some significance.[16] In the first place although the real cost of direct labour had fallen from Rs.672.7 lakhs in 1970 to Rs.567.7 lakhs in 1974, recording a negative rate of growth of 4.2 per cent, this fall has to be set against the deterioration in the growth of capital value which over the same time span decreased at an annual average rate of 8.7 per cent. However, it is most unlikely that this rising (in the sense that the decline in labour cost had been less than the decline in capital value) wage-rental coefficient would have led to the substitution of machines for men. There would have been resistance to such moves because of the militancy of the unions in the larger concerns of the organised sector, the more so since public undertakings which traditionally have poor labour relations dominate the machine tool branch. Greater credence can be given to this explanation by noting that in a period when the value of capital equipment had fallen substantially, the numbers of production workers employed remained more or less stable. A second possible reason for the decline in the K/L ratios could well be related to HMT's 'loss of interest'[17] in machine tool manufacture. Certainly the downturn in the industry's capital intensity does seem to have coincided with HMT's diversification out of machine tool production in the early 1970s, just as its expansion in the decade before had corresponded with HMT's increased production capacity. The very size of the company's market share obviously dictates that its policies considerably influence the statistical picture of the industry.

The data on fixed capital when related to value added in the machine tool industry displays a reasonably stable pattern for the early years of the 1960s. If the 5 observations corresponding to the time periods in Table 32 were plotted on a diagram, the first two observations would proximate to a straight line drawn through the origin. This indicates that increases in capital would lead to the same proportionate increases in value added. For the periods 1960/62 and 1963/65, one Rupee of fixed capital on the average was associated with Rs.0.4 of value added. But whilst the 1966/68 and 1969/71 points lie far below this line denoting a severe deterioration in capital productivity, the final observation for the period 1972/74 is located slightly above this line, indicating an improvement.

Table 32 : Average and Incremental Output/Capital Ratios in the Machine Tool Industry

Period	Value Added (Rs.000s)	Fixed Capital(1) (Rs.000s)	AOKR(2) (Rs.per unit of K-years)	IO (Rs.000s)	IK (Rs.000s)	IOKR(3) (Rs.of VA per unit of K-years)
1960-62	174258	410486	0.4	-	-	-
1963-65	387529	926790	0.4	213271	516304	0.4
1966-68	314057	1521079	0.2	-73472	594289	-0.1
1969-71	408874	1585348	0.2	94817	64269	1.5
1972-74	566812	1263889	0.5	157938	-321459	-0.5
Growth of Capital Productivity : 1.7% (1960-62 to 1972-74)						

Source : Appendix 1, Table A

Notation : AOKR = Average Output Capital Ratio

IO = Incremental Output

IK = Incremental Capital

IOKR = Incremental Output Capital Ratio

(1) Fixed Capital defined according to ASI usage.

(2) AOKR = $\frac{Qt}{Kt}$

(3) IOKR = $\frac{Q}{K} = \frac{Qt - Qt\text{-}1}{In_t}$ (where $In_t = FC_t - FC_{t-1}$)

The fluctuations in value added during the admittedly short-run time periods under review have meant that the average productivity of capital has differed markedly from the marginal. Thus, in the recessionary period 1966/68, the average output/capital coefficient was lower than its 'trend' value since value added was depressed in relation to the size of the capital stock, being relatively fixed. However, while the average capital productivity remained low at the start of the upturn of the business cycle, the marginal ratio had increased rapidly. As the machine tool industry was working well below capacity, very little extra capital was needed to increase output so that substantial growth was achieved with only a modest growth of fixed capital. By contrast, capital productivity for the 1972/74 period showed a distinct improvement over previous periods, rising to 0.5; this is the more remarkable because although value added had increased by close to 40 per cent on the 1969/71 figure, capital stock had, in fact, declined by Rs.3215 lakhs. Even with this rise in the output/capital relation during 1972/74, the average growth of the index over the five periods was dismal, managing only 1.7 per cent.

Thus, the evidence on the machine tool industry's productivity of capital indicates a somewhat unsatisfactory performance. But this is only one side of the coin. Aside from the fact that the industry was almost certainly not working at full capacity over a major portion of the 14 years under consideration, there is also the point that capital was not operating in isolation, but in co-operation with labour; there is good reason to believe that labour productivity fared much better : depending on which K/L index is chosen, the machine tool industry's capital intensity throughout the period has grown some 2 or 4 percentage points, and it is generally held that higher output per person is associated with an increase in capital intensity.

In this context, a significant feature of the development of the industry has been the relatively fast growth in labour-input. While total employment in the organised sector of the economy increased by 59.4 per cent between 1961 and 1974, the number of employees in the machine tool industry rose by 196 per cent; for direct workers only, the figure was 157 per cent. Rapid as this increase in employment was, it was not, however, in the same league as the 362 per cent increase in capital stock over the 1960-74 period. Clearly then, if the complementarity of the factors of production is remembered there should have been a consequential improvement in the productivity of labour.

Given the qualification concerning low capacity utilization, the relation is now made between net output and direct employment in order to provide a judgment on output per man. From Table 33, it may be noticed that labour productivity or the average output/employment ratio has, except for the recessionary years of 1966/68, shown a steady rise throughout the 5 periods. Against this pattern the marginal output/employment index has displayed wide variation : it was high in 1963/65, negative in 1966/68 and, after becoming positive again in 1969/71, accelerated sharply in the final period. Quite clearly, in like manner with the 'trend' of average labour productivity, it was the effects of the recession which caused the major aberration in the growth of incremental labour productivity. Although, for the years 1966 to 1971, average labour productivity was much higher than the corresponding marginal ratios, indicating that the rate of expansion of direct labour was generally higher, or its decline slower, than that for value added. But at 11 per cent, the growth rate of average labour productivity covering the five periods, 1960/62 to 1972/74 is highly satisfactory.

Table 33 : Average and Incremental Output/Labour Ratios in the Machine Tool Industry (Constant Prices, Base = 1970)

Period	Value Added (Rs.000s)	Labour(1) (Nos)	AOLR(2) (Rs. per man years)	IO (Rs.000s)	IL (Nos)	IOLR(3) (Rs.of VA per man years)
1960-62	175448	24637	7120	-	-	-
1963-65	390847	45112	8660	215399	20475	10520
1966-68	322980	53148	6080	-67867	8036	-8450
1969-71	421382	55987	7530	98402	2839	34660
1972-74	616342	57148	10790	194960	1161	167920
Growth of Labour Productivity : 11% (1960-62 to 1972-74)						

Source : Appendix 1, Table A

Notation : AOLR = Average Output Labour Ratio
IO = Incremental Output
IL = Incremental Labour
IOLR = Incremental Output Labour Ratio

(1) Labour = Nos. of 'workers' defined according to ASI usage.

(2) AOLR = $\frac{Qt}{Lt}$

(3) IOLR = $\frac{Qt - Qt\text{-}1}{Lt - Lt\text{-}1}$

The rise in labour productivity, however, was accompanied by a proportionately greater increase in wages. Table 34 provides a comparison of labour productivity with the growth in the wage-bill. In every period, including those of the recession, wage payments grew faster than output per man. This was an unhealthy development for the industry because a wage-bill in excess of productivity would have reduced pro rata the shares of the other elements comprising value added; and a major casuality would likely have been the surplus available for re-investment.[18] As a consequence, the potential for future increases in labour productivity must surely have been affected.

An interesting feature of the table is that in 1972/74 the wage-bill showed a decline over the previous period, something that had not occurred even during the trough of economic activity in the late sixties. A part of the already noted upsurge in capital and labour productivity of this final period can therefore be attributed to the fall in the payments to labour. This exploitation of labour, as Marxists would have it, is clearly shown by the sharply contrasting growth of the wage-bill as against that of labour productivity : whilst the former fell by 3.9 per cent on the 1969/71 period, the latter grew by some 43 per cent.

Table 34 : Comparison Between the Indexes of Growth of Remuneration and Labour Productivity in the Machine Tool Industry (Constant Prices, Base = 1970)

Period	Tri-Yearly Wage-Bill (Rs.000s)	Index	Labour Productivity (Rs.000s)	Index
1960-62	71820	100	7120	100
1963-65	133267	186	8660	122
1966-68	163250	227	6080	85
1969-71	204807	285	7530	106
1972-74	196866	274	10790	152

Source : Appendix 1, Table A

The growth of labour productivity outpacing the wage-bill led to a belated increase in the surplus value which in turn added a degree of respectability to the machine tool industry's profitability record; but this in no way compensates for the poor profits for the whole of the 1960-74 period. These are documented in Table 35 which clearly shows that for almost half the years under review, the industry made negative profits. That this situation could happen is merely indicative of the high concentration of public ownership in the industry where losses could be subsidized by the taxpayer (either directly or indirectly).[19] Without question a wasteful exercise in a developing country such as India.

For those years when a positive rate of return on capital was achieved, the highest in 1964 amounted to 23.6 per cent. However, even the performance in this year does not measure up to the experience of the machine tool industry in China during its development in the 1950s.

Table 35 : Rates of Return to Capital in the Machine Tool Industry (Rs.000s)

Year	Value Added (1)	Fixed Capital (2)	Depreciation + Wages/ Salaries/ Benefits* (3)	Gross Profit (1-3) (4)	Rate of Return To Capital[20] (4/2 x 100) (5)
1960	26186	49599	20748	5438	11.0
1961	37634	93060	30874	6760	7.3
1962	49149	122015	39132	10017	8.2
1963	64776	143088	49842	14934	10.4
1964	104625	185049	61042	43583	23.6
1965	112500	345187	86575	25925	7.5
1966	105256	402618	108700	-3444	-0.9
1967	90602	429663	119357	-28755	-6.7
1968	75948	456707	130014	-54066	-11.8
1969	105377	490883	148950	-43573	-8.9
1970	134806	525059	167886	-33080	-6.3
1971	176829	544380	193645	-16816	-3.1
1972	207415	521540	209123	-1708	-0.3
1973	238000	498700	224600	13400	2.7
1974	346100	560700	270500	75600	13.5

Source : Appendix 1, Table A

* Does not include interest payments.

According to a survey of 29 enterprises in eight branches of the Chinese machine building industry in 1957, the average rate of return to capital in the machine tool branch was 27.6 per cent.[21] Moreover, with a return to capital at this level the Chinese machine tool plants could have recovered their capital investment in under four years. In the Indian machine tool industry, on the other hand, capital recovery, based on the average of the 8 positive rates of return to capital during 1960-74, would have taken about ten years. A capital recovery period of such length must have constrained the ability of the industry to adequately replace capital with all the ills that this would attend.

Technical change in the productive operations of an enterprise is but one aspect in the means to increase efficiency. It is an important component though, because the rationale behind the concept, unlike 'technological progress', is reasonably well-defined and therefore readily identifiable to decision-makers : an increase in capital intensity will tend more often than not to be associated with rising labour productivity. The evidence on technical change in India's machine tool industry between 1960 and 1974 lends support to this argument. The annual growth of capital intensity was, on average, around 2 to 4 per cent. Due to this improvement in production technique there was a related increase in labour productivity of 11 per cent per period. Capital productivity, however, was very low, reflecting the faster growth in capital stock as compared with the expansion of labour. A more serious cause for concern was that wage payments had been growing faster than labour productivity; but there were signs that this 'trend' may have been changing. Finally, there was the disturbing discovery that for many years, the industry's rate of return to capital had been negative. HMT has never disclosed the profit performance of its machine tool operations and the lack of profitability of the industry which is dominated by this one concern perhaps suggests the reason why. Any losses that HMT did sustain could have been made good by the surplus from the other more viable arms of the company's business activities. It will be interesting to observe the future profitability of the industry now that machine tool production is becoming increasingly less important to HMT.

Section 2 : Technological Progress in Machine Tool Manufacture

(ii) Total Factor Productivity

Productivity analysis enables resource allocation in an industry to be measured by comparing the growth of net output with the inputs of labour and capital. But, although single productivity ratios have an important part to play in a global approach toward assessing the degree of efficiency in the machine tool industry, they suffer the drawback of not being able to separate the impact of technological progress from the impact of the complementary factor. Thus, it will be illustrative to compare an index of output with an index for combined factor inputs; this is done in Table 36. The examination is confined to the two factors of production, capital and labour. Value added is, as usual, taken as the proxy for output. The analytical problem concerning the determination of the appropriate weights for the two factors was tackled by calculating the relative shares of output accruing to the two inputs. The relative shares for labour and capital were found to be 74:26.[22] Judging from other empirical studies utilizing country data, it would appear that the above proportion of labour remuneration to income may be somewhat high. Kuznets, for instance, found that the share of compensation of employees in participation income in the underdeveloped countries was 59 per cent.[23] Similarly, Bruton looking at the productivity of a selected group of Latin American countries, estimated labour's share to average 55 per cent.[24] The ratios of these authors however, may not be strictly comparable with the factor share for this study because they cover the whole spectrum of activities within an economy. In capital scarce, low-wage countries therefore, the value of capital would be exaggerated. Furthermore, it is likely to be the case that resource endowments and stages of development between economies would differ sharply. In consideration of these facts, a higher participation of labour in output does seem justified.[25] Thus, in the absence of evidence to the contrary, a labour share of 74 per cent is taken as valid.

Table 36 : Indexes of Combined Input and Efficiency of the Machine Tool Industry (Constant Prices, Base Year = 1970)

Year	Index of Value Added	Input Index Employment* (L)	Input Index Capital (K)	Index of Combined Inputs (L.74+K.26)	Index of Efficiency VA/CI
1960	100	100	100	100	100
1961	144	147	185	157	92
1962	183	179	236	194	94
1963	226	224	263	234	97
1964	357	240	331	264	135
1965	365	299	581	372	98
1966	309	320	630	401	77
1967	253	309	647	400	63
1968	207	342	651	422	49
1969	273	389	666	461	59
1970	330	404	666	472	70
1971	398	454	679	513	78
1972	435	462	603	499	87
1973	445	416	536	477	100
1974	507	393	462	411	123
Annual Average Rate of Growth :	12.3%	10.3%	11.6%	10.6%	1.5%

Source : Appendix 1, Table A

* Annual Aggregated Wage/Salary/Benefits Bill for all Employees.

The results of Table 36 at first glance appear striking. The annual growth of the composite index of labour and capital productivity in the machine tool industry during 1960-74 was only 1.5 per cent. But, due to the volatility of the efficiency index over time, the series is perhaps inadequate as a measure of trend. Furthermore, the rate of growth cannot be gauged against those previously calculated for the single factor indexes of capital and labour because there, the data was arranged into 5 time groupings in relation to key events in the development of the industry such as the early expansion in capacity; the recessionary period; and, more recently, HMT's diversification programme. There is also the point that in the single factor indexes of production the term 'labour' represented only direct employment whereas in the composite factor input ratio it refers to all employment (payments); this is because here, the efficiency of the total factor input is being examined. In the event though, when the growth of output per employee was calculated, it proved to be only fractionally higher, at 1.9 per cent than that of capital and labour productivity combined. This sad indictment of the industry's productive performance is compounded by the fact that except for 1964 when there was a sudden and rapid acceleration in net output, in every year up until the final in 1974, the industry operated at no greater efficiency than that which prevailed in 1960. A poor record by any standard.

The problem with combined factor productivity ratios is that, in similarity to the single factor productivity coefficients, they remain only partial or incomplete indicators. This is the case because both types of index fail to isolate the contribution the factors of production make to the growth process from that of technological progress. A more satisfactory approach would be to apply a measure of total factor productivity under the assumption that machine tool output is a function of the main productive factors, capital and labour. Thus, any increases in output that cannot be accounted for by increases in factor inputs can be attributed to a 'residual' combination of influences, and this may then be equated to technological progress. These relationships are expressed in the form of an aggregate production function.

One aspect of the production function approach which requires elaboration is that factor inputs should ideally relate to 'inputs-used' rather than 'inputs-in-existance' during the process of production. Theoretically, therefore, the utilization of capital and labour should be taken into consideration. This has, in fact, been attempted in studies of advanced countries[26] where unemployment has been used to deflate the net capital series on the assumption that labour and capital are utilized in the same percentage. However, this has not been possible for a sectoral study of machine tool production because the industry's rates of utilization are unobtainable. An additional complication is that in a country like India, most industries will almost certainly have their share of disguised unemployment. Due to these difficulties, the production function analysis is carried out on the basis of factor-stock data rather than on the more ideal services that this stock provides.

