TRADE LIBERALISATION AND TECHNICAL EFFICIENCY

A Panel Study of Capital Goods Industries

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I, hereby affirm that the research for this dissertation titled ***"Trade Liberalisation and Technical Efficiency: A Panel Study of Capital Goods Industries"*** being submitted to Jawaharlal Nehru University for the award of the Degree of Master of Philosophy in Applied Economics, was carried out entirely by me at the Centre for Development Studies, Thiruvananthapuram.

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Certified that this dissertation is the bonafide work of Mr. Parameswaran.M, and has not been considered for the award of any other degree by any other university.

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Chapter 1

INTRODUCTION

The last two decades witnessed unprecedented changes in the development strategy of the developing countries. Essentially, the changes implied a shift away from the earlier import substitution regime to globalisation, from a controlled regime to a liberalised regime with greater role for market forces. In this bandwagon India has not been an exception as evidenced by the wide ranging reforms initiated in the trade and industrial policy regime. The move towards liberalisation initiated in the eighties achieved momentum in the 1990s with the initiation of structural adjustment policies. Accordingly, the import substitution policy regime, accompanied by the host of restrictions and license-permit-raj, has given way to greater reliance on market forces and increasing integration with the world market. It is expected that the policy changes, by removing the rigidities and stimulating the incentive system, would improve the productivity, efficiency and competitiveness of Indian industrial sector and thereby put the Indian economy on a higher growth path. Against this background, the present study is an attempt towards analysing the effect of trade liberalisation on technical efficiency and technical change of Indian industry. This study also considers the importance of the firm level R&D effort in maximising the productivity benefits through trade liberalisation. In what follows, we shall examine the theoretical and empirical evidences on the relationship between trade liberalisation and technical efficiency[1]. This is followed by the statement of the specific objectives of the study and the details of organisation of the various chapters.

1.1 Trade Liberalisation and Technical Efficiency - Theory and Empirical Evidence

In models that presume perfect competition, "opening up" generally improves the allocation of factors across the sectors and thereby induces a one-time increase in the value of domestic production. In this literature, we cannot see any argument that trade liberalisation reduces the volume of inputs needed to produce a given bundle of output. Thus, the traditional literature identifies the level effects of trade liberalisation, but not the growth effects. But now there are

[1] Trade policy reforms as we mentioned here covers measures that move the trade regime more towards a neutral incentive framework and more liberal foreign trade regime. A neutral incentive framework is one that does not distinguish or discriminate between exportables and importables, between sales to domestic market and export market or between tradables and nontradables.

a number of writings that make this link. The micro economic branch of this literature centres around the potential gains from increased competition and exploitation of scale economies that could result from a more liberal policy regime. Increased competition and exposure to foreign markets is also linked to the adoption of and diffusion of improved technology.

The recent theoretical developments in trade theory is based on imperfect competition. The hallmark of imperfect competition is that prices exceed the marginal cost of production. Now consider an economy with imperfect competition, where trade protection is prevalent. In such an economy, in the words of Rodrik (1992) trade reform can affect the welfare through four channels (a) volume of trade effect (b) the excess profit effect or profit shifting effect (c) the scale efficiency effect (d) technical efficiency effect.

The first of these represents the standard theoretical prediction that import should expand in those sectors, where the domestic price has been raised relative to the boarder price. This is the conventional source of gain from trade and the only operative force in a competitive environment. The second and third channels, however, point to some potential conflict with the first channel. The second effect requires that sectoral output expand where super normal profit exists, while the third effect requires that firm output increase in sectors with unexploited scale economies, where, average cost of production exceed the marginal cost of production. The conflict arises from the likelihood that protected sectors in developing countries will be precisely those with excess profits and unexploited scale economies. If the import expansion results in such sectors getting squeezed liberalisation can yield welfare loses (Rodrik, 1992).

Consider the first three channels together; whether domestic output should be reduced or expanded in import competing sectors can be seen to depend on the relationship between world prices and domestic marginal costs. If domestic marginal costs are above the world price, a (small) reduction in domestic production in import-competing sectors is on net still desirable. In a situation of imperfect competition it is also possible that trade liberalisation results in an expansion in the import competing sectors or firms, if the inward shift in the demand curve faced by the firms is to be more than offset by the increase in the elasticity, prompting an increase in the domestic sale. On the whole, the effect of trade liberalisation on scale efficiency is ambiguous.

The effect of trade liberalisation on technical efficiency of domestic firms is one of the most highly debated issues. It is believed that, trade liberalisation increases the technical efficiency of the manufacturing industries. One important argument is that removal of protection will increase the X-efficiency of the domestic firms. It is argued that, effects of protection and monopoly on efficiency within firms are much more important than effects on allocative efficiency. A large gain is expected to come through this source, " in great many instances the amount to be gained by increasing X-efficiency is frequently significant" (Leibenstein, 1966:413)[2]. One important formal explanation for the X-efficiency argument in the context of trade liberalisation is provided by Horn et.al (1995). In their model, market expansion, brought about by the trade liberalisation, leads to an increase in the managerial incentives and thereby more managerial effort. The logic behind the increased managerial incentives in a situation of expansion of the market after trade liberalisation is that, in such a situation the marginal benefits due to increased managerial effort is higher than the marginal cost of inducing that effort. Thus the model predicts an increase in X-efficiency after trade liberalisation in sectors which experience a market expansion.

Another argument is that trade liberalisation increases the profitability of investment in technological progress. In a large market situation, made available by trade liberalisation, it is profitable for the firms to invest in technical progress. Because this investment can be spread over a large amount of output and hence, the marginal cost of investment is less than the marginal benefit from that investment. i.e. the marginal benefit from the investment in technological progress is high, wider the market served by the firms.[3]

Besides the above arguments, there are some other ways also through which trade liberalisation can increase the productive efficiency of the domestic firms. First, trade liberalisation increases

[2] The theoretical model developed by Corden (1970, 1974) and Martin (1978) tried to give an analytical basis for the X-efficiency argument in the context of protection, which reduce the competitive pressure on domestic industry. Generally all these models portrays situations in which owners cum managers of the firm choose the amount of effort to supply, facing a trade off between the profit income and leisure, implied by the choice of effort. The aim of this literature is to identify the situations under which the social opportunity costs of leisure exceed the private cost. In these and like optimising models it is assumed that managerial effort supply curve is backward bending in income space and the owners cum managers are not profit maximisers.

[3]. Formal derivation of the argument can be seen in the Ocampo and Taylor (1998).

the domestic firms' access to foreign technology and knowledge and thereby enable them to move up the technology ladder. But existing literature brings many qualifications to this argument in the context of developing countries. In neo classical tradition it is often assumed that firms choose technologies under conditions of perfect information and foresight with no additional cost or risk and no externalities. But in the context of developing countries, the existing literature highlights the difficulties of technology absorption. In the words of Stiglitz (1989) " to a large extent the problem of development particularly industrialisation is that of the acquisition of the information about technology, of ascertaining what products can and should be produced, how they should be produced, and how the technology should be acquired" (p-200). Most of the technology is characterised by a considerable element of tacitness, difficulties in imitation and teaching and uncertainty regarding what modifications will work and what will not (Nelson, 1979). In this context, the literature on technology development highlights the importance of the firm level research and development activities in increasing the firm's ability to acquire, assimilate and diffuse the imported technology. Hence, it is argued that, development of domestic technological capability is necessary to absorb, adapt and diffuse the imported technology. Cohen and Levinthal (1989 and 1990) and Dollar (1992) support the view that acquisition of the external sources of knowledge complements investments in absorptive capacity. In the words of Cohen and Levinthal (1989) "R&D obviously generates innovations it also develops firms ability to identify, assimilate and exploit the knowledge from the enviournment"(p-569). Wang and Blomstorm (1992) modelled these considerations in a conventional way. In their theoretical model, they highlight the importance of the learning effort on the part of the domestic firms in utilising the transferred technology to tits fullest extent. Thus the literature emphasis the importance of firms' own effort in utilising the opportunities made available by trade liberalisation. Significant implication of this argument is that, having access to the foreign technology is only a beginning of the story, development of the in house R&D is necessary to utilise fully the potentials of the imported technology.

Further, trade liberalisation increases the interaction of domestic firms with the outside world through import and export activities. This interaction enables the domestic firms to acquire more knowledge to increase the production efficiency. The new theories of growth emphasis the knowledge diffusion role of international trade.[4] This literature argues that international trade in tangible commodities facilitates the exchange of intangible ideas[5].

While the traditional discussion often focuses on the final homogenous goods, the case for freer trade is enriched by including the fact that trade liberalisation increases the variety of goods and raises the productivity by providing less expensive or high quality intermediate good. This aspect is explored in the recent models of growth. [6] "In a restricted economy, only a narrow rage of the specialised intermediate goods or capital goods can be profitably produced and therefore, the full range of the technological possibilities which rely on a potentially broader range of inputs, cannot be able to utilise. Thus, access to a variety of foreign inputs at lower cost shifts the economywide production function outward"(Dornbush, 1992:75).

From the above discussion, it is clear that the theoretical basis of the argument that trade liberalisation lead to higher technical efficiency in an imperfectly competitive market is ambiguous. The empirical evidence on the effect of trade liberalisation on technical efficiency is also inconclusive.

There are two approaches to infer the effect of trade regime on technical efficiency of manufacturing. In the first approach, productivity growth in a cross section of countries is taken and the differences in productivity growth are analysed in terms of the extent of openness of the economy. In the second approach, inter temporal comparison of productivity growth of

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[4] In the words of Grossman and Helpman (1991), " we model endogenous technological progress that result from the profit maximising behaviour of the far sighted entrepreneurs. These entrepreneurs invest in R&D in order to capture monopoly rents from the innovative products. The productivity of the employees in the research lab depends on the general state of the scientific, engineering and industrial know how in the country. We argue that this level of know which we shall refer to as the stock of knowledge capital, will be related to the number of contacts that local agents have with their counterparts in the international research and business community. The number of the contacts most probably increases with the extent of commercial exchange"(p-520).

[5] Recent empirical studies also confirm this. In analysing the result from the detailed field interviews in several developing countries, Levy (1994) concludes that foreign buyers are among the most important sources of technological information and support for the small and medium enterprises. Foreign customers transit critical information about improvements in processing or production from other suppliers in the industrial countries. In this study the extent of contact with the foreign buyers is captured by the firm level export. This measure is very similar to that of Dollar (1992); Bee Yan Aw and Batra (1998) also used this way to capture the effect.

[6] Romer (1989) emphasised both the productivity of the specialised resources and limitation given by the size of the market in a restricted economy.

manufacturing sector within a country, which underwent substantial changes in its policy regime, is made to infer about the effect of policy regime. The detailed survey of Pack (1988), concludes " to date there is no clear confirmation of the hypothesis that countries with external orientation benefit from greater growth in technical efficiency in component sectors of manufacturing"(p-353). Further in the words of Bhagawati (1988) "although the arguments for the success of export promotion strategy based on economies of scale and X-efficiency are plausible, empirical support for them is not available"(p-39).

Tybout and Corbo (1991) analysed the effect of trade liberalisation on scale and technical efficiency of 21 manufacturing sectors in Chile. The results show that between 1967 and 1979, around half of the industrial sectors experienced deterioration in scale and technical efficiency, despite the drastic trade reform in the intervening years. However, sectors faced drastic reduction in protection performed less badly in terms of improvement in X-efficiency. Weiss (1992) analysed the effect of trade liberalisation, introduced in Mexico during 1970s, on TFP growth and found that total factor productivity growth rate is positively correlated with the import share, indicating that competition from imports stimulates the productivity growth.

The studies on productivity of Indian industry by Ahluwalia (1991), Goldar (1986, 1990), and Srivastava (1996) try to link the productivity growth to changes in policy[7]. Using aggregate industry level data, Ahluwalia's study shows that productivity growth is high during the early 1980s and she concludes that this is partly due to the changes in the policy enviournment. But her estimates are based on single deflation method. The estimates of total factor productivity, based on double deflation method, by Balakrishnan and Pushpangadan (1994) invalidated Ahluwalia's conclusion of a turnaround in productivity growth after mid 1980s. Goldar tries to explain the effect of import substitution and industrial concentration on TFP growth. The results show that import substitution has a significant negative effect on TFP growth. Srivastava used firm level data to study the effect of liberalisation measures introduced from mid 1980s onwards on productivity, price-cost margin and returns to scale. He made a pre and post reform comparison of productivity growth and found that the productivity growth is high in the post reform period.

[7] Krishna (1987) makes a detailed survey of existing literature on productivity studies in Indian industry.

1.2 Problem of the Study

Indian economy, as noted earlier, witnessed unprecedented changes in its policy framework from 1991 onwards. Trade and domestic liberalisation are the two important aspects of the liberalisation programme. It is expected, these policy changes would have a positive effect on productivity, through reduction in X-inefficiency, creating more favourable climate for investment in technological progress, liberal access to technology-both embodied and disembodied, better utilisation of capacity, greater availability of imported inputs, and better exploitation of scale economies. But regarding the productivity growth through access to better technology, the theoretical literature highlights the importance of firms' own effort, especially on the front of in-house R&D in utilising the imported technology in its maximum potential. In a country like India with little or low firm level R&D, this argument has important implications. This aspect has not been systematically studied in the literature. The present study focuses on these issues. The specific objectives of the study are.

- To review the trade policy reforms introduced in India, particularly from 1991 onwards and examine some of its macro economic implications.
- To empirically measure the technical change and technical efficiency of some selected industries.
- To analyse the role of technology import and in-house R&D on technical efficiency of firms.

1.3 Data and Method of Study.

Since a detailed account of the data and method is presented in chapter three, here we shall be brief. The study makes use of data form various sources like RBI publications, DGCIS, CMIE, ASI, World Bank publications etc. For measuring the technical change and technical efficiency, the study makes use of firm level data obtained from CMIE's computer database PROWESS for the period 1988-89 to 1997-98.We use translog stochastic frontier production function method to estimate technical change and technical efficiency.

1.4 Chapter Scheme

The study is organised in four chapters, including the introduction. The second chapter provides a review of the trade liberalisation policies introduced in India, particularly from 1991 onwards and their macro economic implications. This chapter shows that capital goods industries are more exposed to foreign competition during the post reform period. The share of the capital goods industries in total FDI inflows and foreign technology collaborations is found to be high in the post reform period. Further the export intensity of the capital goods industries is high in the post reform period, compared to that in the pre reform period. On the basis of these evidences capital goods industries are selected for the further analysis of technical change and technical efficiency.

The third chapter contains the analytical framework for the measurement of technical efficiency and technical change, specific model used for the measurement, empirical results and its interpretation. The fourth chapter summarises the major findings of the study.

Chapter II

TRADE POLICY REFORMS IN INDIA: AN OVERVIEW

The process of major economic reforms initiated in the Indian economy has now completed nine years of implementation. With these reforms the economy has entered in to a new phase of development with unprecedented emphasis on globalisation and greater role of market forces in production and exchange. The underlying objective of the policy reforms, especially the trade and industrial policy reforms, is to increase the productivity, efficiency, competitiveness and growth. To quote from the Industrial policy statement of 1991; "The major objective of the new industrial policy package is to build on the gains already made, correct the distortions or weaknesses that may have crept in, maintain a sustained growth in productivity and gainful employment and attain international competitiveness" (Government of India, p-1). Although, economic reform is often considered as a process yet to be completed, it may be appropriate to evaluate the implications of the policy reforms in terms of their declared objectives. The present study is an attempt in this direction with focus on technical efficiency and productivity improvement. While an analysis of all the sectors would have been highly rewarding, given the time constraint, we are forced to restrict our analysis to selected industry groups. Against this background, the specific objective of the present chapter is (1) to review the trade policy reforms in India, particularly since 1991 and to empirically examine their macro economic implications, and (2) based on the observed trends, select an industrial sector for further analysis of technical efficiency implications of policy reforms. The chapter is organised in two sections. The first section provides a review of the trade liberalisation policies and the second section contains an empirical assessment of the effect of trade policy reforms.