The Cobb-Douglas production function may be written as :

$$(1) \qquad Q_t = A_t K^{\alpha}_t L^{\beta}_t$$

Where Q_t is real output (value added) in year t; K and L are quantities of capital and labour available in the same period; A an index of total productivity; and α and β are elasticities of output to capital and labour respectively. As it did not prove possible to estimate the function empirically, α and β were assigned values constraining them to sum to unity. These values are therefore identical to the ones used in the previous analysis in the construction of the index of combined factor productivity, namely, 74:26. The next step is to differentiate the function with respect to time, thus :

$$(2) \quad \frac{(Q_t - Q_{t-1})}{\frac{1}{2}(Q_t + Q_{t-1})} = \frac{(A_t - A_{t-1})}{\frac{1}{2}(A_t + A_{t-1})} + \alpha \frac{(K_t - K_{t-1})}{\frac{1}{2}(K_t + K_{t-1})} + \beta \frac{(L_t - L_{t-1})}{\frac{1}{2}(L_t + L_{t-1})}$$

This technique which is approximately equivalent to taking logs, overcomes the problems of centring the observations in the time series. For simplicity the expression may be written as :

(3) $$r_Q = r_A + \alpha r_K + \beta r_L$$

Where $_Q$, $_A$, etc. refer to the annual proportionate rates of growth of machine tool output, total factor productivity and so on. The $_A$ variable is the most important consideration here. It can be defined as technological progress; this may be made clearer through the transformation of (3) so that :

(4) $$r_A = r_Q - (\alpha r_K + \rho r_L)$$

Although r_A in this study is taken as an index of technological progress, it should be pointed out that logically r_A is nothing more than that part of output growth that is not attributable to the increase in factor inputs; it is, therefore, a 'residual' which not only explains improved allocation but also all the other numerous influences affecting productivity growth, including measurement error in the data series. For this reason, one economist has described the residual as a "measure of our ignorance".[27]

Table 37 shows the growth rates of inputs, outputs and technological progress in the Indian machine tool industry.

The immediate point that can be made about the results of the production function analysis concerns the mean values of r_A and r_A/r_Q. The Indian industry's r_A was found to be 2.9 per cent whilst its r_A/r_Q was a negative 0.14 per cent. These findings appear to conflict with Gerschenkron type theorizing which argues that underdeveloped countries as latecomers to the industrialization process, are in an advantageous position because they possess the possibility of exploiting existing technological knowledge. If this

Table 37 : Growth Rates of Output, Input, and Technological Progress in the Indian Machine Tool Industry (1961-74)

Year	r_Q	r_L*	r_K	$r_{(L.74 + K.26)} = r_F$			r_A	r_A/r_Q
1961	35.9	15.6	59.5	11.54	15.47	27.01	8.9	0.25
1962	24.0	15.8	24.3	11.69	6.32	18.01	6.0	0.25
1963	21.2	21.7	10.9	16.06	2.83	18.89	2.3	0.11
1964	44.9	11.2	27.9	8.29	5.95	14.24	30.7	0.68
1965	2.2	25.5	54.9	18.87	14.27	33.14	-30.9	-14.05
1966	-16.8	5.7	8.1	4.22	2.12	6.34	-23.1	1.38
1967	-19.7	-0.01	2.6	-0.01	0.68	0.67	-20.4	1.04
1968	-20.0	-0.01	0.7	-0.01	0.18	0.17	-20.2	1.01
1969	27.4	4.0	2.2	2.96	0.57	3.53	23.9	0.87
1970	19.0	3.8	0.0	2.81	0.0	2.81	16.2	0.85
1971	18.7	7.6	1.9	5.62	0.49	6.11	12.6	0.67
1972	8.8	-0.01	-11.7	-0.01	-3.04	-3.05	11.85	1.35
1973	2.3	-0.01	-11.6	-0.01	-3.02	-3.03	5.3	2.30
1974	12.9	0.0	-15.1	0.0	-3.93	-3.93	16.83	1.30
		Mean Values of r_A and r_A/r_Q =					2.9	-0.14

Source : Appendix 1, Table A

* : L = No. of employees

were a valid hypothesis, then it would be natural to have expected India's machine tool industry to have experienced a much higher growth of the residual, due to the country's rapid expansion in capital formation.

It should be stated that there are four major criticisms to the use of the Cobb-Douglas function : firstly, integral to the model is the assumption of neutral technical progress; if it were not, only one combination of factor inputs could be examined at any one time and it would thus become impossible to distinguish technical progress (shifts in the function) from technical change (movements along the same function). The difficulty with this type of theorizing though is that technical progress need not be neutral. Secondly, there is not complete consensus among economists concerning the assumption that technical progress is independent of increases in factor inputs, i.e. that it is exogenous. But this does not invalidate the Cobb-Douglas model because it is not a specification error, relating instead to the purpose in which the function is put. Thirdly, changes in the ease of substitution between capital and labour cannot be shown due to the limitation of the function in respect of the constant unitary elasticity of substitution between factors whatever the factor intensity. The final criticism has regard to the measurement of outputs and inputs : is it possible to aggregate so many heterogenous items such as capital goods which were built at different times and, consequently, varying costs and productivities?

That the path of the aggregate production function is treacherous is widely known; it is also, however, well-trodden. This is because most of the criticisms documented above are all basically theoretical and are not so serious as to lead to the invalidation of the production function. Many of the empirical studies of technical progress in the advanced countries suggest that the assumption of neutrality is a reasonable hypothesis; that, additionally, many of these case studies also indicate constancy in the elasticity of factor substitution; and that, although the heterogeneity of output and input is problematical, especially regarding the difficulties over vintage capital, nevertheless, judging from published production function studies, the role of relative factor shares seems to perform adequately in practice. The overall justification is that a production function analysis assists in the investigation of efficiency levels in the Indian machine tool industry and the fact that the findings constitute just one element in the entire exercise is perhaps defence enough for its use.

The production function analysis indicates that technological progress in India's machine tool industry has been a positive but relatively minor factor in its development over the past two decades. There can be no single cause to explain this fact. Some part of r_A can surely be accounted for in terms of research and development activity; and investment into technical education and industrial training will doubtless account for some further part. The progress India's tool-makers have made in this direction will be explored in the final section of this chapter. Another major feature of productivity growth, however, relates to the extent of capacity utilization. Where technology is being utilized at a level below optimum, there will certainly be deleterious repercussions on efficiency. The transplantation of advanced techniques from Western nations into the machine tool plants of India would not have been a costless exercise if the scale of demand to accommodate such equipment did not materialize. In fact, amongst the numerous influences that may have acted to constrain the Indian machine tool sector's technological progress, under-utilization of productive resources could well have been the dominant force.

To seek support for this argument, further investigation of the data in Table 37 is required. A simple regression of r_A on the rate of growth of output should point to the importance of this relationship. The estimates of r_A on r_Q for the Indian machine tool industry over the period 1961-74 yields the following equation:

(1) $r_A = -6.06 + 0.78\, r_Q$ $\qquad \bar{r}^2 = 0.65$
(1961-74) (sig. at 1%)

Such a finding is consistent with the notion that technological progress in the sector is highly dependent on the growth of factor input. The value of the intercept shows that technological progress was always negative unless r_Q was substantially positive. Possible reasons for this state of affairs may be highlighted if separate regression equations are constructed for the period 1961-68 and 1969-74. The equation for the first period which includes the recessionary years becomes:

$$(2) \quad r_A = -12.30 + 0.72\, r_Q \qquad \bar{r}^2 = 0.76$$
(1961-68) (Sig. at 1%)

Clearly, the massive under-utilization of capacity during the years of the recession depresses the intercept still further in comparison with (1). It suggests that the falling level of demand, and hence spare capacity in the industry, was a prime source of inefficiency. This argument is strengthened when the regression for the period after the recession is examined:

$$(3) \quad r_A = 5.08 + 0.63\, r_Q \qquad \bar{r}^2 = 0.77$$
(1969-74) (Sig. at 5%)

With the upturn in the business cycle leading to an increased scale of operation, the intercept for this equation has now turned positive : there is a heightened dependence of r_A on r_Q; the greater $\bar{r}^2$ in comparison with that over the whole 1961-74 period is further confirmation of this. Therefore, as the analysis appears to suggest, it is highly likely that increases in the degree of capacity utilization have been a considerable influence in the observed improvements in technological progress.

(ii) Sources of Inefficiency

The preceding regression analysis of the machine tool sector's production function has thrown up capacity under-utilization as a significant cause for the inefficiency of the industry. Not only does sub-utilization of existing capacity tend to reduce output/capital and output/labour productivities but it also impinges upon the rate of growth of technological progress.

An indication of the impact that underutilization of capacity has on the performance of total factor productivity may be had by comparing in Table 37 the r_A figures with the movements of value added for the corresponding years. Up to 1964, both value added and technical progress were characterized by their continual growth. The very high figures for 1964 cannot readily be explained except to note that it would have been in this year that the production of HMT Pinjore, which commenced operations in the latter part of 1963, would have been felt. It might also have been the case that the Indo-Chinese conflict of 1962 and the increasing tension between India and Pakistan (leading to the Indo-Pakistan war of 1965) placed a special emphasis at that time on the capacity and production of the 'strategic' machine tool industry. Over the ensuing three years to 1968, value added and r_A again moved in unison with both experiencing negative rates of growth. Finally, the table shows that as the industry emerged from the recession in 1969, the increase in the utilization of existing capacity was reflected by the return to positive growth in value added which in turn brought forth an improvement in the index of total factor productivity. These similarities in the direction of the movements in value added and technological progress were obviously more than mere coincidence. Thus, although the level of capacity utilization may not have been the sole consideration in the determination of the efficiency of the industry, it must, nevertheless, have had a crucial part to play in the overall scheme of things.

A capacity utilization analysis will serve as a more concrete affirmation of the importance of the issue. Moreover, it has the additional attraction of breaking still further ground in the accumulating profile on the techno-economic development of the industry. Unfortunately though, due to the non-availability of quarterly and annual data on the industry's potential (or licensed) capacity, the construction of a historical index of the utilization of capacity is not possible. Nevertheless, some indication of the persuasiveness of this issue can be gauged by the findings of the survey and other information from various fragmentary sources.

Before embarking upon this task, however, it is imperative to bear in mind that productive capacity is an elusive concept prone to much misunderstanding in both empirical work and general economic discussion. For instance, it is not possible from an economic perspective to define a maximum level of output unless certain assumptions are made about perfect competition and constant returns, and abstraction is made from technological change. There is also the point that productive capacity has only a most imperfect connection with any technical measure of the productive capacity of machines. The problems regarding this aspect are broadly analogous to those encountered in the earlier part of this chapter regarding technical versus economic efficiency. The technical concept of capacity relates to a consideration of the maximum 'physical' output of an enterprise or industry. An economist's view, on the other hand, would interpret capacity as that which is economically feasible, incorporating into his calculation such elements as productivity theory, factor input prices, aggregate demand, and profit/welfare maximization. Hence on the spectrum of capacity specifications the technical measure would be located at the highest point; this would be followed by optimum capacity, being the economic position for feasible operation. But, due to production bottlenecks, insufficiency of demand, or any other of the myriad reasons why optimum capacity might not be the level of output attained by the enterprise or industry, the notion of 'normal' capacity would then become relevant. Any point below economic full capacity, including the normal level of operation, should be treated as sub-optimal, implying underutilization of capacity. As previously, it was economic efficiency that was held to be the relevant concept in measuring the development of the machine tool industry, so similarly it is again the economic interpretation of capacity that is deemed to be the appropriate index. Consequently, in the subsequent analysis, capacity will always refer to the economic meaning of the concept.

Indian industry has traditionally been associated with low levels of capacity utilization. Needless to say, such a generalization is highly dangerous because rates of utilization would naturally vary from sector to sector. However, a recent report by the Reserve Bank of India[28] does much to suggest that for the capital goods industries of India, the argument may have more than a ring of truth about it. The study, published in 1975, measured capacity utilization by obtaining the percentage of actual industrial production to total potential production; and, although for all sectors it found a declining level of capacity utilization over the period 1961-73, nowhere was it more pronounced than in the capital goods industries : falling steadily from an average 82.9 per cent for the 1961-65 period to only 61.6 per cent in 1973. The corresponding figures for the manufacturing sector were 87.9 per cent and 77.9 per cent respectively.

For the capital goods industry in general therefore, an economically disastrous degree of underutilization of capacity had existed throughout the 1960s and early 1970s. The question is though, was this situation consistent with the experience of the machine tool industry over the same period? Albeit that the evidence on this matter is sparse, figures for the public sector machine tool companies in 1974 indicate that the industry's record may even have been worse. Praga Tools Ltd., of Hyderabad achieved capacity utilization levels of 60 per cent for drill chucks, 50 per cent for lathe chucks, and a mere 29 per cent for surface grinding machines; and while HMT's capacity levels ranged from 80 per cent at Ajmer to 52 per cent at Bangalore, the Heary Machine Tool Plant at Ranchi managed what can only be described as a dire 22 per cent.[29]

In an attempt to supplement the admittedly limited, though nevertheless indicative, statistical evidence on the rates of capacity utilization for the public sector of the machine tool industry, the survey sought information to ascertain whether the problem was widespread throughout the entire branch. The initial approach was to seek information on the extent of firms that were operating below what they considered a full rate of capacity. Table 38 shows the response to this enquiry. From the sample of 40 firms 29, or over 70 per cent, replied affirmatively to the question.

Table 38 : Machine Tool Firms Presently Working Below a Full Rate of Operation

Response (1)	Firms (2)	% of Firms to Total (3)
Yes	29	72.5
No	11	27.5
Valid Cases	40	100.0
Missing Cases	-	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

Difficulties arise, however, with the interpretation of these results; this is because some machine tool units may, as a part of corporate policy, deliberately maintain a proportion of productive capacity under-utilized. Productive capacity surplus to current requirements may be installed to match longterm increases in demand; in anticipation of obtaining a larger share of the market; or as an emergency measure.[30] In order to check the importance of this issue, the question was put to machine tool manufacturers whether, as a matter of policy, excess capacity is maintained in production. From Table 39 it may be seen that only 3 firms, amounting to 7.5 per cent of those questioned pursued such a strategy.

Table 39 : Machine Tool Units Having the Policy of Maintaining Excess Capacity in Production

Response (1)	Firms (2)	(%) of Firms to Total (3)
Yes	3	7.5
No	37	92.5
Valid Cases	40	100.0
Missing Cases	-	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

Although the findings thus far accord with the situation that would have been expected to obtain in the tool industry, one possible distortion still remains : due to the array of processes carried on in engineering activities, most machine tool concerns almost inevitably suffer technological limitations to the achievement of full capacity. On this score also, therefore, the prevalence and impact of sub-utilization of capacity may easily be exaggerated. In an attempt to overcome this deficiency the obverse method was followed of identifying the number of units possessing sufficient capacity to meet demand. Table 40 documents the evidence on this point.

Table 40 : The Possession of Adequate Capacity to Meet Demand

Adequate Capacity (1)	Firms (2)	(%) of Firms to Total (3)
Yes	32	91.4
No	3	8.6
Valid Cases	35	100.0
Missing Cases	5	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

In contrast to the results of Table 38 where 11 firms indicated that they were not working below a full rate of operation, now surprisingly only 3 companies or some 8 per cent of the valid sample stated that they did not possess adequate capacity to match potential production orders. Even accepting that a proportion of the 11 firms listed as not operating below full capacity in Table 38, do not require expansion to cope with the level of demand, the results substantiate the now overwhelming evidence regarding the existence of considerable capacity under-utilization.

Given the fact that there seems to be extensive sub-utilization of capacity throughout the machine tool industry, it is inconceivable to expect more than a minority of enterprizes organising their production on a multi-shift basis. In the fifties, when the industry was established, a predominantly single-shift system could have been seen (although there is little evidence forth-coming to suggest that it in fact was) as an under-utilization of capital resources at the very time when much effort was being expended to enlarge capacity. Generally, however, firms do not have the option of comm-encing production on a multiple-shift system. The principal reason for this, lies in the fact that new companies face complex organisational difficulties; operating a multiple-shift system from scratch would complicate matters still further. Even the Soviet policy makers during their initial industrialization were unable to implement this form of working practice. As Granick has observed ... "the potential inherent in round-the-clock operations was fully recognised by Soviet administrators in the early thirties. The campaign for the three-shift and seven day week was the order of the day. Yet it was never very successful. Second and third shifts seem to have had very few workers, and the shift coefficient (defined as the total number of workers divided by the number working in the main shift) in metal fabricating rose only to 1.5 by 1932, and then, after first declining somewhat, it stagnated" ... thus, ..."plant utilization was an area where, by and large, Russian administrators were pushed back in the direction of a production solution which has been generally applied throughout Western Europe : that of the single-shift."[31] The number of shifts currently being worked in India's machine tool industry is shown in Table 41 ; and as large firms with their need to cover relatively greater amounts of overhead costs are more likely to operate on a multi-shift basis, the response to this question was analysed according to firm size. The results of Table 41 show that there is some justification for the assumption that a positive relation exists between the increasing size of an establishment and multi-shift operation. It appears that over 80 per cent of the large companies were operating on two or even three shifts. Such a situation may seem paradoxical given the high incidence of sub-utilization of capacity prevailing in the sector, but it should be noted that on numerous occasions during the fieldwork it was brought to the author's attention that underutilization of capacity was considerably minimised due to the diversified production activities of the companies. At the other end of the scale, the fact that the vast majority of small and medium sized firms operated on a single-shift system was a result which merely conformed to 'a priori' reasoning on the subject.