Section I

India entered in to an era of planned industrialisation during mid 1950s with the Mahalanobis strategy of development. The emphasis on import substitution and self-reliance implied a highly protectionist trade policy regime characterised high tariffs and series of quantitative controls on imports. Domestic industry, heavily insulated from international competition, was subjected to numerous regulations. While above strategy has led to the establishment of a broad industrial base, the inefficiencies perpetrated by these policies also have been highlighted[1]. It was generally held that the control oriented policy regime, which India followed for four decades, ultimately resulted in all kind of inefficiencies and rigidities, which in turn undermined the growth dynamics of the economy. From late 1970s onwards the government introduced gradual liberalisation measures in India's trade policy regime[2]. This wave of liberalisation gained momentum during the later half 1980s. However, it has been argued that, the changes that took place up to July 1991 were quite small by comparison with what was needed. The dominant view continued to be that if a good could be produced in India, then it should be protected from import competition irrespective of its cost of production. Thus despite all these measures the Indian economy remained a highly protected economy at the end of the 1980s. (World Bank, 1989). The inefficiencies associated with the controlled regime, it was argued, manifested in the macro economic crises, which came out in the form of fiscal and balance of payment problems during the end of the 1980s and early 1990s, which ultimately resulted in the introduction of the new economic policy[3].

The crises at the end of eighties, that compelled the policy makers to institute wide spread reforms, were mostly macro economic in nature. In the year 1990-91 inflation exceeded ten percent, a rate to be considered high in relation to past trends; the gross fiscal deficit of the central government increased from 6.1 per cent of GDP in 1980-81 to 8.4 per cent in 1990-91. This fiscal deficit had to be met by borrowing, mostly from the central bank and the public. As a result, the internal debt as proportion of GDP increased from 35.6 per cent in 1980-81 to 53.5 per cent in 1990-91. And interest payment doubled from 2 per cent of GDP to 4 per cent during the same period. The balance of payment crisis is evident from the fact that the deficit on the current account of the balance of payments rose from three billion dollars in mid-

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[1] For a critical review of India's policy framework see Bhagwati and Desai(1970), Bhagwati and Srinivasan (1975), Lal, D. (1988).

[2] The realisation of the problems associated with the control oriented economic regime was manifested in the appointment of a series of committees in the late seventies to look in to the different aspects of the Indian economy. See for example the reports of the committees led by P.C. Alexander (1977), and Abid Hussein (1984) on trade policy issues, Dagli (1979) committee on controls and subsidies and Tandon (1980) committee on export strategy.

[3] Although the immediate reason behind the new economic policy was the severe macro economic crisis, there were some other internal and external factors that also justified or supported a change in the development strategy. These include, lessons offered by the outward-looking model of development successfully pursued by the fast growing East Asian economies, growth in consumer awareness, increasing dissatisfaction with the interventionist policies on the part of the electorate, and the surge towards market oriented policies in the developing world (Balasubramanyam, 1995:82). Further, the gradual development of a new trade policy regime based on ideas like less protection, freer market access etc under the auspices of the GATT (later WTO) also necessitated grass root changes in the trade policy regime.

eighties to more than seven billion dollars (around 3% of GDP). The gap between domestic investment and saving grew from 1.5 per cent of GDP in 1980 to around 3.3 per cent by the end of the 1990, and this was reflected in the current account deficit referred earlier. The current account deficit was financed partly through reduction in the official reserves, as consequences of which foreign currency reserves could finance only no more than two weeks of imports in June 1991 and the country was on the verge of defaulting (Nayyar, 1996; Balasubramanyam, 1995).

This crisis got aggravated by the Gulf war, which not only pushed up the oil prices, but also led to the loss of several million dollars of workers' remittances from the Middle East. This was compounded by the trend towards withdrawal of the deposits by the non-resident Indians during the first half of the 1991. As a response to the crisis, the government introduced fundamental changes in the economic policy regime. The two components of the reform packages were stabilisation component and a long-term growth component (Agarwal et.al, 1995:2). Stabilisation involved short-term demand management through monetary and fiscal policies. The specific objectives of the stabilisation programme *inter alia* included, bringing inflation under control through restrictive monetary policy, correcting the deficit in the balance of payments through the devaluation of the exchange rates along with other reforms in the external sector, and reducing the fiscal deficit by curbing the government spending, particularly the non development expenditures. Thus the stabilisation programme aimed to achieve and maintain a stable macro economic position. While a stable macro economy may provide an essential backdrop for growth, the impetus for growth is most likely to come from a fundamental reallocation of the economy's resources in a way that maximises their productivity. Hence, structural adjustment programmes aims at maximising the long-term growth rate of the economy by improving efficiency, productivity and competitiveness. The underlying assumption of the structural adjustment programme is that the economy suffered from certain structural rigidities, which not only hindered the growth process, but also undermined its capability to respond to crisis situations. Structural rigidities emanate from governmental intervention, like controls on entry and exit, restrictions on scale of operation, interventions in the pricing (both in the product and factor market) and so on (Joseph, 1995). The important elements of the structural adjustment programme include domestic and external deregulation measures. Major structural reforms were introduced in the industrial and trade policy regimes and in the financial sector with a view to improving efficiency, productivity and international competitiveness of India's manufacturing sector.

Significant changes in the industrial policy regime have already led to industrial delicensing and a larger role for the private sector. Changes in the trade policy involved abolishing import licensing as well as reduction in the import duties, freer access to foreign technology and investment. Reforms also have been initiated towards streamlining the indirect tax structure in India. The external sector reforms, on the whole, marked a major departure from the protected inward oriented trade regime to an open, external oriented trade regime. In what follows we shall discuss the important trade policy reforms. This is followed by a discussion of the macroeconomic effect of these policy changes.

2.1 Liberalisation of Import Licensing

Prior to the economic reforms of 1990s, India operated a system of quantitative restrictions (QRs) through an import-licensing regime. The QRs are in the form of non-automatic licenses, import through canalised agencies, Special Import Licences (SIL), actual user criteria etc. This system generally banned the import of consumer goods and subjected the imports of raw materials, intermediate goods and capital equipment to highly restrictive and discretionary licensing regime, dominated by the considerations of "essentiality" and "indigenous availability". Only essential consumer goods such as food grains, edible oils, sugar and kerosene oil could be imported (generally through the official agencies) to alleviate domestic shortages.

The second half of 1980s witnessed some attempt to simplify the licensing system with a view to provide easier access to intermediate goods imports for domestic production by placing many such items on the readily importable OGL[4] list. To a lesser extent capital goods imports were also eased through flexible operation of the discretionary licensing regime to encourage technological up-gradation, particularly for the export-oriented industries. Higher tariffs accompanied the liberalisation of the quantitative restrictions in 1980s, however, and this tariffication offset any significant reduction in the protective effect.

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[4] Items under the OGL are subjected to tariffs but not quantitative restrictions.

Until 1991, imports were subjected to a complex licensing system consisting of 26 commodity list covering all merchandise. For most goods, other than for the final consumer goods, the reforms in the very first year largely swept away QRs on imports. The Export-Import policy reform of 1992 replaced the positive list with a consolidated negative list of goods subject to licensing. All items not in the negative list can be imported freely without license. Initially the negative list consists of all consumer goods including consumer electronics goods, drugs and pharmasuiticals, chemicals and allied items. Items in the negative list are subject to import licenses and the actual user conditions, which requires that the importer of the goods also to be the end usr of the goods. Another move towards liberalisation relates to the reduction in the number of so called canalised items, which could only be imported, by the state trading agencies. "The QR coverage for manufacturing (defined as the share of the value added of the items subject to import licensing in the total value added) declined from 90 per cent in the pre reform period to 51 per cent in 1994-95 (estimate). It dropped to 29 per cent for capital goods and 35 per cent for raw materials and intermediate goods" (Ahluwalia, 1996: 21).