Table 41 : The Number of Shifts Currently being Worked in Machine Tool Units According to their Size

	Companies							
Number of Shifts	Small (nos)	Small (%)	Medium (nos)	Medium (%)	Large (nos)	Large (%)	Row Totals (nos)	Row Totals (%)
1	19	79.2	3	75.0	2	16.7	24	60.0
2	3	12.5	1	25.0	7	58.3	11	27.5
3	2	8.3	-	-	3	25.0	5	12.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

On the findings in general, there was surprise over the high number of firms working double shifts, amounting to 27.5 per cent of the total. It is likely that some of India's tool manufacturers having experienced low or even negative levels of capital replacement for several years have now been forced to double-up on the operating time of the installed equipment to cater for the increased output since the recession years. But whatever the reasons are for a higher number of units than expected organising their production on a double shift basis, they should not detract from the fact that overall, the predominance of one shift working reinforces the belief of widespread sub-utilization of capacity in the machine tool branch.

It is perhaps worth mentioning that many of the firms having adequate capacity expressed the view that profitable investment opportunities existed (these were probably 'progressive' firms in an 'unprogressive' market) but could not be taken advantage of for a variety of reasons : a shortage of skilled labour figured prominently, above the scarcity of managerial talent or even the inability to raise external finance; much more important than all of these, however, was the dominant problem of shortages in internal finance. This aspect is, of course, simply another symptom of the 'vicious circle' of low demand leading to sub-utilization of capacity which in turn leads to high cost-price methods of manufacture, so further constraining the growth in demand. The Indian machine tool industry has for the last decade or so been locked into such a vicious circle where infra-marginal operation has resulted in reduced profits and for many years even outright losses. The concomitant diseconomies of scale have been considerable; even the significant wage differentials over foreign competitors have likely been insufficient to create the maximum competitive level. Consequently, the level of penetration into overseas markets (even though on a rising trend, it remains relatively very tiny) has not been such as to allow increasing scale and efficiency, thwarted in the Indian market, to be achieved abroad. The vicious circle is thus compounded.

Aside from the hardy perenial of low rates of capacity utilization, there are other problems which have reduced the industry's ability to operate at optimum levels of efficiency. Many of these difficulties have 'dogged' the industry for years, others, not quite so long. For fullness of discussion, a brief mention of these secondary influences is perhaps required.

A factor, quite recent in appearance which many machine tool entrepreneurs singled out as being de-stabilising to manufacturing performance was breakdowns in industrial relations. A number of causes seem to be behind this problem. For many workers, the increased freedom that has come about since the ending of the period of 'emergency' has provided them with the opportunity of re-asserting their industrial rights. The easiest way of achieving this is of course, through membership of a labour union. But many machine tool employers have attempted to resist the inevitable 'wind of change' blowing across the industrial map of India and, as a result, have become embroiled in union recognition disputes. Moreover, the fervour of unionisation has even spread to engulf existing unionised firms with strikes and lock-outs caused by inter-union rivalry. Finally, in addition to these purely 'worker representation' disputes there were the more conventional conflicts arising from the employees' claims for improvements in pay and conditions.

Table 42 illustrates the incidence of labour force unionisation amongst machine tool enterprises as it was in 1978. It can be seen that even in the late seventies, unions were only a fact of life in half the companies under review. In the small scale sector of the organised machine tool industry, unions had a foothold in less than 30 per cent of undertakings, whilst in the medium sized firms there was only a 25 per cent representation.

Table 42 : The Incidence of Labour Force Unionisation Amongst Machine Tool Units According to their Size

	Companies							
Labour Force Unionisation	Small (Nos)	(%)	Medium (Nos)	(%)	Large (Nos)	(%)	Row Totals (Nos)	(%)
Yes	7	29.2	3	75.0	10	83.3	20	50.0
No	17	70.8	1	25.0	2	16.7	20	50.0
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

At a time when there was reaction to the stringency of life under the 'emergency', the denial of the right to belong to a union must surely have been a source of irritation to workers in the industry.

Of the firms that were unionised, the majority had a maximum of 5 unions operating within their organisations. As Table 43 indicates, 42.5 per cent of companies had between 1 and 5 unions representing their employees. Two of the larger units had between 6 and 10 unions and one firm had as many as 26 unions to contend with. The analysis if taken a stage further reveals for those firms that are unionised, a very high unionisation ratio. Even though many of the firms in question did not operate 'closed shops' for their workers, clearly, as is depicted in Table 44, an extremely high proportion (90 per cent) of those enterprises that did allow unions had unionisation ratios within the 75-100 percentage bands.

Although poor labour relations in the industry was continually stated by manufacturers to be the next biggest headache after inadequate demand, contrary to what would have been expected, difficulties of supply in raw materials and intermediate goods did not even figure a mention further down the scale of sources of inefficiency. The supply of

Table 43 : The Number of Trade Unions Operating in the Machine Tool Units According to their Size.

Number of Unions	Companies: Small (Nos)	(%)	Medium (Nos)	(%)	Large (Nos)	(%)	Row Totals (Nos)	(%)
0	17	70.8	1	25.0	2	16.7	20	50.0
1 - 5	5	20.9	3	75.0	9	74.9	17	42.5
6 -10	2	8.4	-	-	-	-	2	5.0
26	-	-	-	-	1	8.3	1	2.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

Table 44 : The Percentage Unionisation of the Labour Force of Each Machine Tool Firm According to the Size of Establishment

Percentage Unionisation	Companies: Small (Nos)	(%)	Medium (Nos)	(%)	Large (Nos)	(%)	Row Totals (Nos)	(%)
0	17	70.8	1	25.0	2	16.7	20	50.0
1 - 24	-	-	-	-	-	-	-	-
25 - 49	-	-	-	-	-	-	-	-
50 - 74	-	-	-	-	2	16.7	2	5.0
75 - 99	2	8.3	2	50.0	3	25.0	7	17.5
100	5	20.8	1	25.0	5	41.7	11	27.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

these factors, at least for the machine tool industry, does not seem to present the problems of earlier times. It is probable that the recent slackness in engineering activity may, by easing the demand on scarce inputs, have had something to do with this. An exception, has regard to the supply of electricity. In some areas (Calcutta being one notable example) problems are still encountered with power generation. Major reductions or even black-outs in electricity supply usually occurring in the summer periods when shortages of rain restrict the hydro-electric sources of power.

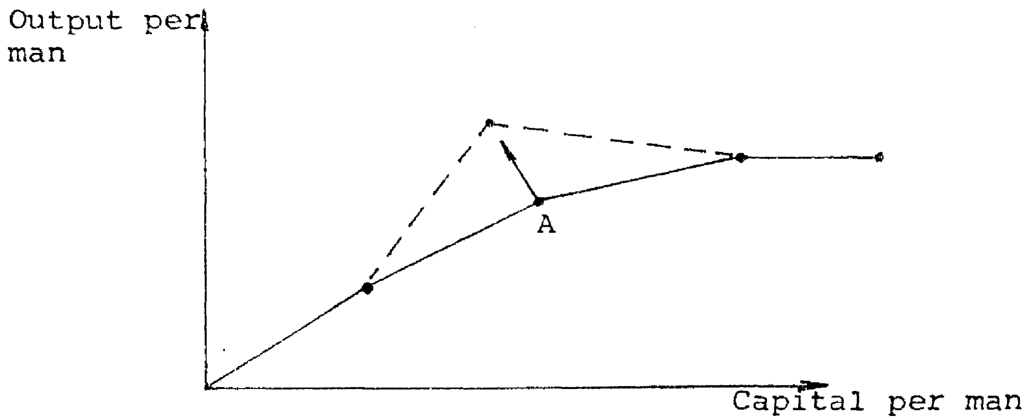
(iii) The 'Evolutionary' Theory of Technical Progress

It was mentioned in Chapter 2 that patent registrations might not be an accurate reflector of a developing country's ability to innovate. There is a need at this juncture to explore this proposition a little more deeply.

A country such as India at the start of its industrialization push might not be expected to become a major innovator in comparable terms to the already advanced countries. This is not to deny, however, that technical progress in the third world's industrializing countries does take place. But the nature of the change could well be somewhat different : with minor, imperceptible amounts of innovational performance being the norm.[32] Thus, when the 'residual' is mentioned to account for that portion of growth which is not explained by increases in the factors of production it is, under this different approach, considered to envelope all the various forms of learning that can be acquired in an industrial environment, and not simply patented innovation.

Atkinson and Stiglitz[33] were among the first economists to draw attention to an associated aspect of this new approach : the 'localised' character of innovational occurrence, which they felt came about through workers' preoccupation with problems that are close at hand. In the extreme case this would lead to a situation as depicted in Figure 8 below.

Figure 8 'Localised' Technical Progress



It is clear that here, technical progress does not raise output per head for all possible techniques. To clarify this fact, it should not be forgotten that a production function represents numerous production possibilities and the different points on the curve signify different manufacturing processes. Now when learning takes place at one point it should be evident that the resultant change in the function will also be confined solely to that point; an outward movement at A, as opposed to a general shift to the entire production function to a more efficient level. In Figure 8 it is assumed that no "spillover" improvements into other techniques ensue from the heightened efficiency at A. But as the authors point out : "In reality we should expect that a given technical advance would give rise to some spillovers and that several techniques would be affected. However, we would reach the traditional position only if there were spillovers to 'every' technique. This means that a technical advance would have to be such as to raise productivity on, say, every type of textile loom from the fully automated to the crudest hand loom".[34]

Although the above work broke fresh ground in the examination of technical change, a very important lesson to be learnt remained misted over. N. Rosenberg[35] has drawn explicit attention to the improvement opportunities in the operation of production techniques which derive from the actual experience of the worker. This constitutes a long-run form of learning by doing, a process of inter-play between man and machines or between groups and organizations, rather than the passive conformity of the ordinary agents of production to rules and systems laid down by heroic inventor-entrepreneurs.[36]

It was left to Nelson and Winter to formally theorize these modifications on the neoclassical view of technical change into what they termed as the 'evolutionary' model of economic growth.[37] In the pursuit of this aim, the authors distinguish between Schumpeterian theory where 'the most important firms are those that serve as the vehicles for action of the real drivers of the system - the innovating entrepreneurs', and neoclassical theory where maximization of profit is based on equilibrium (rather than Schumpeterian dynamism) principles. Unlike either of these 'growth' theories, however, the evolutionary model is held to represent a 'behaviourist' approach to individual firms. The basic behavioural prémise is that a firm at any time operates largely according to a set of decision rules that link a domain of environmental stimuli to a range of responses on the part of firms.[38] The neoclassical interpretation of such happenings would be that they are primed by profit maximization; the evolutionary's, that they are given, at least in the short-run. Over the long-run, of course, decision rules may well have to be modified to adapt to changing technological circumstances. In the description of the elements of evolutionary long-term technical change, it is best to quote from the authors' paper directly : "On our reading, at least, the neoclassical interpretation of long-run productivity change is sharply different from our own. It is based on a clean distinction between 'moving along' an existing production function and shifting to a new one. In the evolutionary theory, substitution of the 'search and selection' metaphor for the maximization metaphor, plus the assumption of the basic improvability of procedures, blurs the notion of a production function. ... The exploration of the set [being] treated as an historical, incremental process in which non-market information flows among firms played a major role.[39]

This debate on the incremental diffusion of innovation was taken a step further with the publication in the mid-1970s of a book by P. David. An important point to emerge from the treatise is the author's qualification of the adjective 'evolutionary' by his greater emphasis given to the 'historical'. The modified theory of David contains the Darwinian principle of 'survival of the fittest' a la Nelson and Winter but now also the Mendelian principle of 'heredity'. Thus, because Nelson and Winter's 'natural selection' process in the treatment of the generation of technological innovation corresponds to a stationary state - where technical 'improvements' are determined completely within the span of the present epoch and independently of the path by which the current state was reached - it clearly fails to consider the historical feature of technical change as an irreversible, evolutionary development. In this respect their theory of secular change remains fundamentally neoclassical in spirit, even though their conception of micro-economic behaviour departs from the neoclassical tradition.[40]

Whether the evolutionary theory of technical change belongs to the neoclassical school or not should not be allowed to detract from the important contribution it makes to the study of economic growth, and especially in the context of developing countries. For the particular case of the Indian machine tool industry it suggests that technological progress may well have been more significant than patent registrations indicate. It is difficult to quantify but clearly much 'learning' has undoubtedly taken place. In the private small scale sector, adaption of foreign designed technology has gradually evolved to serve the needs of the local market. And in the larger public sector companies new designs have emerged indigenously that have led to technical improvement in both process and product. HMT, for instance, now designs and manufactures sophisticated numerically controlled machine tools for domestic and export markets. Furthermore, the export of HMT's technical expertize to assist in the establishment of machine tool plants in other industrializing nations, e.g. Algeria and Kenya, gives credence to the view that substantial scientific and productive skill has been accumulated by this company. The build-up of such technical knowledge is a heartening factor as the problem is, when technological innovation or improvement is 'localised' to particular processes, the import of technical advance from Western countries - either through learning by doing or research and development - will leave the choice-set of the less capital-intensive though possibly more appropriate techniques, comparatively unaffected. The examination of the state of scientific knowledge in India's machine tool sector is attempted in the next and final section of this chapter.

Section 3 : The State of Scientific Knowledge in the Machine Tool Branch

(i) Research, Development and Design

Amelioration in productive knowledge is the final and most literal interpretation of technological development. There are a plethora of economic activities which are involved with improving the ability to produce; the most important of which is the process of research, invention, development/design and, ultimately, innovation. These factors, by expanding the frontiers of industrial knowledge, are conventionally regarded as the primary agents in the area of technical advance. But as a spin-off from either developmental work and straightforward production or as a direct result of government, company or individual initiative another aspect, that of the educational level of the workers also has a vital role to play. In the first part of this concluding section, the state of the arts in respect of research, development and design in the machine tool industry is explored. This is followed by a brief assessment of the contribution that education has made to the development of the sector.

Under the Western machine tool manufacturing strategy that India chose to follow, there is general agreement that research and development (R & D) expenditure makes a fundamental contribution to economic growth. Indeed, the so far insuperable obstacles to a precise measure of technical progress has in recent years led many economists to include in their development analyses an evaluation of R&D as a gauge of the impact of technological progress; in many cases to act as a supportive index for other measures but increasingly as in indicator in its own right. This increased interest in the pursuit of scientific knowledge has been prompted by the positive relationship that exists between R&D and industrial innovation : the cornerstone to the Brown-Rosenberg paradigm. The view is frequently advanced, for instance, that Britain's industrial revolution was fuelled by the abundant supply of inventors, innovators, and risk-takers; and that the role of capital accumulation, though indispensable, was of secondary significance in the acceleration of economic growth. Schumpeterian theory epitomizes this approach. Enshrined in Schumpeter's work is a term coined to describe the impact of the innovatory cycle : "the process of creative destruction." [41] Competition was regarded as the driving force behind this process;

but whether it be the cause or the effect as another body of opinion contends, there is little controversy surrounding the fact that patented-innovation is almost entirely the province of the rich countries.

In the case of machine tool technology, special emphasis is required in the bid towards self-reliance and accelerated technological build-up because it is the 'mother' technology which provides the nation essential tools that generate production in almost all sectors of its economy.[42] This statement is the opening line to India's Science and Technology Plan for machine tools which was published in the early 1970s. But, although there is a clear awareness of the importance of the industry in the process of industrialization, only limited progress has been made in the field of patented-innovation. Traditionally, the machine tool industry has been a leader in invention-innovation; this has not occurred in India. Instead, foreign collaboration has been the main purveyor of change and progress in the product-mix of the sector. A fact which may have undermined rather than enhanced the technological development of the industry.

There are no published statistics on the extent of research and development in the Indian machine tool industry. Consequently, the only data on the subject is that which was obtained from the survey to this study and although the sample appears quite small, it should be remembered that excluding HMT, the majority of the important establishments were covered. However, due to the enormous size of HMT in relation to the industry, its omission obviously impairs the accuracy of the findings; to that extent, the analysis of R&D expenditure has more relevance if it is taken to relate only to the private sector of the machine tool branch.

An obvious way of judging the emphasis given to R&D by machine tool manufacturers is via the numbers of technical and design staff employed in the industry. Table 45

Table 45 : Research and Development Staff Employed in the Machine Tool Industry

R&D Staff (1)	Firms (2)	(%) of Firms to Total (3)
0	22	59.5
1 - 5	8	22.0
6 - 10	2	5.0
11 - 20	2	5.0
21 - 50	3	8.0
Valid Cases	37	100.0
Missing Cases	3	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

provides figures to this effect. It is quite evident that for many companies R&D had no role to play at all in their activities; this situation is applicable to 22 firms, close to 60 per cent of the valid sample. Furthermore, only 3 firms (large units) employed a staff of more than 20 solely for the purposes of R&D. The data on the employment of design staff is somewhat similar. Table 46 shows that while 14 companies only had between 1 and 5 designers on the payroll, a further 10 firms employed no design staff at all.