Liberalisation of the import of consumer goods started in 1992, when large exporters received Special Import License (SIL) (about 5 per cent of the fob value of the export) to import certain consumer goods specified in the positive list. Now the government started further liberalisation of the import of consumer goods. In the Import-Export policy of 2000-01, the government removed QR on 715 items and these items include a large number of consumer goods.

The removal of quantitative restrictions on imports is further accentuated by the India's obligations to WTO agreement. India maintained these quantitative restrictions under the presumption of an unfavourable balance of payment position. However, this argument lost its significance in recent years. At present, India's current account deficit is 1.26 per cent of GDP (in 1996-97) and foreign exchange reserves cover more than seven months of imports. Hence, it became obligatory on the part of India to remove the QRs within a specified time period. In this regard, India reached a mutual agreement with Australia, Canada, Japan, the European Union, New Zealand and Switzerland and also agreed to phase out her QRs over a time period of six years, i e, 1997-2003. But US had objections to the time schedule, which India had initially put forward and filed a dispute against India. In accordance with the directions of the dispute settlement body of the WTO, India had unilaterally removed QRs on a large number of items under the import-export policy of the recent years. Based on the import export policy of 1999-2000, India had to remove QRs on 1429 lines, which were maintained for BoP reasons in 1999-2000. The removal is being carried out in to phases: 715 items by March 31, 2000 and 714 items by March 31, 2001. The EXIM policy of 2000-01 has removed QRs of 715 items (Mehta, 2000).

2.2 Reform of the Tariff Regime

A complex tariff structure with high and differential rates across industries, supplemented by quantitative controls on imports prevailed before the liberalisation era. As access to imports was eased after the mid 1980s by shifting many items from the restricted list to open general license list (OGL), higher tariffs accompanied this shift. Tariff reforms have held a centre stage in the process of opening up the Indian economy. "Designed to dismantle systematically the higher cost of inward oriented industrial regime and make Indian industry globally competitive, policy aims to reduce the rates as well as dispersion of the tariffs, and shake the Indian capital goods sector out of its lethargy and facilitate its technological renaissance." (Ahluwalia, 1996: 24). As a part of the economic liberalisation of the nineties attempts have been made towards bringing down the tariff rates and rationalisation of the tariff structure. The main thrusts of the tariff reforms as stated in the Tax Reforms Committee Report (1992) are,

1. Reduction in the general level of tariff,
2. Reduction in the spread or dispersion of the tariff rates,
3. Simplification of the tariff system
4. Rationalisation of the tariff rates, along with the abolition of the numerous exceptions and concessions, and
5. Abolition of the practice of making changes in the official rates through notifications.

From 1991 onwards, there has been a substantial decline in the tariff. The maximum tariff declined from 300 per cent in 1990-91 to 40 per cent by 1997-98 budget.

Table 2.1 gives the trends in the reduction in nominal and effective rates of protection among the different industrial sectors. The table shows that all the sectors faced a decline in protection, both nominal and effective. Although consumer goods have generally less tariff rate the amount of protection is high because of the prevalence of quantitative restrictions. Also it may be noted that the dispersion of tariff rate is higher in the case of consumer goods. Tariff protection on capital goods shows a decline during the post reform period; since capital goods have less quantitative restrictions the reduction in the tariff is equivalent to a reduction in protection.

Table 2.1 Trends in Nominal and Effective Rates of Protection (Based on End-Use Industries)

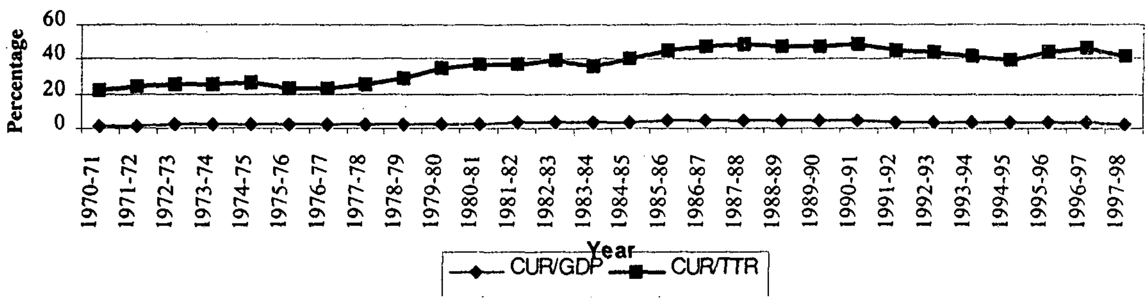
Sector	Nominal Rate of Protection			Effective Rate of Protection		
	1989-90	1993-94	1995-96	1989-90	1993-94	1995-96
A. Simple Average						
1. Consumer Goods (a) Primary	64.25 (0.92)	19.00 (1.32)	11.63 (1.06)	57.48 (1.24)	10.20 (3.38)	6.70 (2.22)
(b).Semi-finished, finished food and averages	116.33 (0.15)	82.33 (0.05)	40.45 (0.13)	110.92 (0.49)	92.15 (0.10)	40.50 (0.49)
(c) Non food	130 (0.13)	78.20 (0.13)	47.34 (0.06)	140 (0.17)	80.41 (0.14)	50.28 (0.08)
11. Intermediate goods (a) Agro-based	95.00 (0.34)	70.75 (0.35)	41.75 (0.23)	92.96 (0.43)	66.77 (0.51)	41.47 (0.29)
(b) Other Primary	103.60 (0.16)	76.80 (0.16)	25.20 (0.41)	102.77 (0.18)	77.68 (0.18)	23.90 (0.49)
(c) Semi-finished and finished	121.67 (0.17)	81.93 (0.06)	43.62 (0.16)	123.35 (0.25)	83.08 (0.11)	46.07 (0.20)
111. Capital Goods	95.00 (0.21)	68.11 (0.19)	35.30 (0.22)	78.51 (0.43)	62.79 (0.36)	31.26 (0.38)
B. Import Weighted Average						
1. Consumer Goods (a) Primary	67.05	40.5	21.87	59.34	39.81	19.05
(b).Semi-finished, finished food and beverages	140.59	77.09	47.87	186.36	104.37	68.18
(c) Non food	140.19	81.39	48.08	151.58	84.94	50.86
11. Intermediate goods (a) Agro-based	58.87	34.58	28.88	44.76	16.73	24.59
(b). Other Primary	114.56	84.92	31.10	115.19	86.18	30.54
(c). Semi-finished, and finished	120.05	81.40	41.44	116.69	81.30	45.13
111. Capital Goods	94.31	62.30	33.24	77.05	54.44	27.80

Note: figures in brackets are the coefficient of variation (CV)
Source: Mehta (1997)

In the presence of quantitative restrictions tariff data understates the extent of protection; this is true in the case of consumer goods. On the other hand, with the presence of exemptions to the exporters and other end users, statutory tariff rates over states the extent of protection. Further given the complexity of the domestic indirect tax regime and lack of value added tax with corresponding countervailing duty on imports, domestic producers bear certain duties, which are not born by the importers. As a result the protective element of the customs duty is often lower than the nominal rate. Nevertheless, even if allowances are made for these factors, the import duty collection rate in India still reached 47 per cent in 1990-91, much higher than the corresponding rates of 5 per cent in Mexico and Indonesia, 6 per cent in Korea and 7 per cent in Brazil (Ahluwalia, 1996:22).