Table 46 : Design Staff Employed in the Machine Tool Industry

Design Staff (1)	Firms (2)	(%) of Firms to Total (3)
0	10	28.6
1 - 5	14	40.0
6 - 10	3	8.6
11 - 20	5	14.3
21 - 50	3	8.6
Valid Cases	35	100.0
Missing Cases	5	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

Most of these units were small scale organisations that could not afford a full-time design engineer. In these circumstances, the normal practice would be either to employ a designer-cum-draughtsman on a part-time arrangement or, as the need arose, on a consultancy basis. In many instances, however, the small scale entrepreneur was himself the designer. It certainly would appear from the evidence of the two tables, that research, development and design activity in the industry has a low priority.[43]

The data on R&D expenditure reinforces the above conclusion. In this connection, Tables 47 and 48 present information on two of the ways in which such expenditure can be channelled : for the improvement of existing output and for the development of new products. The figures contained in both tables heavily suggest that many of the major manufacturers are continuing to rely on the same old collaborators' designs. Even though R&D expenditures are generally on a rising trend, it is little comfort when the absolute amounts are so derisory : in 1974 a total of only Rs.23.5 lakhs was spent by the sample firms on R&D as against an industry sales turnover of Rs.88850 lakhs (approximately 0.03%). As would be expected therefore, the low R&D expenditures are in symmetry with the minimal employment of development and design staff.

Various other data, not specifically on the machine tool industry, support the above findings. A 1964 study reported that about 50 per cent of the chemical and metal working firms in India spent nothing on research, about 25 per cent spent less than 0.1 per cent of turnover, and the remaining 25 per cent spent on average 0.25 per cent of turnover. The study concluded that the average R&D expenditure of these industries did not exceed 0.1 per cent of turnover.[44] According to a 1970 report by the Committee on Science and Technology, "the private contribution to R&D is small and is estimated at about 0.2 per cent of the turnover of industry.[45] In the case of

Table 47 : Machine Tool Firms' Expenditure on Product Development for the Years Specified (Rs.Lakhs)

Expenditure	Years 1974	1975	1976
Product Improvements	2.7	3.4	7.3
Valid Cases	19	20	20
Missing Cases	21	20	20
Sample	40	40	40

Source : The Indian Machine Tool Industry Survey (1978)

Table 48 : Machine Tool Firms' Expenditure on the Development of New Products for the Years Specified (Rs.Lakhs)

Expenditure	Years 1974	1975	1976
Development of New Products	20.8	16.2	49.8
Valid Cases	20	20	20
Missing Cases	20	20	20
Sample	40	40	40

Source : The Indian Machine Tool Industry Survey (1978)

firms with foreign licenses, Kapoor reports the findings of a 1965 survey : "There is hardly any R&D activity by Indian licensees. Less than 5 per cent of the respondents (licensees) claimed to be engaged in any development activity while not over 2 per cent were engaged in research ... The 5 per cent of the respondents engaged in some form of R&D activity are the large companies with an industrial background ... Though 5 per cent of the respondents are engaged in some sort of R&D, even these licensees became nearly completely dependent on the licensors' R&D in the licensed area."[46]

The end result of R&D should, in the main, be innovation. Yet, here again the results from the survey are consistent with the other findings on the subject; with a limited input of R&D resources into the machine tool industry, clearly innovational rewards will also be few. Table 49 provides the evidence on this point. Strikingly, only 3 companies out of the 38 respondents stated that they currently held a patent. By contrast, of the 4 machine tool firms interviewed in Britain, 3 were patent holders. Out of these firms, 1 company held around 50 patents whilst another had 60 current patents with a further 60 in the process of application, and over 300 that had already expired. The paucity of patents originating from Indian machine tool units seems convincing proof of the poor innovational performance of the industry;

Table 49 : The Number of Machine Tool Firms Holding Patents

Possession of Patents (1)	Firms (2)	(%) of Firms to Total (3)
Yes	3	8.0
No	35	92.0
Valid Cases	38	100.0
Missing Cases*	2	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)
* Includes HMT Ltd.

it argues conclusively that the Brown-Rosenberg paradigm is inoperative in such an industrial environment and thus that the traditional Western argument that the tool industry is the harbinger of technological progress in an economy is of vacuous content in the case of India.

Now that low levels of research, development and design inputs and innovational output have been empirically established, the discussion proceeds to attempt a determination of the principal underlying causes behind this state of affairs. It is postulated that the following three factors have been of major significance in this context : the first two considerations are what might be termed the macro-aspects of the problem; they are foreign collaboration and government policy. The third factor, on the other hand, concerns the various means that entrepreneurs can take, of their own volition, to improve the technological state of their products; this part of the analysis is micro-economic in nature, involving company decisions to seek technical advice and/or assistance from outside research bodies, university departments, and government technical centres and institutes.

Macro-Constraints :

The development of the machine tool sector has been characterised by an almost total dependence on foreign collaboration for original design. It should be pointed out though, that a sizeable minority of Indian machine tools, especially in the small scale sector have been manufactured without the assistance of foreign collaborators. Certain generalizations can be made of the machinery branch in general regarding these ostensibly 'indigenously designed' products : (i) they were generally close, if not identical copies of products which were previously imported; (ii) they were relatively simple products which did not require advanced manufacturing techniques; and (iii) few of them had not been produced in advanced countries a decade or two earlier.[47] A great deal of this imitative design work has been occurring continuously since independence; it was by no means a new phenomenon, brought on by India's programme of industrialization. Of course though, with the emergence of the public sector in the machine tool industry and the increased demand that emanated from the early phases of import-substitution, the trend was for relatively more sophisticated technology which could not effectively be copied. Thus, the clamour for modern design of Western machinery set the stage for the entrance of foreign collaboration as the prime vehicle for the technological development of the industry.

It might validly be asked why foreign collaboration has been categorised as a macro-constraint to the encouragement of indigenous design capacity when the decision to seek a foreign partner is clearly a matter for the individual entrepreneur. To some extent this is correct but such decisions are rarely taken in isolation and can be influenced by a whole manner of things, including indirectly government policy. It may not have been an overt strategy but the industrial and trade control regime did create a situation where a bias was given to link-ups with foreign manufacturers as the source for designs, rather than on domestic efforts. The clearest indictment has reference to the licensing arrangements of the authorities. Certainly throughout the first three of the Five Year Plans, the issuance of industrial and capital goods licenses was made contingent on foreign investment covering the foreign exchange requirement of the import of capital goods. There was a definite preference in this respect as Kidron has stated : "These and other factors have so affected official thinking that it is now virtually impossible for an Indian firm to start up or expand without presenting a scheme for foreign collaboration. As one journal put it : 'it has become difficult to get a manufacturing license without prior arrangements for foreign technical collaboration ... whether (an industry) really needs technical know-how and foreign capital or not.'"[48]

Aside from this indirect incentive that was given to foreign collaboration agreements for the introduction of new machine tool designs, it is argued that the entire direction of government policy was largely responsible for the poor design capacity of the industry. In particular, many of the more deleterious consequences of the restrictive control regime stemmed from the way in which the forces of competition were stifled. Irrespective of production costs or quality, the import of any product already manufactured in India was automatically banned or, if allowed, the level of protection was so high as seldom to make it a realistic proposition. Furthermore, the fact that the industry had its capacity, production, raw and intermediate material inputs, and capital goods investment all licensed, virtually established a monopolistic structure in the manufacture of given machine tools, particularly amongst the larger members of the branch. The up-shot of government policy was the creation of an industrial environment where some machine tool producers were able to manufacture equipment of inefficient and inappropriate design without being forced out of business.

Micro-Constraints :

To this point in time, the major thrust of the little R&D that has taken place in the industry has largely been aimed at achieving the goal of technological independence. Strictly speaking, however, it is illogical for any country to attempt to be 100 per cent self-sufficient in the production of all types of machine tools. Even the highly advanced countries continue to import a large proportion of their requirements : in 1975, the import of machine tools into France amounted to 50 per cent of domestic production; in Britain it was 35 per cent; whilst for the United States, the world's most sophisticated producer, it was still a significant 13 per cent. There is no mystery surrounding the high level of international trade in machine tool technology. The NCST Report on machine tools provides a good explanation of its importance : ... "Because of the very large variety of machine tools and because of the very small numbers in which some varieties of machine tools are required, it does not pay to carry out R&D in all varieties of machine tools. Some countries have attained such extreme degrees of specialization and competence in some types of machine tools which it would be unrealistic and wasteful to duplicate." [49] Even if in the near future technological independence in machine tool manufacture could be attained in India, the price might still be too high for another reason: As there is only a limited R&D capacity in the country, it could be argued that the designs would tend to come from the advanced nations and, as has been argued repeatedly, they will be of dubious advantage to a capital scarce economy. Moreover, the rationale of machine tool production under the Brown-Rosenberg paradigm is based on the premise of 'forced obsolescence' where still productive capital equipment is compulsory retired by the competitive pressures originating from evermore productive innovations. This type of industrial philosophy is at the moment completely alien to the capital starved machine tool users in India.

Corroboration for this argument was sought from the survey. This was attempted by asking manufacturers to indicate on a scale what they felt the current life of machine tool designs to be. Table 50 lists the responses received to the question. A majority of entrepreneurs, over 67 per cent, considered the current life of Indian machine tools to be over 9 years; one third of these, however, believed the design life extended even beyond 16 years. Furthermore, it would appear that such views were equally distributed amongst both small and large enterprises. This widespread conception of the longetivity of the life of plant is a characteristic of the machine building industries in India. The probable causes are two-fold : the first should by now be almost self-evident, having regard to the suggested high cost-price of indigenous machine tools. In a low-income market a further reason has been advanced by S.Patil, the recently retired Managing Director of HMT. Commenting on the demand nexus between the machine building industry and the

Table 50 : The Average Current Life of Designs in the Machine Tool Industry, According to Size of Establishment

	Companies							
Life of Design(Years)	Small (Nos)	Small (%)	Medium (Nos)	Medium (%)	Large (Nos)	Large (%)	Row Totals (Nos)	Row Totals (%)
3 - 5	3	12.5	-	-	2	16.7	5	12.5
6 - 8	4	16.7	2	50.0	2	16.7	8	20.0
9 - 12	8	33.3	2	50.0	2	16.7	12	30.0
13 - 16	3	12.5	-	-	3	25.0	6	15.0
16	6	25.0	-	-	3	25.0	9	22.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

machine tool manufacturers he suggested that ... "our tax formula for allowing depreciation on it [the purchase of new machinery] actually discourages any large accumulation of depreciation reserves. The low resulting demand for new machinery has meant an even smaller demand for machine tools. As a result, HMT's market surveys have shown that only 7 per cent of machine tools are replaced every year in India as against 20 to 30 per cent in the U.S.A., Europe and Japan."[50] The consequential continued use of out-dated equipment has resulted in low user-productivity on the one hand, and low take-off of manufactured machine tools on the other.[51] The argument is not that India's machine tool stock should be composed of best-practice Western technology but rather that the designs be both 'modern' and reflect the economic conditions of the country. At the moment there seems a case for believing that the age and inappropriateness of Indian machine tools have meant that they are inefficient even for developing countries.

Machine tool R&D should take into account the needs of the machine building industry; this has not happened in India. At the firm level, the machine tool manufacturers and machine tool users have been functioning in almost total isolation to one another. The NCST Report on machine tools had this to say on manufacturer-user collaboration : "The machine tool users have taken for granted that they would not get any assistance from the manufacturers to improve their technology, productivity etc. The manufacturers, on the other hand, have been too preoccupied with their own manufacturing and technological problems without keeping in touch with the needs of the machine tool users regarding product innovation, accessories, tooling, job engineering etc. ... an inter-face between the manufacturers and the users for feedbacks and exchange of ideas does not exist."[52] Thus, the Indian machine tool industry has not, in Rosenberg's terminology, acted as the main 'transmission centre' for the dissemination of knowledge and techniques to the rest of the machine building industry as its counterparts in the West had done a century or two earlier.

The establishment of a machine tool institute (CMTI) orientated almost entirely towards R&D was promoted and sponsored by the government as a solution to the low R&D investment of individual companies. Domestic firms have been urged by the authorities to participate closely in the work of the Institute in order to improve their products and economic performance. In addition, the CMTI has testing and design facilities which can be made available on request to entrepreneurs who wish to utilise these services. The objective of the Institute appears fine in theory but how far in practice has it been an effective substitute to R&D engendered through the organic link between tool-maker and machine-builder? The results contained in Table 51 suggest hardly at all. Of the 40 companies in the sample, less than a third had ever taken advantage of the facilities offered by the CMTI.

Table 51 : The Machine Tool Companies According to their Size that have taken Advantage of the facilities offered by the Central Machine Tool Institute

Use of C.M.T.I.	Small (Nos)	Small (%)	Medium (Nos)	Medium (%)	Large (Nos)	Large (%)	Row Totals (Nos)	Row Totals (%)
Yes	6	25.0	1	25.0	6	50.0	13	32.5
No	18	75.0	3	75.0	6	50.0	27	67.5
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

This state of affairs was common to all firm sizes : 75 per cent of small and medium sized companies had never utilized CMTI's services whilst the figure for large firms was 50 per cent. Many of the small manufacturers explained their reluctance in terms of the high costs charged by the CMTI for the services provided. In respect of the units in the Northern States there were also the additional costs of transportation to be considered : one entrepreneur in Ludhiana, for instance, stated that the CMTI had at one time been asked to test his product, but he was later to discover that the Institute's fees coupled with the freight charges involved in shipping his machine to Bangalore would have proved prohibitive.

Scientific knowledge need not solely be acquired from a research institute. In Britain, for example, many machine tool companies are members of research associations such as those of MITRA (machine tool) and PERA (production engineering). For India, as Table 52 shows, the reverse has been the case. In similarity with the findings of the previous table, the level of contact of the large companies with research bodies other than CMTI was somewhat higher than for the small and medium sized establishments though still disappointing. A minority of units did have links with a mechanical engineering organisation though all firms thought the benefits derived from membership were minimal. The small industry institutes were mentioned by some of the small scale companies, however, their importance is limited mainly to production assistance purposes such as testing and inspection.

Table 52 : The Strength of Contact between Machine Tool Units according to their Size and Outside Research Bodies

	Companies							
Degree of Contact	Small		Medium		Large		Row Totals	
	(Nos)	(%)	(Nos)	(%)	(Nos)	(%)	(Nos)	(%)
Strong	5	20.8	-	-	5	41.7	10	25.0
Weak	4	16.7	1	25.0	5	41.7	10	25.0
None	15	62.5	3	75.0	2	16.7	20	50.0
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

Interaction between the machine tool firms and universities was almost non-existant. The evidence for this is listed in Table 53. Only 12.5 per cent of entrepreneurs described their companies' relationship with engineering universities or engineering departments of other universities as strong. In fact, for many companies the maximum level of contact that they had experienced with universities was when engineering students had visited them in connection with their own study projects. This lack of inter-play between the universities and industry is not confined solely to the machine tool industry but is widespread, affecting all sectors of the economy. The situation is in sharp contrast

Table 53 : The Level of Association between Machine Tool Firms According to their Size and Engineering Universities or Engineering Departments of Universities

	Companies							
Level of Association	Small (Nos)	(%)	Medium (Nos)	(%)	Large (Nos)	(%)	Row Totals (Nos)	(%)
Strong	3	12.5	-	-	2	16.7	5	12.5
Weak	2	8.3	1	25.0	6	50.0	9	22.5
None	19	79.2	3	75.0	4	33.3	26	65.0
Valid Cases	24	100.0	4	100.0	12	100.0	40	100.0
Missing Cases	-		-		-		-	
Sample	24		4		12		40	

Source : The Indian Machine Tool Industry Survey (1978)

to that in the advanced nations where basic research and the training of research personnel is undertaken in close co-operation with institutes of higher learning. The Indian authorities though, have long been aware of the importance of this relationship as the Draft Outline of the Fourth Five Year Plan bears testament : "An overwhelmingly large number of R&D personnel are working in government laboratories, in most cases without adequate contact with either higher educational and technological institutions or with industrial establishments. The research staff in higher technological or educational institutions have little contact with industry; while the number of R&D staff within industry itself is very small." [53]

Thus, although the R&D activities of the Council of Scientific and Industrial Research and the planning efforts of the NCST have been prodigious over the last decade or so, India's R&D expenditure per capita still remains amongst the lowest in the world : in 1974/75 it was 0.61 (in U.S. $) compared to 85.0 for the Soviet Union and 139.4 for the United States in 1973. In the specific case of the machine tool industry, the evidence that has been presented in this section is convincing that an equally poor level of R&D activity exists there also.