The downward movement of the customs duty after 1991, despite considerable increase in the quantum of imports, can also be seen from the data on the customs revenue collection. The customs revenue amounted to 48.9 per cent of the total (net) tax revenue of the government in 1987-88. This ratio declined to 38.9 per cent in 1998-99. Figure 2.1 shows the trend in the customs revenue as a percentage of the total (net) tax revenue (CUR/TTR) and GDP (CUR/GDP). The share of the customs revenue in the total tax revenue was high during the second half of the eighties. This may have been due to the tariffication of the quota restrictions during the second half of the 1980s.

Figure 2.1Trends in Customs Revenue as percentage of Total (Net) Tax Revenue and GDP



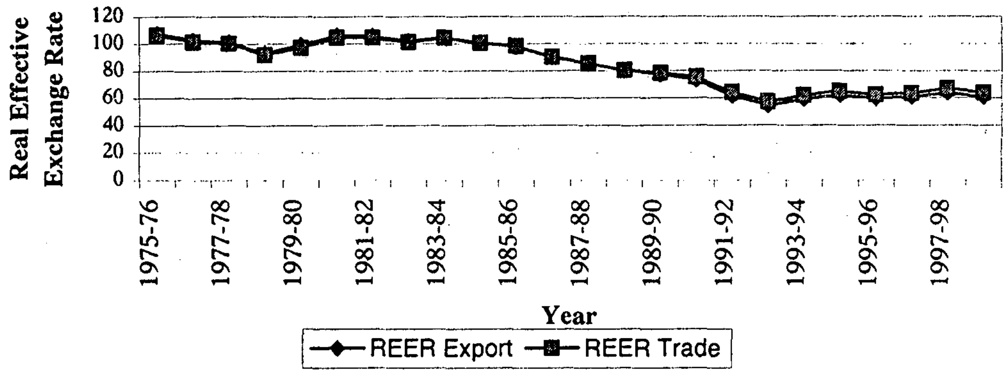
From the above discussion we can infer that compared to the pre reform period, during the post liberalisation period there is a significant reduction in the trade barriers, both tariff and non-tariff barriers. Among the different industrial groups the capital goods sector faced the largest reduction in the tariff and non-tariff barriers. But recently the government started the liberalisation of the consumer goods imports also.

2.3 Exchange Rate Policy

High tariff and pervasive quantitative restrictions in the 1980s produced an effectively overvalued exchange rate compared to what would have prevailed with lower trade restrictions. Exchange rate reforms are manifested either in the devaluation or revaluation of the domestic currency. If the exchange rate reforms result in devaluation as happened in India, exports are made more competitive and imports are made costly. There had been two major downward adjustments in the exchange value of rupee in 1991. The RBI effected a down ward adjustment in the value of rupee by 8.7 per cent to 9.7 per cent in relation to four major currencies (Pound Sterling, US Dollar, Douche Mark, and Japanese Yen) and further by 10 per cent to 11 per cent in relation to five major currencies (including French Franc) resulting in an overall appreciation of these currencies in relation to rupee by about 21 to 23 per cent.

In the context of exchange rate of reforms, an important development has been the introduction of the current account convertibility. Initially, the government introduced a system of partial convertibility in 1992. This resulted in dual exchange rate for the rupee, by creating a free market rate and an official rate. Under this regime the exporters surrendered 40 per cent of their foreign exchange earnings to the RBI at the official exchange rate, retaining the remaining 60 per cent for sale in the free market. Encouraged by the ease, with which the system adjusted to market-determined exchange rates and abolition of the import controls, the government introduced convertibility in trade account in March 1993. Ultimately in August 1994, the government introduced full convertibility in current account.

Figure: 2.2 Trends in Real Effective Exchange Rate.



Note: REER Export is the REER based on Export Weights and REER Trade is the REER based on trade based weights. The exchange rates are 36 country bilateral weights. REER of 1984-85 =100
Source: Reserve Bank of India, (1999), Hand Book of Statistics on Indian Economy.

Figure 2.2 shows the movement of the real effective exchange rate (REER) from 1975-76 onwards. The figure shows that, from 1978-79 to 1982-83 REER had been increasing. This real appreciation of the rupee was cited as one of the reasons behind the poor export performance during the period of 1979-80 to 1985-86 (Agarwal et al, 1995:178). But from mid 1980s onwards, rupee depreciated steadily to reach in 1991, 64.5 per cent of 1984-85 level. Figure2.2 shows that from 1993-94 onwards the real effective exchange rate of the rupee has been steadily appreciating. This real appreciation seems to have adversely affected the export growth of the country during this period (Economic Survey, 1996).

2.4 Other Trade Policy Measures

Recognising the critical role of the capital goods in augmenting the productive capacity, the procedures of capital goods imports have been highly simplified. The coverage of the products under Open General License List (OGL) was widened to include a number of capital goods. In 1991 it was announced that new units undergoing substantial expansion would automatically be granted licenses for the import of capital goods without any clearance from the indigenous availability angle. According to the EXIM policy (1992-97) all items, including capital goods, are allowed to be imported without any restriction except to the extent such imports are regulated by the negative list. Second hand capital goods were also permitted to be imported with or without license depending on the nature of goods. The introduction of a new scheme Export Promotion Capital Goods (EPCG)[5] Scheme- in 1992 further enhanced the accessibility of exporters to imported capital goods.

The Advance Licensing Scheme[6] was liberalised to include all imported inputs and the procedures for the grant of Advance Licenses were simplified. Further, government announced special schemes to encourage those engaged exclusively in export activity like the setting up of Export Processing Zones (EPZs) and software and hardware technology parks. The units located in these zones are allowed duty free import of raw materials and capital goods. More over, in the trade policy for 2000-01 the government announced the creation of Special Economic Zones (SEZs) on the Chinese model in Gujarat and Tamilnadu to promote exports. The units in these zones can import capital goods and raw materials at zero duty and have access to duty free goods from the domestic market. The government also announced the conversion of the existing EPZs in to SEZs. The policy announcement included the extension of the Export Promoting Capital Goods Scheme to all sectors without threshold limit and the extension of the duty free replenishment certificate for more than 5000 products.

2.5 Policy towards Foreign Direct Investment and Technology Import

The rationale of FDI liberalisation for a developing country rests *interalia* on the proposition of a relatively better export performance of TNCs. This proposition in turn is derived from the neo factor endowment and neo technology theories of international trade. According to these theories, FDI is associated with substantial technology diffusion, dissemination of the better management practices, and stimulation of competition. Besides, TNCs are generally considered to be better placed to tap international markets as compared to their local counterparts in view of their easy access to information, marketing net works, advanced technology, patent right, trademarks etc. It is thought that all these would not only facilitate increased exports, but also stimulate the local firms to produce higher quality products and to enter in to export markets (Joseph and Veeramani, 1999:10).

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[5] Under this Scheme manufactures exporters are permitted to import capital goods at concessional import duty subjected to some stipulated export obligation.

[6] An Advance License is granted to a merchant exporter or manufacturer exporter for the import of inputs required for the
manufacture of goods without payment of basic customs duty.

India was not a major recipient of the foreign direct investment (FDI). Both controls over trade and complex set of regulations governing inward investment and technology flows have deterred the foreign investors from investing in India. During the period 1988-89, FDI in India amounted to a meagre 0.2 per cent of the capital formation, compared to 25 per cent in Singapore, 15.2 per cent in Hong Kong, 1.4 per cent in Korea (Balasubramanyam, 1995:85). The liberalisation of the rules and regulations relating to FDI counts a significant move towards integrating India with World economy- the primary objective of the reforms. Significant departures from the earlier restrictive regime include abolition of the requirement that FDI inflows should be accompanied by technology transfers and automatic approval of FDI up to foreign equity participation of 51 per cent in a range of industries.