(ii) Industrial Learning

Economists that have studied the economic development of the already industrialized countries have concluded from the results of their analyses that improved knowledge and the acquisition of skills have been important ingredients in the rates of technological progress achieved. Denison, for instance, has identified and measured the contribution of various factors to the growth of the United States economy.[54] He found that 23 per cent of the annual average growth rate of 2.9 per cent between 1929 and 1957 could be attributed to education. Indeed, his analysis showed no less than 42 per cent of the per capita growth rate in the United States represented the contribution of education. Another study by T. Schultz calculated that returns on educational expenditure explained between 20 to 30 per cent of the growth of income in the United States from 1929 to 1956 and accounted for an even higher proportion of the rise in per capita earnings of the labour force. Schultz argued that the differential in earnings corresponded closely to the differential in education and believed that one was the consequence of the other. In addition, he felt that many of the paradoxes of economic growth could be resolved once human investment was taken into account : ... "Thus, it would explain the behaviour of capital/output ratios in advanced countries, the quick recovery of Germany and Japan which suffered heavy physical capital losses in war-time destruction, and the difficulties the underdeveloped countries sometimes have in 'absorbing' capital despite great scarcity."[55]

When 'learning' is related to improvements in the performance of plant and machinery, it can be broken down into two components :

The first has reference to what has been termed 'learning-by-doing' which is the accumulation of experience by the workers in the process of production thereby increasing the efficiency of manufacturing operations. This is, again, a characteristic of the 'division of labour' concept made famous by Adam Smith. Specialization of tasks is beneficial because it increases the dexterity of the workforce; it economizes on time spent in production; and finally, it encourages innovation through the need to improve the abridgement of labour involved in the constituent manufacturing activities. The resultant reductions in direct labour input per unit of output to cumulative output have been variously described as : measures of experience, learning curves, and progress functions. Whatever term is used however, they all reflect temporal changes of irreversible knowledge. Technological development in this sense is, therefore, the inculcation by the workers of increases in the skill and general ability in performing their tasks; it is usually considered as disembodied technical progress. The exogenous nature of the concept has been succinctly described by W. Hirsch : ... "They [progress functions] are dynamic cost functions and are distinctly different from conventional long-run cost functions which are timeless or assume stability in technical knowledge. A conventional long-run cost function is related to points on a number of production functions, each being associated with a different plant, but all plants using the same general technical knowledge. By contrast, a progress function is related to points on different production functions which are arranged in chronological order so that technological knowledge is permitted to change while the size of the plant and scale of production either do not change or do not affect costs."[56] Clearly then, the residual in a production function must to some degree reflect the extent of learning-by-doing. Although the most notable studies on the empirical verification of the concept have centred on firms with homogenous type output[57] there have also been others which have sought evidence on the impact of progress functions in ship-building and machine tools.[58] Unfortunately, for the purposes of this study, no easy means existed to identify the contribution of this element to the technological development of the Indian machine tool industry.

The second component of industrial learning is the more obvious one of education; this is the widely accepted interpretation of knowledge that both Denison and Schultz had in mind when conducting their studies. The importance that Indian manufacturers of machine tools have placed on this aspect was assessed by enquiring the minimal level of formal education, if any, that was required for their direct workers. Table 54 shows the response to this question.

Table 54 : Minimum Level of Education Required by the Machine Tool Firms for their Machine Operatives

Scale (1)	Firms (2)	Row (%) of (2) (3)
None	12	30.0
High School Certificate	10	25.0
Engineering College (I.T.I.)	18	45.0
Post Graduate Qualifications	-	-
Valid Cases	40	100.0
Missing Cases	-	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

It can be seen from the table that the most important educational attribute in the view of the manufacturers is graduation from one of the government sponsored industrial training institutes (ITIs) which are scattered throughout India. Post-graduate qualifications, on the other hand, have no part to play in the required educational level of productive workers. But while high school certificates were required by 25 per cent of the establishments, amazingly 30 per cent asked for no qualifications at all; these latter companies were usually in the small scale sector where on-the-job training was the normal and accepted way of doing things.

Although the ITI training schemes have been afforded most favoured status by the machine tool firms which responded to the question, their effectiveness at raising the capabilities of the workers has been criticised by the NCST Report; it had this to say : ... "One of the major impediments to rapid technological advancement has been the lack of good facilities for training skilled workers. Productivity too has remained at low levels because of this. The shortcoming can be traced to the industrial training institutes from which the present crop of skilled workers comes."[59] But the institutionalized engineering centres need not be the only source of worker education : firms can possess their own training schools. It was felt relevant, therefore, to seek information from the sample enterprises regarding the provision of their own technical training programmes. The replies are contained in Table 55.

Table 55 : The Provision of Technical Training by the Machine Tool Units for their Machine Operatives

Scale (1)	Firms (2)	Row (%) of (2) (3)
None	18	45.0
Company Training School	4	10.0
Engineering College Courses (ITI)	18	45.0
Valid Cases	40	100.0
Missing Cases	-	
Sample	40	

Source : The Indian Machine Tool Industry Survey (1978)

Evidently, only 10 per cent of the companies surveyed supplemented the industrial knowledge of their workers through the provision of company training schools. These units will naturally have been the major undertakings in the industry; it is only they that possess the numbers of employees to make investment into such facilities worthwhile and, moreover, could afford the costs that would be involved. The remainder, being the small and medium sized companies, would perforce have to rely on the maligned ITIs for the training of their workers.

The contemporary significance given to the role of education in the process of economic growth derives from the numerous studies of its importance in the advanced countries. The inference that has been promulgated from these studies pinpoints the low quality of human capital in the developing countries as being the major brake on the absorption of physical capital and hence technological progress. Although an attractive explanation for the retardation in the levels of industrialization in the third world, its importance should not be overstated. The aim of this study has been to show that the efficiency in the production of capital goods is at least as critical though certainly more disregarded an element in economic development as the act of capital formation itself. In as much as investment in human capital can assist in the amelioration of productive efficiency then it should be accorded preferential treatment by governments and manufacturers. But it should be stressed, the issue constitutes just one aspect of the problem and on its own will not be able to supply the key to the conundrum that is economic development.

References and Notes

1. See for instance : H.J. Habakkak, 'American and British Technology in the 19th century', Cambridge Uni. Press (1962) and D. Landes, 'The Unbound Prometheus', Cambridge (1969).

2. N. Rosenberg : 'Capital Goods, Technology and Economic Growth', Oxford Economic Papers, Vol.15, (Nov.1963) p.226.

3. S. Kuznets : 'Quantitative Aspects of the Economic Growth of Nations : The Share and Structure of Consumption, Economic Development and Cultural Change (July 1960) Part II, pp.23-4.

4. This distinction comes from K. Norris and J. Vaizey : 'The Economics of Research and Technology', Allen and Unwin, (1973) p.24. Also see A.P. Thirlwall : 'Growth and Development', MacMillan (1974),p.105.

5. A. O'Donnell : 'The Measurement of Efficiency', privately circulated paper (1974) p.1.

6. A. Beacham and L. Williams : 'Economics of Industrial Organisations', Pitman and Sons Ltd. (1961) p.144.

7. W. Salter : 'Productivity and Technical Change', Cambridge Uni. Press, (1958) p.3.

8. M.J. Farrell : 'The Measurement of Productive Efficiency', Journal of The Royal Statistical Society, Series A, Part III, Vol.120 (1957).

9. Chu-Yuan Cheng : 'The Machine Building Industry in Communist China', Edinburgh Uni. Press (1972) p.175.

10. Machine tools are purchased as producer goods, hence the price paid should be a measure of potential profitability (in yielding factor services) to the purchaser as a producer rather than a consumer satisfaction.

11. It is accepted that the measurement of employment by numbers is implicitly an 'overhead' or 'fixed cost' method of approaching the problem. Although man-hours of labour is closer to the flow of factor inputs, the data on the same was held to be unsatisfactory for the task (the fact that there were 4 years of figures missing from the series did not help matters).

12. This approach will inevitably attract criticism from some quarters. Buildings, including offices and office staff, clearly make a claim on scarce capital resources and thus some portion of output should seemingly be attributable to these factors. But the intention here, by adopting a 'direct' approach to the measurement of the K/L index, is simply to get closer to the production process.

13. There are three measures of capital which are potentially available :

    (a) Ideally, gross stock less economic depreciation, i.e. the loss of productive potential through wear and tear;

    (b) gross stock; and

    (c) written-down value.

    In the present study there is no choice but to use (c). The problem, however, is that often depreciation is not estimated as an approximation of (a), but rather for the purposes of investment incentive, etc.; this may introduce distortions into the capital measure, depending on the age and asset-mix of the capital. There is also difficulty regarding assets-in-place viz à viz assets-in-use; it has led some analysts to consider measures of the flow use of capital services such as man-hours and even electricity consumption though these are equally open to objections.

14. B. Dholakia : 'Measurement of Capital Input and Estimation of, Time Series Production Functions in Indian Manufacturing', Indian Economic Journal (1976/77) p.336. For some of this evidence see, G. Gupta and K. Patel : 'Production Function in Indian Sugar Industry', Indian Journal of Industrial Relations, Vol.II, No.3 (Jan.1976) pp.315-37.

15. If differing writing-down provisions exist over time, then this will distort these comparisons. If this occurred after 1971, it may well account for some portion of the decline in the capital stock.

16. In fact, these two reasons do not exhaust the list of possibilities. A further consideration of some importance, has to do with the reasons behind investment or the lack of it : was it the effects of the recession which reduced the capital stock or could it be simply due to the policies of the authorities. In other words, it may be that capital was written-off to improve profitability and hence encourage investment. The difficulty is judging how far the decline in capital is a statistical rather than an economic phenomenon.

17. To empirically verify this argument, it would be necessary to look at the company's investment schedule regarding the purchase of new assets for the manufacture of machine tools. An exercise that has not been possible in this study.

18. Unfortunately, it was not possible to gather information on skill composition; this is important because a rise in average skills tends to be associated with a rising wage-bill (output) which would not reduce profits in a neo-classical world.

19. There is no evidence that price controls were applied directly to machine tool products. However, if this were the case, then negative profits ought not to be necessarily interpreted as being reflective of productive inefficiency since commercial criteria have not been applied at other points in the investment/output/pricing sequence.

20. As a rough cross-check : multiply column 2 by column 5; the answer should approximate to the level of profit, i.e. column 4.

21. Chu-Yuan Cheng : Op.cit., p.161. It should be noted, however, that the qualification contained in 19 above, applies equally to the Chinese case.

22. The averaged data of the years 1967, 1969 and 1972 were not taken into consideration in the calculation of this ratio.

23. Chu-Yuan Cheng : Op.cit., p.175.

24. H. Bruton : 'Productivity Growth in Latin America', AER., Vol.52 (1967) p.1101.

25. A high participation of labour was also found by Dholakia in his production function analysis of India's iron and steel industry. Over the period 1946-66, he estimated the labour input regression coefficient to be 0.7675, based on a net stock measure of capital at 1960/61 prices. See B. Dholakia, op.cit.

26. See R. Solow : 'Technical Change and the Aggregate Production Function', The Review of Economics and Statistics, Vol.39 (Aug.1957) and also B. Massel : 'Capital Formation and Technical Change in U.S. Manufacturing', The Review of Economics and Statistics, Vol.XLII, No.2.(Aug.1960).

27. M. Abramovitz : 'Resource Output Trends in the United States since 1870', American Economic Review, Papers and Proceedings, Vol.XLVI, (May 1956) pp.5-23.

28. Reserve Bank of India Bulletin (Sept.1975), cited in R. Datt and K. Sundharam, 'Indian Economy' (1977) p.539.

29. Association of Engineering Industries Handbook, New Delhi, (1977) see table 19.2, pp.190-200.

30. W. Stevens : 'Capital Absorptive Capacity in Developing Countries', A.W. Sijthoffleiden (1971) p.63.

31. D. Granick : 'On Patterns of Technological Choice in Soviet Industry', A.E.R. - papers and proceedings (May 1962) p.152.

32. In this context, note that ... "technological innovation is not a 'production' process in the sense that a given combination of inputs leads to a predictable quantity or quality of output. It is basically a cumulative process of learning and experience, of making mistakes and taking risks, which is initially quite costly and perhaps unproductive, but which must be undertaken seriously if LDCs are to build up capacity to do things themselves". S. Lall : 'The Patent System and the Transfer of Technology to Less Developed Countries', Journal of World Trade Law, Vol.10, No.1, (Jan:Feb 1976) p.4. For studies on the various types of incremental diffusion of technical learning, see the following:

Studies on Learning-by-doing: (labour productivity on set tasks with given equipment is likely to improve over time; a number of studies have demonstrated that the physical labour input per unit of output in the engineering sector declines with cumulative experience):

(i) David P., Technical Choice, Innovation and Economic Growth, (New York : Cambridge Uni. Press, 1975).

(ii) Dudley L., Learning as an Explanation of Productivity Change : A Study of the Colombian Metal Products Sector, 1959-66. PhD dissertation (New Haven : Yale Uni., 1970).

(iii) See also Alchien A., and Hirsch W., Op.cit. this chapter.

Studies on Learning-by-Adaption: (whereby small changes are made within a plant to a given technology by shop-floor technicians, managers and engineers to raise productivity with a given technology):

(iv) Katz J., 'Imports of Technology, Domestic Learning and Dependent Industrialization', Mexico, Fondo de Cultura Economica, (1976).

(v) Katz J. and Ablin E., 'Technology and Industrial Exports : A Micro-Economic Analysis of Argentina's Recent Experience', Desarrollo Economico (1977).

Studies on Learning-by-Improved Design: (indigenous changes in the design of equipment to make it more appropriate to local conditions):

(vi) Cortes M., 'Argentina : Technical Development and Technology Exports to other LDCs', (Washington DC : Economics of Industry Division, World Bank, Feb. 1978) Processed.

(vii) Pakistan, Government of, Planning Division, 'Potential of the Engineering Industry for the Manufacture of Industrial Machinery in Pakistan (Lahore : NDISC, 1976).

33. A. Atkinson and J. Stiglitz : 'A New View of Technological Change', Economic Journal, Vol. LXXIX, (Sept. 1969).

34. A. Atkinson and J. Stiglitz: Ibid., p.573-74. In a footnote the authors add: "Indeed, the usual assumption of Harrod neutrality assumes that the percentage reduction of labour requirements per unit of output be the same for all techniques", p.574n.

35. N. Rosenberg : 'The Direction of Technological Change : Inducement Mechanisms and Focusing Devices', Economic Development and Cultural Change, Vol.18, No.1. Pt.2 (Oct. 1969).

36. P.A. David : Technical Choice, Innovation and Economic Growth, Cambridge Uni Press (1975) p.60.

37. R.G. Nelson and S.G. Winter : 'Neoclassical versus Evolutionary Theories of Economic Growth : Critique and Prospects', Economic Journal, No.336, Vol.84, (Dec 1974).

38. Ibid., p.891.

39. Ibid., p.901.

40. P.A. David., Op.cit., p.76.

41. Taken from A.P. Thirlwall : 'Growth and Development', MacMillan, (1974) p.110.

42. Sectoral Science and Technology Report on Machine Tools, National Committee on Science and Technology, New Delhi (Dec 1975) p.2.

direction at HMT Ltd.; it is reported that 600 design engineers were employed there in 1975 (but presumably not all were engaged in the field of machine tools), See 'A Quarter Century of HMT', by S. Patil, Company pamphlet (1978) p.37.

44. M. Frankena : 'The Industrial and Trade Control Regime and Product Designs in India', Economic Development and Cultural Change, No.22 (1973/74) p.256.

45. See Commerce (Magazine), Bombay (Dec.19th 1970) p.1272.

46. M. Frankena : Op.cit., p.257.

47. M. Frankena : ibid., p.256.

48. M. Frankena : ibid., p.262.

49. NCST Report on Machine Tools, Op.cit., p.202.

50. S. Patil : 'A Quarter Century of HMT', Op.cit. p.47.

51. NCST Report : Op.cit., p.202.

52. NCST Report : ibid., p.191.

53. Draft Outline of the Fourt Five Year Plan, Planning Commission, p.333.

54. E. Denison : 'The Sources of Economic Growth in the United States and the Alternatives Before Us', Supplementary Paper No.13, Committee for Economic Development, New York (1962) p.266 in D. Bhattacharya : Op.cit., p.143.

55. T. Schultz : 'Reflections on Investment in Man', Journal of Political Economy Vol.LXX, Supplement No.5, Part 2 (Oct.1962) pp.1-8.

56. W. Hirsch : 'Firm Progress Ratios', Econometrica 24 (April 1956), p.137.

57. For instance see A. Alchian : 'Reliability of Progress Curves in Airframe Production', Econometrica 21, (Oct.1963), pp.679-92.

58. W. Hirsch : 'Progress Functions of Machine Tool Manufacturing', Econometrica, Vol.20 No.1 (Jan.1952).

59. NCST Report : Op.cit. p.203. Most medium and large size enterprises are required by law to send employees to the ITIs for a period of tuition ranging from one to two years. According to the relevant legislation one in every seven workers at these plants must receive the ITI training although in practice the law appears much abused.

Chapter 6

Summary and Appraisal

The purpose of this final chapter is to provide an overview on the theoretical and empirical analysis undertaken in the preceding pages. The study itself is an attempt at correcting the unaccountable gap in the knowledge of one of India's most important industries; it is both a review of the existing literature on the role of the machine tool industry in the process of industrialization and a preliminary attempt at further conceptual development. In a work of this type, however, it is only possible at best to scratch the surface of the complex set of issues involved. Nevertheless, a stage has now been reached where there is a need to gather together some of the various threads that have been spun through the text in an effort to make a concluding statement regarding the identification of the observed and potential motive forces as do bear upon machine tool manufacturing practices in India. Before offering the results and an appraisal of the industry's economic performance it might be useful if the theoretical reasoning of the first two chapters is brought together and briefly outlined.

(i) Theoretical Review

The search for ways and means of 'evolving' or adapting technology so that it relates more closely to the requirements of the developing countries is a major issue in world policy forums. Actuating this search is a profound concern with the economic development of these countries coupled with the recognition that the simple emulation of Western production techniques and practices has not led to the high rate of growth in employment and output that was at first thought possible. A major plank to the argument that the transference of advanced foreign technology is beneficial to the developing countries was based on the premise that latecomers to the industrialization process were at an advantage because they could exploit the technical progress that had already been accumulated elsewhere. There is probably a major weakness to such reasoning in that successful industrialization is not achieved merely through the implantation of sophisticated machinery; the acquisition of the ability to originate and sustain appropriate technological progress is also required. This and other reasons for the establishment of indigenous machine tool capacity were given in Chapter 1.

The origins of mass production of machine tools in India began with the establishment of the public sector company, HMT, in 1956. Since the inception of the industry it has been argued that machine tool manufacture has followed a pattern of development that is characteristic of the methods and practices in Western countries. The principal feature of production under this type of industrial philosophy is the emphasis given to product-innovation; its importance stemming from the nexus between the machine tool branch and its customers in the machine building industry. Specifically, there are two motivational pressures for the machine tool-makers to innovate and these come into play in correspondence with the opposing extremes of cyclical activity in the demand for their products. In broad form, the theoretical basis of these two external motivations to innovate derive from the analysis of two economists: W. Brown and N. Rosenberg. The indeterminancy between the approaches of these authors regarding the timing of innovation can be resolved to a great extent by the assumption which underpins both theories: 'the desire to maintain or acquire monopoly profits'. As such, a synthesis of the two models becomes possible with the resultant composite theory of innovation in machine tool production being termed the 'Brown-Rosenberg Paradigm'. This Western model emphasises innovation and capital replacement as the motive forces operating between the machine tool-users and the machine tool-makers in an economy.

It is fair to argue that India's machine tool industry, through foreign collaboration with Western machine tool companies, tended to follow conventional thinking and practices concerning the nature and production thereof of its products. On acceptance that this was the case, the question needs to be asked : what has been the operational significance of the Brown-Rosenberg paradigm under Indian industrial conditions? The minimal number of patents registered with India's indigenous machine tool producers since 1956 would seem to suggest that the model has had only limited validity in an economic environment characterised by a high degree of government penetration and low levels of competition, demand and product specialization. It seems evident that the type of industrial activity to which the Brown-Rosenberg paradigm relates is more likely the outcome of an 'evolutionary process'. The judgement that India, or any other developing country for that matter, can create conditions that are ripe for innovation, merely via the transplantation of foreign technology appears, therefore, to be erroneous.

It may be that the Soviet strategy of machine tool manufacture pursued in the thirties could have provided a more successful approach in a country where capital-saving ought initially to have been the dominant objective. In fact, the essence of the Soviet 'model' was its pre-occupation with the economising of capital. The development of the industry from an ex-post perspective was framed towards achieving very high levels of specialization, standardization and scale in the manufacture of a limited range of labour intensive products. Product innovation, save for the purposes of 'scaling-up', was accorded a much lower priority.

The Soviet approach might also have been appropriate .o India not only because both countries operated capital-oods led growth strategies and rigorous import-substitution rogrammes but also because both the Soviet Union and India ere characterised by the paucity of capital resources at he start of each country's industrialization drive. erein lies the crucial feature of the Soviet model : the oviet Union was interested in capital-saving, not purely n the realm of manufacturing basic labour-intensive achine tools, nor it should be added, through the economies o be obtained in specialization as in the traditional view f organizational practices, but through the economies of cale also.

The machine building industry of the Soviet Union in he 1930s had to obtain its machine tools, which were haracterised by their high labour intensity, from ndigenous sources; there was never an overt policy to upply this sector with sophisticated producer equipment rom abroad. This 'capital-stretching' philosophy made ood sense in two important respects: firstly, the various oviet metal-working industries were supplied with technology hat was appropriate to the factor proportions of their conomy at that time - secondly, because of the economies f scale and specialization involved in the mass production f standardized tools, increases in the labour productivity f the Soviet machine tool industry became consistent with lower K/O ratio. The significance of this model of machine ool manufacture should not go unnoticed: not only were the oviets able to lay a mechanized base to their economy in he shortest possible time, but they did it in a capital-saving way. Consequently, technological progress Soviet style was a combination of capital saving influences which ncluded both high operational efficiency in the machine ool branch with appropriate technical change in the machine uilding industry.

(ii) Evaluation of Goal Performance

In consonance with the philosophy of a capital-goods led growth strategy, the Indian machine tool industry developed in accordance with three principal goals of industrialization: rapid growth of output, technological self-sufficiency, and high operational efficiency; the first two factors have been explicit objectives whilst the third, although implicit, must necessarily also have been a priority aim of the authorities. The performance of the machine tool industry in respect of each of these three goals was analysed in detail in three separate chapters. But to assist in an overall judgement on the progress that has been made, a resumé of the main findings of these chapters is now presented.

Growth

There is no question that an enormous expansion in machine tool capacity has been successfully achieved. Before 1956, there was hardly an industry to speak of, with indigenous production barely above 1,000 machine tools annually. Since the inauguration of HMT Ltd., however, India's machine tool output grew rapidly : between 1960 and 1974, the annual average increase in the production of tools was 10.8 per cent as against 6.7 per cent for all industrial production. In addition, there was also a rapid change in the structure of this output; the industry, and HMT in particular, achieved in an extraordinary short space of time the capability to manufacture a very wide range of machine tool products. Today, HMT is one of the world's ten largest machine tool houses, manufacturing the world's widest range of machine tools. This spectacular growth in capacity has been helped a great deal by the favourable institutional environment of the Indian market. Government policy provided a rigorous regulatory framework within which companies had to operate; a major feature of the system being the legal requirement that the import of machine tools was prohibited if a similar model could be obtained from domestic sources. But, although growth has been rapid, it is not to state that the development of the industry has therefore been smooth. Efficiency has been lost because many of the larger concerns have internalised activities which are usually undertaken by the ancillary industries in the 'mature' economies of the Western countries.[1] There have also been low levels of standardization of components which, coupled with small batches or even one-off methods of production, has meant that lower scales of output than possible have been attained. The low level of absorption of machine tools has been confirmed by the need for most credit in the machine tool industry to be used for variable capital rather than in the replacement of capital stock, over two-thirds of which is now between 10 to 15 years of age. The inherent difficulty with such a poor organisation of production is that a high cost/price structure of output will be encouraged.

Technological Self-Sufficiency

The underdeveloped countries come up against a severe external obstacle to growth : their capacity to import lags behind their needs, for economic development brings in its wake a rise in import requirements. The need for the indigenous production of capital goods is brought out by the meagre 2 to 3 per cent growth in the third world countries' capacity to import machinery between 1954 and 1977. India recognised this problem very early on; indeed, one of the aims of the two-sector growth policy was to rid the country of its dependence on imported technology. In the case of machine tools, and notwithstanding the 'captive' nature of the domestic market, India's surge in the self-sufficiency of machine tool manufacture was perhaps even more remarkable than the growth in output : by 1975, the country was 78 per cent self-sufficient in its machine tool requirements. The existence of a strict foreign trade control regime was a considerable help to the industry in achieving this degree of diversification. There is evidence, however, that import substitution possibilities have begun to dry up. The machine tool industry has been aware of this and has attempted to compensate for the slackening in domestic demand by turning its attention to the export market. As a result, there has been a fairly fast growth in exports of machine tools, especially to the industrialized countries though not insignificantly to the semi-industrialized countries as well. The evidence that companies have operated a discriminatory pricing policy favourable to machine tool exports is inconclusive.

Efficiency

In respect of the 1960-74 period, the capital-intensity of the machine tool sector's manufacturing processes increased by either 2.4 per cent or 4.3 per cent annually; the difference depending on whether labour, the denominator in the relation, is measured in terms of wages or workers. The increase in the K/L index was reflected in the machine tool industry's productivity coefficients over the same period; there was, however, a wide disparity between the main indexes : whilst the O/K ratio grew by only 1.7 per cent over each 3 year period, the O/E index on the other hand, increased much more rapidly at 11 per cent per period. The far superior growth of labour productivity derives from the development path the machine tool industry chose to follow. To be specific, a crucial contra-distinction lies between the Soviet strategy of machine tool production in the 1930s and the traditional model based on Western practices : in the former country, characterised by low-income and capital scarcity, it was capital productivity that was maximised; by contrast, in the rich, labour-scarce countries (and India, also), it was labour productivity that was held to be of a premium. Alongside the dramatic growth in the labour productivity of India's machine tool industry there was also a concomitant rise in the wages of the workers. At a more aggregative level, the index of value added to combined inputs indicated that the growth in 'efficiency' had been low, though positive, at an annual average of 1.5 per cent. The situation improves when technological progress in the industry's production function is isolated and measured over the period 1961-74, growing annually by 2.9 per cent. Low levels of capacity utilization appeared to be a continual problem. Some 70 per cent of the companies in the sample were operating beneath what they themselves regarded as a 'normal' level of capacity. Efficiency in production was found to be hampered by another factor; the increasing prevalence of industrial unrest. The level of resources devoted to research, development, and design was also revealed. From the survey: 60 per cent of companies showed no commitment to research and development, and 70 per cent had only one person in the way of design staff. The natural corollary to this low research and development input was the dire output of patented-innovation from the branch : only 3 out of 38 respondent firms holding a patent. The level of interaction between the manufacturers and the Central Machine Tool Institute (70 per cent of companies had had no contact) was poor; the strength of the relations with the universities was also low (no contact by 65 per cent of the firms); and the level of contact with external research bodies (50 per cent) consolidated this unsatisfactory state of affairs. Finally, from a schematic examination of the importance of education and training in the industry, it was found that the Industrial Training Institutes had an important role to play in the training of engineering personnel, though they had attracted some criticism in relation to the quality of tuition provided.

(iii) A Critical Appraisal

This study has been concerned with examining the technological development of India's machine tool industry. Major emphasis has been given to efficiency in the operations of the branch because as a 'core' sector it has the ability to effect cost savings that percolate throughout the rest of the machine-building industries. In Chapter 1, a Soviet 'model' of machine tool manufacture was constructed which acted as a framework of reference for the evaluation of the productive organization of India's tool sector. The Soviet model of the 1930s was held to be apposite to India in the 1950s because both economies at the start of their respective industrialization drives were characterized by a profound scarcity of capital. In addition, both the Soviet and Indian central authorities had embarked upon programmes of planned industrialization through rigorous import substitution regimes on the basis of 'closed-market' economies.

Further to this, a detailed discussion was presented in Chapter 2 on the mechanics of the traditional approach to machine tool manufacture in the West; the path which India in actuality was adjudged to have followed. Here, a dual-hypothesis was advanced on (i) the appropriateness of the Soviet approach whatever the particular circumstances of India's development were, against (ii) that the Soviet model would not have been a rational strategy for India in the light of the various divergent conditions in the economy that would have impaired the efficiency of the model's operation.

It should be said immediately, however, that great caution needs to be exercised in the interpretation of data based on what has to be described as a highly generalised hypothetical scenario. Although there were symmetrical policy approaches to the development of both the Soviet and Indian economies there was also much (largely unquantifiable) incongruence in other important matters : the divergent levels of industrialization in both countries at the start of planning; differences in skill and technology; the degree of autarchy imposed; the comparative size of effective demand; and the relative importance of agricultural output and cyclical demand in the two countries, are amongst the more significant factors which can be mentioned. It also has to be recognised that the Soviet tool industry in the 1930s faced a period of prolonged demand for its products not only in support of the rapid mechanization taking place in the Russian economy but also from the massive build-up of capacity that was simultaneously occurring in the ordnance factories at that time. The situation was somewhat different for India in the fifties and sixties where machine tool absorption after an initial spurt was critically affected by periodic downturns in the level of investment in the engineering industries; ar the fragility of agricultural production frequently undermined the Indian Government's ability to secure adequate investment resources for industry. Couple this with the damaging effects of the recession in the latter half of the 1960s and it becomes clear that the comparative framework of analysis sketched out in Chapter 2, possesses quite fundamental defects.

Over and above the deficiencies of analysing comparative Soviet and Indian development, there exists a weakness in the argument that India's (traditional) machine tool strategy has 'failed'. The prime mover of the Western approach of machine tool production is the primacy that is given to innovation in the creation of fresh markets to stimulate demand. Thus, an indicator of the 'success' of this strategy is obviously the level of patent registrations achieved. The fact that it has been shown that India's machine tool sector had obtained only minimal patents since 1956 appears at first sight to suggest that the Brown-Rosenberg paradigm - the theoretical foundation to the Western model - has broken down under Indian conditions. But are patents an adequate signal that technological progress has taken place in a developing country environment? Discussion in Chapter 5, suggests that they are not. Much technological progress has clearly taken place in India's machine tool branch. HMT, for instance, possesses a consultancy wing which is vigorously, and successfully, engaged in exporting the accumulated skills and expertise of its workforce to other industrializing countries. Other companies in the industry have been actively imitating, adapting, and modifying technology on a more or less continual basis. All of this acquired and assimilated learning is not reflected in formal patented-innovation but it must be accepted that it is, nevertheless, technical progress.

Given all these qualifications to an enquiry of whether a Soviet strategy of production might have proven to be of value to the development of India's machine tool industry, the reader might be forgiven for wondering the continued relevancy of the exercise. There are nonetheless some important benefits which can be identified. Evidence does exist that the Soviet Union's machine tool sector did develop very rapidly by producing simple, general-purpose machine tools.[2] In the Soviet Union the technical level of machine tools changed over time in almost imperceptible degrees in accordance with the gradual progression of technical specifications required in the machine building industry. This structure of output mirrored the demands from the machine tool branch's customers and was appropriate to the factor-proportions of the Soviet economy at that time.[3] Not only was this a capital-saving form of development from the product-side but it allowed for capital-saving on the process-side also through the possibility of obtaining economies of scale. Previously, the advantages of scale in machine tool production had always been regarded as insignificant but now they could be seen to be of quite major importance.[4] Finally, the fact that the Soviet machine tools of the thirties were simple and were produced in long-production runs meant that the final product was inexpensive for the machine builders to purchase; this gave added impetus to the laying of a mechanized base to the Soviet economy.

To specifically argue that each of the alleged advantages of the Soviet model would have benefited India's tool sector would require a far too liberal sprinkling of normative supposition. Additional research (if feasible) would be needed to substantiate the validity of such claims. The fact is that 'appropriateness' in one economy at one stage in time might equal 'inappropriateness' in another economy at a later time. Further, the costs of adapting standard tools to suit the requirements of individual manufacturers would also need to be taken into account. Notwithstanding the inconvenience involved to the users of the machine tools the costs of adaption might well be onerous, significantly affecting the low cost/price advantages derived from mass production of standardized machinery. The ability to draw firm conclusions is also impaired by the lack of knowledge on projected levels of demand at particular prices.[5] It must be frankly acknowledged that to all extents and purposes the above information has been unobtainable.

Looking directly at the results of the empirical investigation of India's performance in the manufacture of machine tools there is, in fact, much to be commended. Growth in output value has been highly satisfactory and the goal of self-sufficiency has also been successfully achieved. Efficiency in production has been a more problematical area of analysis; nonetheless, it can be said that labour productivity has been rapid and technical progress has grown at a positive level of around 3 per cent since the early 1960s. However, the industry's profit record has not been good with many years showing a negative level of profit.[6] But most of these losses were incurred during the recessionary years of the late sixties and it is therefore dangerous to draw firm conclusions from this sort of evidence. It is also difficult to be dogmatic concerning the generally held belief of the high price of India's machine tools. There exists much anecdotal comment on this subject but little hard empirical fact. The present study attempted to obtain cost/price data on the production of equivalent machines in the domestic Indian market and abroad but unfortunately efforts in this direction were unsuccessful. Therefore, a judgement on this highly important point is not possible and clearly undermines the ability of this final chapter to make definitive conclusions on the efficiency of India's machine tool branch.

There may well be some elements of the Soviet model which could have had an important part to play in the development of India's tool sector; indeed, they may still have relevance today, e.g. scale and standardization effects. However, the inefficiency of the import substitution system under which the industry had to operate must surely have nullified much of the benefits to be obtained.[7] Thus, perhaps the most that can be said is that neither hypothesis can be put forward as being the most appropriate. The actual development of the Indian industry has under the circumstances been dynamic and whether 'selective' components of the Soviet strategy could have improved upon this performance remains an open question.