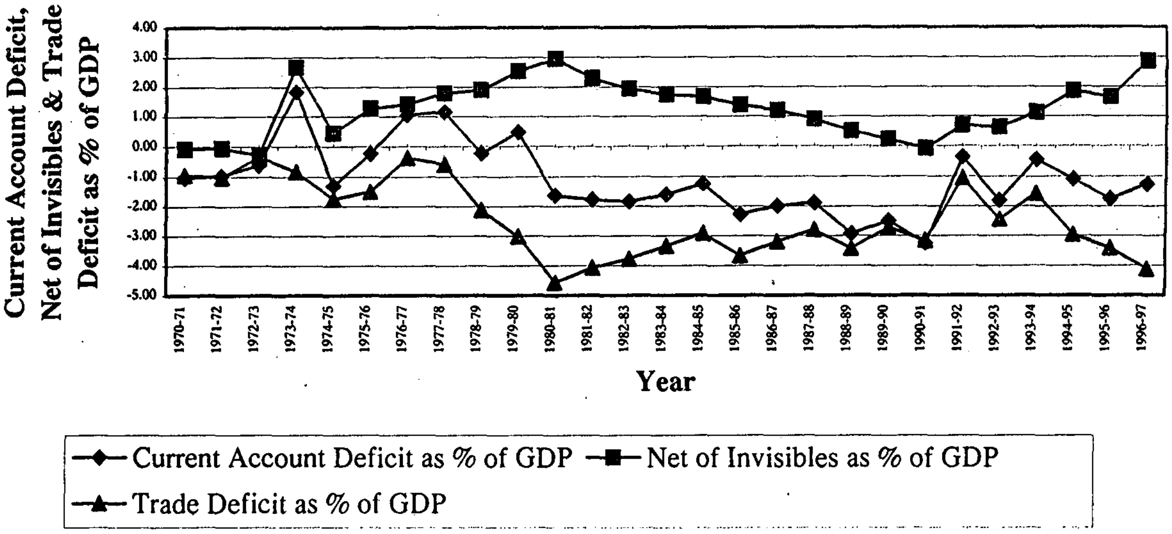
As per the statement of the industrial Policy 1991 a list of 35 industries eligible for the Automatic approval by RBI for foreign equity up to 51 per cent was published. In an another press note in 17th January 1997 it was decided to include 3 categories of industries/items relating to mining activities for foreign equity participation up to 50 per cent, thirteen additional categories of industries/items for equity up to 51 per cent and 9 categories of industries equity up to 74 per cent in the list of industries/items eligible for the automatic approval by the RBI. In 34 high priority industries identified in Annex-III of the policy statement of July 24 1991, foreign investment up to 51 per cent was approved automatically, provided the foreign equity inflow was sufficient to cover the costs of imported capital goods. Moreover, the remittances of dividend were to be balanced by export earnings over a period of time (seven years from the commencement of production). Foreign equity proposals did not necessarily need to be accompanied by foreign technology agreements. Trading companies, engaged primarily in export activities allowed foreign equity participation up to 51 per cent. To attract MNEs to the energy sector, 100 per cent foreign equity was permitted in the power sector. In April 1992 India signed the convention of the Multilateral Investment Guarantee Agency (MIGA) for the protection of foreign investments.

New Industrial Policy liberalised foreign technology collaborations and made provisions for automatic permission to foreign technology collaborations in high priority industries specified in Annex-3 (1991, policy statement) up to a lumpsum payment of Rs.10 million, 5 per cent of royalty, for domestic sales, and 8 per cent for exports, subject to total payment of 8 per cent of sales over a 10 year period from the date of agreement or seven years from the commencement of production. Further, in respect of industries other than those in Annex-3, automatic permission will be given, subject to the guidelines as above, if no free foreign exchange is required for any payment. All other proposals needed specific approval under the general procedures in force. No permission would be needed for hiring foreign technicians or foreign testing of indigenously developed technologies.

Section II

This section provides an empirical examination of the developments in the external sector as a result of the changes in the policy regime. Any change in the policy regime in the external sector has its own impact on the current account deficit and the foreign exchange reserves of the country. The crisis that caught the Indian economy during the early 1990s mainly emerged from an unsustainable current account position and low foreign exchange reserves. So we begin our empirical analysis by considering first the trends in the current account position of the country. The figure 2.3 shows the trend in the current account deficit as a percentage of GDP as well as the trend in its constituent variables, namely the trade deficit and the net of invisibles as a percentage of GDP.

Figure 2.3 Trends in the Current Account Deficit



In 1990-91, the current account deficit as percentage of GDP was 3.24 and this declined to 1.28 per cent in 1996-97. The figure shows that from 1991 onwards, net of invisibles as a percentage of GDP, has been increasing. It was 0.69 per cent of GDP in 1991-92 and it increased to 2.84 per cent in 1996-97. The trade deficit has been increasing during the post 1990 period; it increased from 3.16 per cent of GDP in 1990-91 to 3.4 per cent in 1995-96 and further to 4.12 percent in 1996-97. It indicates that the increased surplus in the invisible account is contributing towards the declining current account deficit during the nineties. Table 2.2 gives the foreign exchange reserves of the country during the nineties.

Table 2.2 Foreign Exchange Reserves (in US million $)

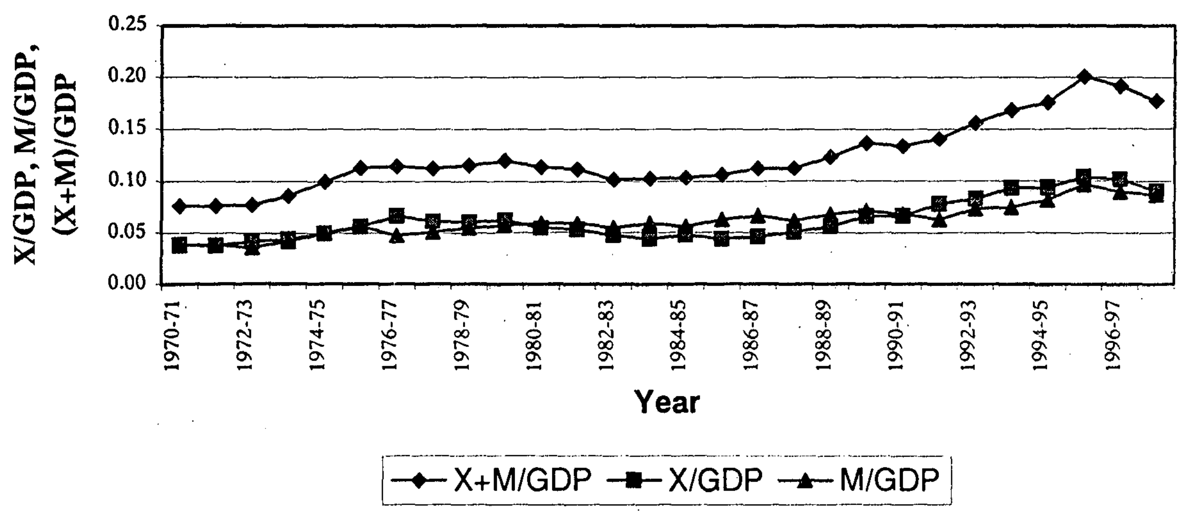
Year	Reserves
1990-91	2236 (1.0)
1991-92	5631 (3.2)
1992-93	6434 (3.3)
1993-94	15068 (7.2)
1994-95	20809 (7.8)
1995-96	17044 (4.9)
1996-97	22367 (5.5)
1997-98	25975 (7.3)

Note: Figures in brackets represents the import cover (No of months) of foreign currency assets.
Sources: *RBI Report on Currency and Finance* (different years) and Government of India, Ministry of Finance *Economic Survey* (Different years), (Reproduced from Joseph and Veeramani, 1999)

The table shows a significant increase in the foreign currency reserves of the country during the post reform period. In 1997-98 the available foreign exchange reserves were sufficient to meet the 7.3 months of imports. This indicates that economy's performance in terms of two important macro economic variable i.e. current account deficit and foreign exchange reserves has been encouraging.