Alternatively, it might be argued that the hypothesis regarding the appropriateness of the Soviet model in India's machine tool sector was the correct one but it was framed under the wrong economic scenario. If, as Bhagwati and Desai have asserted, that Mahalanobis in the early fifties falsely assumed India faced a situation of 'stagnant export earnings' - the relevant strategy for the machine tool industry might have been one of specializing in the production of labour intensive machine tools for export (though built upon a sound domestic base) whilst importing the more limited demand for sophisticated machine tool technology. Thus, an export-oriented Soviet model of machine tool production could have been customized to fit the dynamic comparative advantage of India's tool sector. The fact is that the changing pattern of comparative advantage has led many of the presently industrializing countries increasingly to export skill intensive commodities and the less developed countries to export unskilled labour-intensive commodities of the 'mature' type. The most advanced countries are tending to specialize in new, 'product-cycle', goods regardless of whether they are capital intensive or labour intensive. Thus, the expansion of manufactured trade of an intra-industrial character may have allowed India to have developed its machine tool operations by specializing within the branch according to its 'revealed' comparative advantage.[8] This pattern of specialization could have had, in turn, more favourable effects on resource allocation and economic growth than the import substitution regime actually followed. The recent growth in intra-industry trade amongst developing countries tends to lend support to such a conclusion.[9]

In many respects, this study has posed more questions than it has supplied answers. But it should be emphasised, that although the development experience of India's machine tool sector is obviously of major importance to other developing countries in their attempts to foster indigenous capital goods capacity, the topic is a much neglected one in economic research. This study represents not only the first empirical examination but also, seemingly, the first study of any description on the industry. To repeat the statement contained in Chapter 2: 'There has never been a study on the development of the Indian machine tool industry' (p.84). To this extent, then, the project, due to the dearth of primary and secondary sources of information, has been a major exercise. It also means, of course, that the study should be doubly valuable. In this vein, the attempt of the study has been to open up discussion, rather than to settle it, in the hope that it makes interested parties in India, and indeed elsewhere, more aware of the vital importance of the issue and motivates them to make their own contribution to the debate.

References and Notes

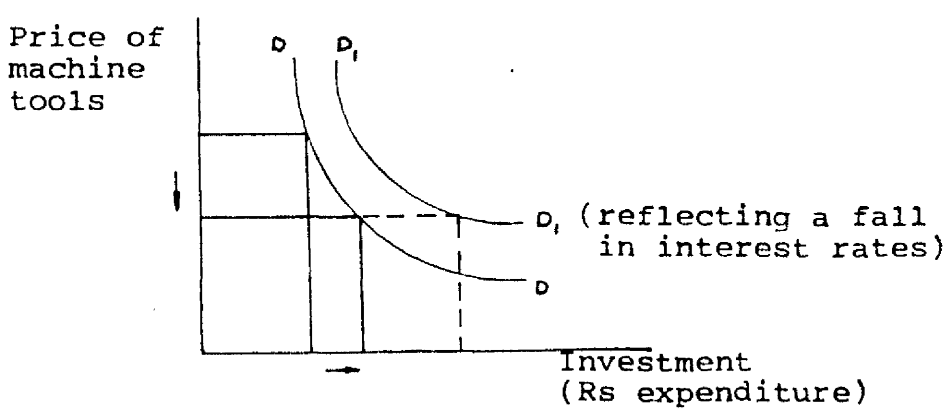
1. On this, the present study's findings are in agreement with Frankena's ... "Despite efforts to foster subcontracting in the late 1960s, the largest Indian machine tool producer purchased only 10% of its inputs externally; for one Western European collaborator the comparable figure was 40%".. Quoted from : Howard Pack, 'Fostering the Capital Goods Sector in LDCs', World Development, Vol.9, No.3 (1981) p.233. Original source, see M. Frankena : Export of Engineering Goods From India, PhD dissertation, M.I.T. (1971).

2. See A. Pronitov : 'Repair and Maintenance of Machine Tools in Developing Countries', United Nations Industrialization and Productivity Bulletin, No.10, (1966) p.75.

3. Even in the 7th-Plan Period (1959-65) of Soviet industrialization, 70 per cent of aggregated machine tool orders were for universal, i.e. labour-using machines.

4. More recently a study has shown empirically that scale economies are important in the realization of quite important cost reductions in the manufacture of machine tools. See C. Pratten : 'Economies of Scale For Machine Tool Production', Journal of Industrial Economics, Vol.19 (1970-71).

5. However, it is clearly true that at the end of the day the price elasticity of demand for machine tools will be elastic. The decision to purchase machine tools comes under the special category of investment theory. If the supply price of machine tools fall, there is an automatic improvement in the marginal efficiency of capital (MEC), so making investment to the businessman a more attractive proposition. This is an economic law as espoused by : Irving Fisher - 'rate of return over cost'; Bohm-Bawerk - 'net productivity'; and, Keynes - 'marginal efficiency of capital'. Intuitively, machine tools possess an elastic demand schedule because the MEC = investment demand; both are in positive relation and a rise in the MEC will lead to a rise in demand. Thus graphically, at a given rate of interest, a fall in the supply-price of machine tools must improve the level of investment.



6. It may be assumed that this has been caused by poor performance of HMT and the other smaller public sector companies. Although HMT as a unit is a highly profitable industrial enterprise, profit figures for just its machine tool manufacturing business have never been published; in fact, this aspect of HMT's operations now account for only 40 per cent of the company's total output value. Clearly, if it were the private sector firms which were losing money this would be reflected by their departure from the industry; this has not occurred (according to ASI figures). Public sector companies can remain in business by (i) government subsidizing the losses, and/or (ii) the transfer of surpluses from other more profitable lines of production.

7. Some writers argue that in the short-run indigenous technology will be more expensive than imported technology but that these expenses are necessary if indigenous technology is to develop. For review of the literature, see D. Crane : 'Technological Innovation in Developing Countries : A Review of the Literature', Research Policy, 6, (1977), pp.374-395.

8. S. Lall : 'Developing Countries as Exporters of Industrial Technology', Research Policy, 9, (1980), p.26.

9. See, B. Belassa : 'Trade in Manufactured Goods : Patterns of Change', World Development, Vol.9, No.3, (March 1981).

APPENDIX 1

The Data

Table A : Data for the Machine Tool Industry of India (Rs.000s)

Year	Output (curr- ent)	Output (con- stant) 1	Value Added (curr- ent)	Value Added (con- stant) 2	Fixed Capital (curr- ent)	Fixed Capital (con- stant) 3	Wages (curr- ent)	Wages (con- stant) 4	Total Employee Remuneration (curr- ent)	Total Employee Remuneration (con- stant) 5	Deprec- iation (curr- ent)	Direct Labour (nos)	Empl ees (nos
1960	63514	99086	26186	40852	49599	78854	8996	17300	15981	30733	4767	7372	9292
1961	92568	144412	37634	58711	93060	145634	11784	22618	23559	45219	7315	7481	10862
1962	128273	194944	49149	74695	122015	185998	17004	31902	29365	55094	9767	9784	12725
1963	170324	242973	64776	92405	143088	207374	22475	39779	38848	68758	10994	13178	15820
1964	222565	310411	104625	145920	185049	261000	26824	41847	47304	73797	13738	14444	17704
1965	280328	371788	112500	149204	345187	458416	35632	51641	63500	92029	23075	17490	22870
1966	309855	371084	105256	126055	402618	497059	43732	54597	78660	98202	30040	17850	24206
1967	304588	347703	90602	103427	429663	510289	46429	51992	84868	95037	34489	17716	24070
1968	299320	333318	75948	84575	456707	513731	49125	56661	91076	105047	38938	17582	23934
1969	369674	390776	105377	111392	490883	525009	58197	64592	107646	119474	41304	17996	24908
1970	440027	440027	134806	134806	525059	525059	67268	67268	124216	124216	43670	18409	25881
1971	582824	536177	176829	162676	544380	535280	77251	72947	147787	139553	45858	19582	27918
1972	608062	521047	207415	177734	521540	475858	85026	73807	163494	141922	45629	19270	27647
1973	633300	484174	238000	181957	498700	423704	92800	66286	179200	128000	45400	18957	27376
1974	888500	531718	346100	207121	560700	364327	101000	56773	215100	120911	55400	18921	27463

Source : Annual Survey of Industry Reports, Government of India.

1 and 2 : Deflated by the U.N. implicit price index of GDP by manufacturing (1970=100)
3 : Deflated by the U.N. implicit price index of GFCF by manufacturing (1970=100)
4 and 5 : Deflated by the U.N. implicit price index of the wholesale and retail trade (1970=100)

N.B. Data for the years 1967, 1969 and 1972 have been arrived at by calculating the arithmetic mean of the two adjoining years, i.e. $\frac{T-1 + T+1}{2}$

APPENDIX 2

The Questionnaires To The Indian And British Machine Tool Industry Surveys

A SURVEY OF MACHINE TOOL MANUFACTURERS
IN THE ORGANISED SECTOR OF INDIA

DEPARTMENT OF INTERNATIONAL
ECONOMIC STUDIES
UNIVERSITY OF GLASGOW - U.K.

(1) Questionnaire No. ________

(2) Year of Initial Production ________

(3) Period of Accounting Year ________

Please tick the space adjoining the code number appropriate to your Company.

TYPE OF ORGANISATION :

(1) Individual Proprietorship ____
(2) Partnership : Joint Family ____
(3) Partnership : Others ____
(4) Public Limited Company ____
(5) Private Limited Company ____
(6) Public Corporation ____
(7) Others (please specify) ____

TYPE OF OWNERSHIP :

(1) Central Government ____
(2) Private Enterprise ____
(3) Foreign Owned ____
(4) Parastatal Enterprise ____

INDEX

This form of return is divided into three parts :

PART A : INTRODUCTION AND DEFINITIONS OF TERMS USED

INTRODUCTION :

To secure increases in the standard of life for her people India has, since the early 1950's, embarked upon an ambitious programme of industrialization. Initial development centred around the Mahalanobis policy of a rapid build-up in capacity. The emphasis was on the expansion of those industries which contributed most quantitatively to the growth of investment goods capacity e.g. the iron and steel industry, which to a great extent was achieved through the use of foreign technology.

Recent planning periods have moved more towards the goal of "Self-sufficiency" articulated through the Government's import-substitution programme. This change in emphasis provided the Indian producer durable goods industries with the opportunity to influence the technological character of the manufacturing sector. How far these industries were and are able to meet this challenge turns ultimately on their ability to design and produce machinery which caters to the specifications of domestic industry; to some extent it must also prove viable and competitive in international markets.

Within this general schema the machine-builders and especially those manufacturing machine tools have a significant responsibility to ensure that "indigenisation" is successfully achieved. The following factors suggest the importance of this industry :

(i) As the economic health of the machine tool industry is inexorably linked to the level of industrialization : the demand for machine tools is positively related to economic growth, it is necessary to ensure that machine tool manufacturers operate as close as is possible to optimal efficiency. Improvements in the operating efficiency of machine tool production will, through an economic 'rippling effect', raise the marginal efficiency of capital in the rest of the machine using sectors. This, in turn, should have favourable repercussions on investment opportunity and hence also on the pace of industrialization.

(ii) The machine tool industry may be looked upon as constituting a pool or reservoir of skills and technical knowledge which are employed throughout the entire machine using sectors of the economy. Because these skills and techniques are developed in response to the demands of specific customers and as the machine tool industry deals with processes and problems common to an increasing number of industries the sector may be described as a transmission centre in the diffusion of new technology. Moreover, this pattern peculiar to the machine tool industry, i.e. the distribution of its sales to all other machine building industries, has, if viewed from a long-term criteria, a significant impact on the degree of 'technological cross-fertilization'. That is, the original innovation in the machine tool industry's product induces increased competition among firms comprising the markets for machine tools and may thereby influence further innovation in the tool industry, to the benefit of all machine-makers.

(iii) It is arguably preferable that India develops indigenously her own machine technology because special consideration can then be given to the design and manufacture of techniques most appropriate to the economic conditions prevailing within the domestic economy. Imported technology is expensive in terms of the high opportunity costs of foreign exchange and further, it may conflict with internal employment generation policies as foreign machinery is invariably capital-intensive.

This survey which is being undertaken by a doctoral student at the University of Glasgow's Department of International Economic Studies, forms the basis to a study which will examine the techo-economic aspects of the Indian Machine Tool Industry. It will be an independent and impartial analysis of the industry's development performance since India began its industrialization drive in the mid-fifties. Your Company as a member of the machine tool industry is asked to participate in the survey in which either through an interview or postal contact your co-operation will be sought for completion of Part B - the questionnaire. In conclusion it should, of course, be emphasised that <u>all returns will be treated in the strictest confidence</u>.

DEFINITIONS OF TERMS USED

The terms used in questions which correspond to the Government of India's 'Annual Survey of Industries' questionnaire have definitions equivalent to those found in the Annual Survey's Memorandum on Definitions, Concepts and Procedure. Some further definitions which may prove helpful are given below :

<u>Accounting Year</u> :

Information furnished in all questions of this return should relate, unless otherwise stated, to the accounting year of the company : closing on any day between 1st April, of each year and 31st March of the subsequent year.

<u>Direct Labour</u> :

The term 'direct labour' is defined as workers employed directly or through any agency but excluding persons holding positions of management or supervision or employed in a confidential position. Whether for wages or not, in any manufacturing process or in cleaning any part of the machinery or premises used for manufacturing process, or in any other kind of work incidental to, or connected with the manufacturing process, or the subject of the manufacturing process.

Man/Days Worked :

The total number of man/days worked during the accounting year for each category of employees is to be obtained by summing up the number of persons attending in each shift over all the shifts worked (including overtime) on all days.

Salaries, Wages etc. :

The amount of wages, salaries paid during the accounting year should be entered gross, i.e. before deductions of taxes, provident fund, employees' State Insurance contributions, etc.

Gross Value of Plant and Machinery :

Total original (undepreciated) price for installed plants and machinery as at the end of the accounting year.

Electricity Produced and Sold :

The book value will be shown in case of supply to concerns under the same ownership, and market value in other cases.

Sales :

The total invoiced value of the products sold.

Costs :

The total costs of producing a particular model (including direct labour/material and overhead costs) but before the addition of the manufacturer's margin.

PART B : TECHNO-ECONOMIC DATA

I. INFORMATION ON EMPLOYMENT

(1) In the table provided below please indicate the average number of workers employed by your firm in each of the occupational categories and as far as possible, their total emoluments for the years specified.

ACCOUNTING YEAR

	1974/75			1975/76			1976/77		
Employment Classification	Av.no. of persons worked	Salary, Wages	Bonus	Av.no. of persons worked	Salary, Wages	Bonus	Av.no. of persons worked	Salary, Wages	Bon
Direct labour :									
Skilled									
Semi-skilled									
Unskilled									
Apprentice									
Other									
TOTAL									
Indirect labour :									
Managerial & Supervy.									
All other (Admin. etc.)									
TOTAL									
GRAND TOTAL									

(1)(b) How many workers are employed in the following Departments?

(i) Inspection ______

(ii) Research & Development ______

(iii) Design ______

(2) How many shifts are currently being worked at your firm? If more than one please complete the table in (3), otherwise go straight to (4).

	1	______
Shifts	2	______
	3	______

(3) Please indicate in the table below the number of your employees according to this employment classification who are employed on each shift.

Length of shift : ______ hours

Employment classification	Av.No. of employees	Shift 1	2	3
	(Sub-totals)			
1) Direct labour				
2) Managerial & Supervy.				
3) All other				
TOTAL				

(4) Please provide information on time lost (man/days) for the calendar years 1974-76 inclusive. Data should be readily available on time lost through absenteeism but it would also prove helpful if estimates can be given for man/days lost through the effects of strikes.

EMPLOYMENT CLASSIFICATION	1974			1975			1976		
	Man/days worked	Man/days lost due to absence	Man/days lost due to strikes	Man/days worked	Man/days lost due to absence	Man/days lost due to strikes	Man/days worked	Man/days lost due to absence	Man/days lost due to strikes
Direct labour									

(5) Is all or part of your company's labour force unionised? If yes, please answer questions (6) and (7), otherwise go straight to (8).

Yes	1	______
No	2	______

(6) Please state the number of trade unions operating in your company.

No. of unions

1	____
2	____
3	____
4	____
5	____
6	____
7	____

(7) What percentage of your company's labour force is unionised?

%		
0	1	____
1-24	2	____
25-49	3	____
50-74	4	____
75-99	5	____
100	6	____

(8)(a) What minimum level of technical education does your company require of its machine operatives?

None	1	____
High School Cert.	2	____
Engineering college (I.T.I.)	3	____
Post-Grad. Qualifications	4	____
Other (please specify)	5	____

(8)(b) What form of technical training does your company provide for its machine operatives?

None	1	____
Company Training School	2	____
Engineering college course (I.T.I.)	3	____
Other (please specify)	4	____

II. PRODUCTION DATA :

(9) For the years specified, please supply information on the volume and value of sales for each of the major models in your company's range.

		ACCOUNTING YEARS								
		1974/75			1975/76			1976/77		
Product Group	Code (leave blank)	Vol-ume	Va-lue	Unit price	Vol-ume	Va-lue	Unit price	Vol-ume	Va-lue	Unit Price

(10) For the years specified, please supply data on either unit or total costs of production for each of the major models in your company's range.

		ACCOUNTING YEARS					
		1974/75		1975/76		1976/77	
Product Group	Code (leave blank)	Unit cost	Total cost	Unit cost	Total cost	Unit cost	Total cost

(11)(a) In order that your company's value added component may be calculated, please supply the following data on <u>total items</u> of output and input. This information should be readily available as it may be extracted directly from your records relating to the Government's 'Annual Survey of Industries' return.

	ACCOUNTING YEARS (Rupees)		
Output	1974/75	1975/76	1976/77
(1) Products and By-products manufactured during each year. (Block 14-item 20)			
(2) Output other than those reported in Block 14. (Block 12-item 7)			
(3) Total Output			
Input			
(4) Materials consumed during each year (Block 13-item 22)			
(5) Fuel and lubricant consumed during each year (Block 9-item 14)			
(6) Other items of input consumed during each year. (Block 10-item 7)			
(7) Cost of non-industrial services rendered by others (Block 11-item 7)			
(8) Total Input			
(9) Depreciation during each year			
(10) Total input plus depreciation ((8)+(9))			
(11) Value added = ((3)-(10))			

N.B. The figures within the brackets relate to the relevant section in the 'Annual Survey's' return.

(11)(b) Additional data from your company's 'Annual Survey of Industries' records.

	ACCOUNTING YEARS (Rupees)		
	1974/75	1975/76	1976/77
(1) Employees other benefits (Block 8B-Column 4 - total of items 1-4)			
	1974/75	1975/76	1976/77
(2) Quantity of electricity produced (Block 12-item 8-Col.2)			
(3) Quantity of electricity produced and sold (Block 12-item 9 - Col.2)			
(4) Quantity of electricity purchased (Block 9 - item 11 - Col.4)			

(12) What percentage of your company's output went to home and export markets for the years specified?

	ACCOUNTING YEARS		
Sales analysis by market	1974/75 %	1975/76 %	1976/77 %
Home			
Export (Please list the major countries)			
Other			
TOTAL	100	100	100

(13)(a) The tables below have regard to your company's expenditure on plant and machinery for the years specified. For your convenience this information again relates to particular entries made in the 'Annual Survey of Industries' questionnaire.

ACCOUNTING YEARS (Rupees)

	1974/75				1975/76				1976/77			
	Value of additional investment											
	Purchased		Own construction	Total	Purchased		Own construction	Total	Purchased		Own construction	Total
	New	Used			New	Used			New	Used		
Plant and Machinery (Block 4-item 4-cols. 3,4,5 and 6)												

(13)(b)

ACCOUNTING YEARS (Rupees)

	1974/75	1975/76	1976/77
Gross value of plant and machinery at accounting year end (Block 4- item 9)			

(14) Please indicate the type of depreciation provision used by your company.

Historic (based on original price) 1 ____

Replacement (based on market price) 2 ____

(15) What is the percentage your company allows for the depreciation of its assets?

Assets	%
Land and building	
Plant and machinery	
Other (please specify)	

III. TECHNOLOGY AND PRODUCTION ORGANISATION

(16) With respect to their age, state the number of machine tools installed in your firm.

Installed Machinery	AGE (Years)					
	1-5	6-10	11-15	16-20	21-25	25+
1)Lathes : a)G.P.)						
b)Semi Auto)						
c)Auto)						
2)Milling Machines						
3)Grinding, polishing and Finishing Machines						
4)Shaping, Planing, Slotting and Broaching Machines						
5)Drilling and Boring Machines						
6)Gear and Thread cutting Machines						
7)Cutting-off Machines						
TOTAL						

(17) What percentage of machine tools installed in your firm originate from home and foreign suppliers (please specify)

Country of origin	Machine tools installed %									
	10	20	30	40	50	60	70	80	90	100
India										
Foreign countries (Please specify)										

(18) Which type of investment criteria is used by your company?

Payback period	1	____
Discounted cash flow	2	____
Other (please specify)	3	____

(19) Is it your company's strategy to acquire the latest, most sophisticated production technology?

In all cases	1	____
Usually	2	____
Never	3	____

(20) Does your company possess its own casting facilities?

Yes	1	____
No	2	____

(21) Has your company introduced, or does it in the foreseeable future envisage introducing, continuous flow techniques into its production organisation?

Yes	1	____
No	2	____

(22) What progress has been made towards standardization of machine tool components?

Considerable	1	____
Limited	2	____
None	3	____
Planned	4	____

(23) Has your company pursued any policy involving the rationalization of material inputs?

Yes	1	____
No	2	____
Planned	3	____

(24) Does your company regard the internal handling and transportation of material as essentially the province of labour-intensive activity?

Yes	1	____
No	2	____

(25) Please state the average batch size for each of the major models in your company's product range.

Model	Batch Size

IV. ANALYSIS OF CAPACITY UTILIZATION

(26) Please indicate, for the years shown on a quarterly basis, your firm's actual output and also its theoretical (planned output given market conditions) and licensed capacity in value terms.

		Actual Output	Theoretical capacity	Licensed capacity
		(1)	(2)	(3)
1974	1			
	2			
	3			
	4			
1975	1			
	2			
	3			
	4			
1976	1			
	2			
	3			
	4			
1977	1			
	2			

(27) Factors likely to limit your capital expenditure authorisations on buildings, plant and machinery over the next twelve months are listed below. If you tick more than one reason in part (b) or (c) it would be helpful if you could rank them in order of importance.

(a) I have adequate capacity to meet demand ______

(b) Although I have adequate capacity, I have also capital investment opportunities which would be profitable at the present cost of finance, but I shall not be undertaking some of them for the following reason(s) :

Shortage of internal finance	1	____
Inability to raise external finance	2	____
Shortage of managerial/technical staff	3	____
Shortage of skilled labour	4	____
Other (please specify)	5	____

(c) My capacity is not adequate to meet expected demand but I do not intend increasing my capacity. This is for the following reason(s) :

Not profitable because of the cost of finance	1	____
Shortage of internal finance	2	____
Inability to raise external finance	3	____
Shortage of managerial/technical staff	4	____
Shortage of skilled labour	5	____
Other (please specify)	6	____

(d) None of the above is applicable ____

(28) Is your present level of output below capacity (i.e. are you working below a satisfactory full rate of operation)?

Yes	1	____
No	2	____

(29) Is it a deliberate part of your company's corporate strategy to maintain a proportion of productive capacity under-utilized in preparedness for a rapid expansion in demand?

Yes	1	____
No	2	____

V. INFORMATION ON RESEARCH AND DEVELOPMENT

(30) For the accounting years listed and according to each heading, please indicate your company's expenditure on R & D.

	R & D Expenditure		
	1974/75	1975/76	1976/77
Improvements of existing products			
Development of new products			
Other (please specify)			
TOTAL			

(31) Does your company possess a designing capability?

Yes	1	____
No	2	____

(32) If the answer to (31) was no, then where do your designs originate?

From Indian design offices	1	____
From foreign sources	2	____

(33) In your view what is the average current life of machine tool designs in the field of production in which your company specialises?

Years		
3 - 5	1	____
6 - 8	2	____
9 - 12	3	____
13 - 16	4	____
+ 16	5	____

(34) State the degree of contact your company has with Government or Independent research bodies?

Strong contact	1	____
Weak contact	2	____
No contact	3	____

(35) What level of association has your company with engineering universities and/or university engineering departments?

Strong Association	1	____
Weak Association	2	____
No Association	3	____

(36) Has your company ever taken advantage of the research facilities offered by the Central Machine Tool Institute?

Yes	1	____
No	2	____

(37) Please state below the number and title of patents held by your company.

Title			
	0	1	____
	1	2	____
	2	3	____
	3	4	____
	4	5	____
	5	6	____
	+5	7	____

(38) Are you able to give an estimate for the total initial costs involved in developing a new machine tool for any of the major models your company manufactures?

Product name	Initial cost

(39) What is your estimate of the initiation lag between the research stage of developing a new machine tool and actual production of that machine tool?

Initiation lag (months)		
12 months	1	____
18 "	2	____
24 "	3	____
30 "	4	____
36 "(and above)	5	____

VI. MISCELLANEOUS DATA

(40) For 1976/77, what were your company's sources of credit, stating also interest rates and credit limits?

Sources of credit	Rate(s) of interest	Credit limits

(41) What percentage of your firm's total credit for 1976/77 was allocated to the areas of business activity listed below :

Destination	Percentage									
	10	20	30	40	50	60	70	80	90	100
Investment into fixed capital										
Working capital										
R & D										
Other (please specify)										

(42) From the list given below please indicate your company's assessment of the quality of components supplied by ancillary industries.

Low Quality 1 ____
Good Quality 2 ____
Excellent Quality 3 ____

(43) To what extent does your company enjoy price economies in the purchase of material inputs?

Material input	Discount %				
	1-4	5-8	9-12	13-16	17-20
Castings					
Pig Iron					
H.S. Steel					
Scrap					

(44) Does your firm seek to obtain economies from the sharing of its organisational resources, (i.e. advertising, marketing, casting) with other Indian concerns?

Yes	1	____
No	2	____

(45) On a regular basis, does your company monitor the efficiency of its labour and capital inputs?

Do you monitor :

Labour	1	____
Capital	2	____
Both	3	____
Neither	4	____

(46) Does your company have any technical assistance/ collaboration agreements with Indian or foreign machine tool manufacturers?

None	1	____
Indian	2	____
Foreign (Please specify)	3	____
Both 2 & 3	4	____

(47) In connection with collaboration agreements,what has been the cost, if any, to your company for royalties and licenses?

ACCOUNTING YEARS

	Annual costs		
	1974/75	1975/76	1976/77
Royalties			
Licenses			

(48) Is there any restriction on the export of machine tools which your company manufactures under a license from a foreign collaborator?

Yes	____
No	____

(49) Is it your company's view that the machine tools it manufactures under license from a foreign collaborator are models now obsolete in industrialized countries?

Yes ____

No ____

(50) What is the policy of your company with regard to discounts on the export price of its machine tools?

It is company strategy to give price discounts because of :

the costs of breaking into the market	1	____
increased profitability as the costs of marketing are greater than the costs of discounts	2	____
smaller back-up services to distributors so reducing the private cost of exports	3	____

OR,

It is not company policy to give discounts on exports	4	____

PART C : TOPICS FOR DISCUSSION

During the interview and aside from the formal completion of Part B there are a number of issues of company policy which it is hoped will be examined. Informative discussion will be directed to the topics listed below which have been assembled under appropriate functional areas. (If your firm has been included in the postal survey your comments on these type of points will also be most welcome).

Manufacturing :

Methods of production

Quality Control

Shift working

Price determination

Research and Development :

Scope and approach

Marketing :

Policy in relation to the product-mix

Plans for export expansion

Sales forecasting and market research

Delivery periods

Spares service

Price discounts

General :

Managerial skills

Industrial relations

Government policy :

- Import controls
- Licensing arrangements
- Investment strategy
- Monetary and Fiscal policy

Ancillary industries

Availability of Annual Reports

A SURVEY OF SELECTED BRITISH MACHINE TOOL MANUFACTURERS

Please indicate :

(i) Period of Accounting Year ....

(ii) Type of Company Organisation ....

(iii) Type of Ownership ....

July 1978

Ron G. Matthews
Dept. of International
Economic Studies
University of Glasgow

SECTION 'A'   Qualitative Information

1) How many workers are employed in the following departments?

   (i) INSPECTION
   (ii) R.D.
   (iii) DESIGN

2) How many shifts are currently being worked in your factory?

3) Please state the number of Trade Unions operating in your Company?

4) What percentage of your Company's labour force is unionised?

   % : 1 - 24   25 - 49   50 - 74   75 - 99   100

5) What minimum level of technical education does your Company require of its machine operatives?

   NONE :
   G.E.C. :
   UNIVERSITY DEGREE :
   POST GRADUATE QUALIFICATIONS :
   OTHER (Please specify) :

6) What form of technical training does your Company provide for its machine operatives?

   NONE :
   COMPANY TRAINING SCHOOL :
   APPRENTICESHIP :
   ENGINEERING COLLEGE (day release etc.) :
   OTHER (please specify) :

7) Has your Company introduced, or does it in the foreseeable future envisage introducing continuous flow techniques into its production organisation?

8) Does your Company possess its own casting facilities?

9) Is it the policy of your Company to regard the internal handling and transportation of material as essentially the province of labour intensive activity?

10) Does your Company possess a designing capability?

11) In your view what is the average current life of machine tool designs in the field of production in which your Company specialises?

YEARS :

3 - 5

6 - 8

9 - 12

13 - 16

\+ 16

12) Has your Company ever taken advantage of the library and/or research facilities available at P.E.R.A. or (please specify) any other similar establishment?

13) What level of association has your Company with engineering universities and/or university engineering departments?

NO ASSOCIATION

WEAK ASSOCIATION

STRONG ASSOCIATION

14) What is your estimate of the "initiation lag" between the research stage of developing a new machine tool and actual production of that machine tool?

LAG (Months)

12 months

18 "

24 "

30 "

36 "

(and above)

15) Please state the number and title of patents held by your Company.

16) Does your Company monitor, on a regular basis, the efficiency of its labour and capital inputs?

Do you monitor : LABOUR :

CAPITAL :

BOTH :

NEITHER :

17) Is your Company's present level of output below capacity? If the answer to this question is yes, can you provide an estimate of capacity underutilization?

18) How does your Company market its products (e.g. directly, selling houses etc.)?

19) What is the policy of your Company regarding price discounts on exports?

Re : Foreign Collaboration

20) What were the main factors which prompted your Company to enter into collaboration with the Indian Concern?

21) In your view is/(was) the arrangement successful?

22) What major problem does/(did) your Company experience during the course of collaboration?

23) Would you agree that the machine tools your Indian partner manufacture(d) under license are/(were at that time) of obsolete design?

24) When the period of collaboration began was your Company still manufacturing these "licensed" machine tools?

25) What is (was) your opinion of the quality of your Indian Collaborator's output?

26) Why was the collaboration ended?

27) What advice would you offer to a foreign machine tool manufacturer who is contemplating entering into collaboration with an Indian Concern?

28) How optimistic are you regarding the development of the Indian machine tool industry?

SECTION 'B' Quantitative Data

29) On the table provided overleaf please indicate the average number of workers employed by your firm in each of the occupational categories and as far as possible, their total emoluments for the years specified.

	1971/72		1972/73		1973/74		1974/75		1975/76		1976/77	
	Av. No of Persons Worked	Salary Wages (+ Bonus)	Av. No of Persons Worked	Salary Wages (+ Bonus)	Av. No of Persons Worked	Salary Wages (+ Bonus)	Av. No of Persons Worked	Salary Wages (+ Bonus)	Av. No of Persons Worked	Salary Wages (+ Bonus)	Av. No of Persons Worked	Salary Wages (+ Bonus
DIRECT (1) LABOUR												
INDIRECT LABOUR (2)												
TOTAL												

1) Direct labour includes: Skilled, Semi-skilled, unskilled, apprentices.

2) Indirect labour includes: Managerial, supervisory and all other staff (admin. etc.)

30) For the years specified please indicate the supplementary costs connected with the employment of your company's total workforce.

	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
Employment Related Costs e.g. National Insurance etc.						

31) Please provide information on time lost (man/days) for the calendar years 1971-76 inclusive. Data should be readily available on time lost through absenteeism but it would also prove helpful if estimates can be given for man/days lost through the effects of industrial unrest.

	Calendar Years					
DIRECT LABOUR ONLY	1971	1972	1973	1974	1975	1976
1) Man/Days Worked						
2) Man/Days Lost (Absence)						
3) Man/Days Lost (Strikes etc.)						
4) Total Man/Days Lost						

32) For the years specified please provide information on your Company's value added and depreciation components.

	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
Value-added						
Depreciation						

33) Please supply information in the two tables below which have regard to your Company's expenditure on plant and machinery for the years specified.

	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77
Annual value of additions to Plant and Machinery :						
Gross Value of Plant and Machinery at accounting year end :						

34) What percentage of your Company's output went to home and export markets for the years specified?

SALES ANALYSIS BY MARKET	1974/75 (%)	1975/76 (%)	1976/77 (%)
Home Sales :			
Export Sales : (Please specify major countries)			

35) What is the percentage your company allows for the depreciation of its plant and machinery?

36) Which type of investment criteria is used by your Company?

(i) Payback period

(ii) Discounted Cash flow

(iii) Other (please specify)

37) For the accounting years listed and according to each heading please indicate your Company's expenditure on research and development.

	R & D Expenditure		
	1974/75	1975/76	1976/77
Improvements of existing products			
Development of new products			
Total			

38) With regard to your collaboration agreement what remittances, if any, have accrued to your Company over the past three years in respect of royalties and license payments?

	1974/75	1975/76	1976/77
Royalties			
License Payments			

39) Please attach a list of the number and main types of machine tools installed in your factory.

....

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