Given the fact that one of the objectives of policy reform has been to integrate the Indian economy with rest of the world it may be appropriate to examine the trend in this direction. A simple method to measure the extent of openness of an economy is to calculate the trade intensity of that economy. The larger the share of trade in GDP, the greater is the degree of integration with the world market. Commonly used measures of integration with rest of the world are; export as ratio of GDP, (X/GDP), the ratio of import to GDP, (M/GDP) and the ratio of sum of import and export to GDP (X+M/GDP). Trade intensity measured as a ratio of the sum of export and import to GDP was 7.6 per cent in 1970-71. In 1985-86 this ratio increased to 10.38 per cent and to 13.39 per cent in 1990-91. By 1997-98 trade intensity of Indian economy increased to 17.71 per cent indicating an increase in the extent of openness in the post liberalisation period (see figure 2.4).

Figure 2.4 Trends in the Trade Intensity.



From the figure 2.4 we can distinguish three phases in the trade intensity of the economy. Up to 1979-80 there has been an increase in the trade intensity of the economy, measured by the ratio of total trade to GDP. From 1979-80 to 1985-86 the trade intensity showed a downward trend. From the figure it is evident that this decline in the trade intensity could be mainly due to the decline of the export intensity of the economy. As already stated, the real appreciation of the rupee between 1978 and 1983, the expansionary fiscal policy which increased the domestic incomes and absorption and slackened world demand, were some of the factors contributed to the poor export performance during this period (Agarwal et.al, 1995:178). From the second half of the 1980s, the trade intensity has been increasing and this upward movement becomes sharper during the 1990s. The same movement can be seen in the export intensity and import intensity of the economy, during the nineties. This movement in the trade intensity corresponds to the degree of liberalisation injected in to our trade regime.

In this context a comparison of openness of Indian economy with that of other developing countries may be of interest. The table 2.3 presents the extent of openness of the different countries during different time points. In the table 2.3 the openness of an economy is measured as the sum of exports and imports of goods and non-factor services as a share of GDP.

Table 2.3 Trade Intensity of Various Developing Countries.

Country	1985	1990	1992	1993	1994
Brazil	19	13	16	15	12
Chile	54	65	58	56	55
China	25	34	42	49	49
India	15	19	21	23	25
Indonesia	43	53	55	53	55
Republic of Korea	67	60	59	58	55
Mexico	26	33	30	29	32
Turkey	44	30	31	34	42
Thailand	49	76	77	78	80
Pakistan	34	35	36	38	36

Source: World Bank (1995) *Trends in Developing Countries*.

The table shows that countries like China, Korea Mexico and Pakistan always have higher openness ratio than that of Indian economy. This indicates that in terms of extent of integration with the world economy, we have still to go a long way to catch with others.

The table 2.4 gives the import intensity of the various industrial sectors during the pre and post reform years. Import intensity of an industrial sector is defined as the ratio of import of goods produced by that sector to its total output.

Table 2.4 Trends in Import intensity of various Manufacturing Sectors (in per cent)

Sector	Year								
	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96
Food Products	1.23	0.37	0.46	0.37	0.39	0.79	0.52	4.41	3.13
Chemicals	8.99	12.99	18.83	15.91	26.77	25.35	21.23	25.51	27.30
Textiles and Textiles Products	2.72	3.56	2.96	2.94	2.42	2.79	3.12	3.63	3.51
Wood and Wood Products	38.44	44.91	48.65	51.37	46.49	53.49	33.55	46.96	50.57
Paper and Paper Products	13.75	14.45	12.11	14.12	10.35	11.59	12.22	11.45	14.57
Leather and Leather Products	1.74	2.91	4.67	6.75	6.04	5.04	5.33	4.02	4.72
Rubber, Plastic and Petroleum Pro:	29.68	29.08	28.15	40.02	40.69	37.10	35.12	30.68	31.97
Nonmetallic mineral Manufactures	8.90	10.33	11.07	11.05	9.29	1.97	1.94	2.46	2.30
Basic metals and Metal Products	12.29	13.10	14.28	12.18	9.72	7.12	7.97	12.77	12.78
Capital Goods	17.83	15.70	17.03	15.87	12.49	22.53	25.97	23.38	24.01
Electrical Machinery	11.94	13.47	12.64	10.22	8.17	10.32	15.18	14.29	17.69
Nonelectrical Machinery	31.81	27.25	25.74	27.14	23.14	27.49	31.43	38.07	40.91
Transport Equipment	8.90	6.82	11.52	10.51	5.75	6.54	17.15	11.06	7.76

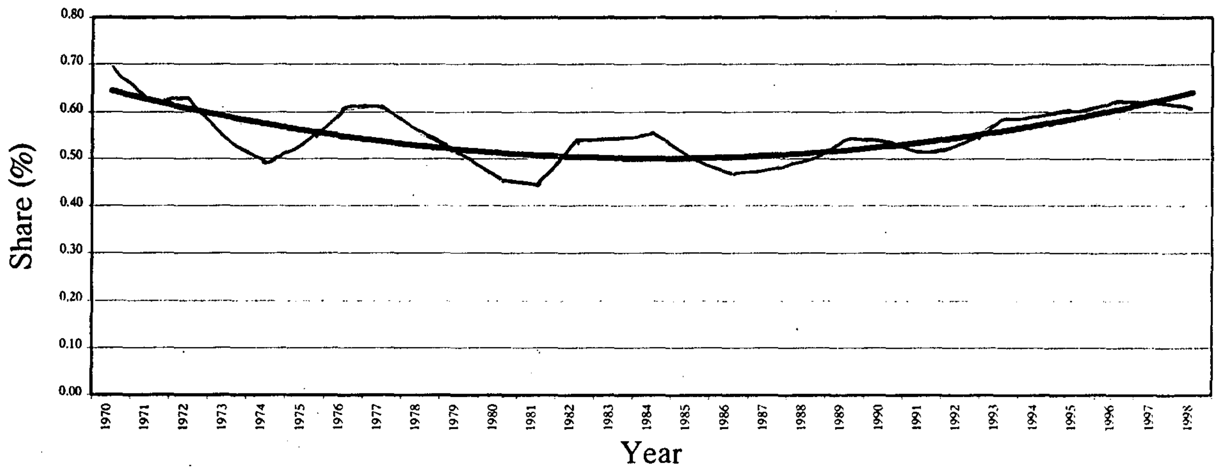
Note: The import data are taken from DGCIS and Output data from ASI Summary Results for the Factory sector.

Data presented in table 2.4 show that the import intensity of the sectors like food products, chemicals, leather and leather products, capital goods including electrical machinery, nonelectrical machinery and transport equipment is high during the post liberalisation period compared to that in the pre reform period. Among these sectors the import intensity of chemical and capital goods sector increased more than that of other sectors.

2.6 Export Performance

A protected system involves a bias against or tax on export production. Because of this reason our exports were less competitive in the world market[7]. An empirical manifestation of this can be seen in the declining trend in India's share in world exports. In 1970 it was around 0.691 per cent and it declined to 0.453 per cent by 1980. During the second half of 1980s, there had been a gradual increase in India's share in the world export. In 1990 this share was 0.539 per cent, by 1998 it increased to 0.605 per cent. This share is still lower than what India had in 1970. The figure 2.5 shows the trend in the India's share in world export. The trend in the export share shows that up to mid 1980s there had been a continuous decline and after the mid 1980s, India's share in world export has been gradually increasing. This movement in the export share corresponds to the reduction in anti export bias in the trade regime.

Figure 2.5 Trend in India's share of World Export

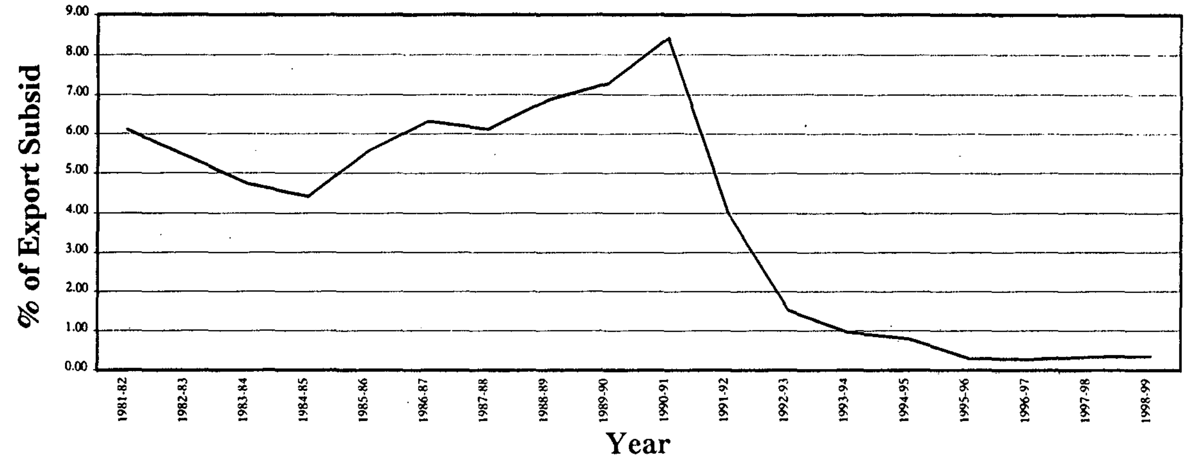


The presence of an anti export bias in the trade regime and the increased cost structure of the economy due the inefficiencies in the import substituting industries, reduced the competitiveness of Indian export in the international market. As is typical in such regimes the authorities sought to offset the anti export bias in trade policy with export incentives and subsidies. These included schemes for providing cash assistance to offset the burden of indirect taxes at earlier stages of production, and to provide an element of subsidy to cover

[7] An inefficient industrial structure emerged from the import substitution policies and protection as well as the over valued exchange rate were some contributing factors to the reduced competitiveness of export.

various hidden costs, duty drawbacks to refund customs duties paid on imported inputs etc. The export subsidy, included under the heading "subsidy for export promotion and market development" was more than 8 per cent of export value in 1990. With the removal of quantitative restrictions and a shift to a new competitive exchange rate, the need for export subsidy as an incentive scheme is also reduced. Cash compensatory support ended very early when the rupee was devalued by 24 per cent in July 1991. Subsequently the International Price Reimbursement Scheme (IPRS), which refunded to the user the difference between the world and domestic prices of major inputs such as steel and rubber was abolished from 31st March 1994. Because of these changes the export subsidy as a percentage of export value has been declining through the post reform period and reached less than 1 per cent of export value in 1997-98. From the figure 2.6 we can see the drastic decline in the export subsidy during the nineties[8].

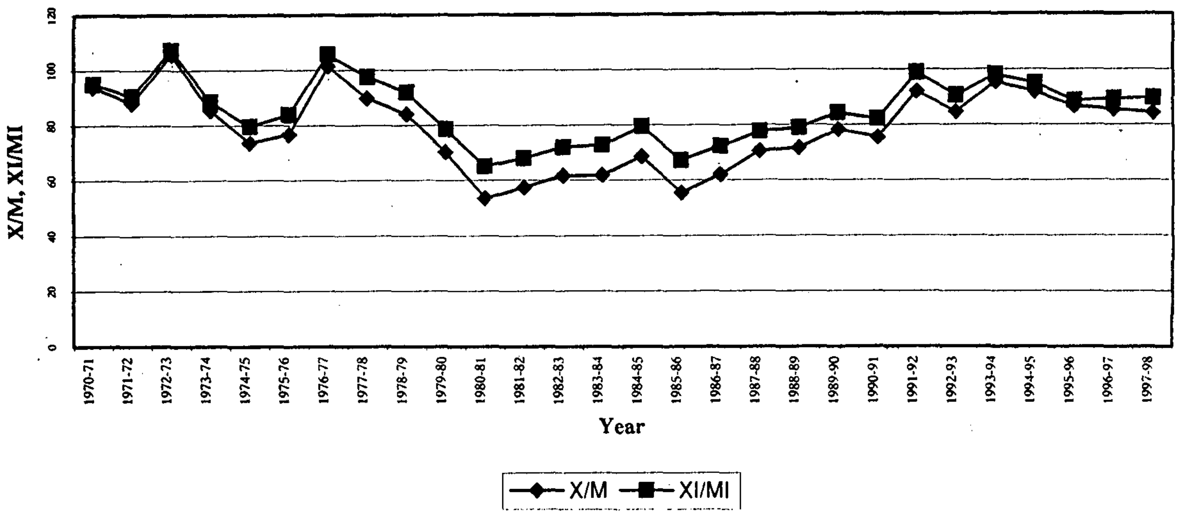
Figure 2.6. Export Subsidy as Percentage of Export value.



Another way of looking at our post liberalisation export performance is through the change in our ability to finance imports by our own exports. The figure 2.7 shows the movement of the export as a percentage of our imports. In the diagram X/M indicates the movement of the export of commodities (including oil) as a percentage of import of commodities (including oil), and XI is the sum of earnings through the export of commodities and receipts through non factor services; similarly MI is the sum of payments to the import of commodities and non factor services.

[8] Export Subsidy is taken from the Budget documents of the various years.

Figure 2.7 Export as a Percentage of imports.



In 1970-71 our export (XI) was 95.07 per cent of our imports (MI) and it declined to 68 per cent in 1980-81. In 1985-86 also, this remained at 67 per cent. During the 1990s there has been an increase in the economy's ability to finance imports through its own exports i e, (XI/MI). In 1997-98 exports amounted to 89.62 per cent of our total imports.

Trade liberalisation measures affect the export performance of the various industrial sectors differently. Industries having comparative advantage or scale advantage can improve their export performance during the post reform period. The table 2.5 gives movement of the export intensity of the various industrial groups during the pre and post reform period. The export intensity of an industrial sector is defined as the ratio of export to total out put of that sector.

Table 2.5 Export intensity of the Different industrial sectors (in per cent)

Sector / Year	87-88	88-89	89-90	90-91	91-92	92-93	93-94	94-95	95-96
Food Products	0.34	0.35	0.43	0.38	0.67	5.18	5.96	6.49	6.62
Chemicals	3.57	5.75	10.23	8.63	15.79	23.41	25.18	28.58	27.50
Textiles and Textiles products	24.85	23.71	25.25	29.20	35.12	35.80	34.08	35.33	35.92
Paper and Wood Products	1.03	1.04	1.24	1.04	1.37	1.69	2.67	2.98	3.08
Leather and Leather Products	60.22	60.86	62.08	60.44	65.11	86.51	85.18	90.22	98.86
Rubber, Plastic & Petroleum Products	4.60	3.39	3.60	4.04	3.90	4.96	5.77	5.54	5.10
Machinery-Electrical & Nonelectrical	4.30	5.02	5.44	5.41	5.99	5.76	7.43	7.00	7.49
Transport Equipment	3.03	3.29	3.95	4.52	7.63	7.55	8.00	7.66	6.49
Basic Metals and metals products	1.80	2.59	3.37	3.33	4.70	5.97	7.77	6.61	6.48
Non metallic mineral manufactures	3.03	3.25	3.77	3.57	3.62	2.29	3.66	3.76	3.10

Note: data on export obtained from DGCIS and output data obtained from ASI Summary Results for the Factory Sector.

The data presented in table 2.5, (though indicative) shows that the export intensity of the sectors likes food products, chemicals, textiles and textiles products recorded significant increase in their export intensity. The export performance of capital goods like machinery (electrical and non-electrical machinery) transport equipment etc during the post liberalisation period although increased lagged much behind other sectors.

2.7 Foreign Direct Investment and Technology Import

As a result of policy changes from 1991 onwards and active promotion of India as destination, the amount of FDI approved and received rose sharply. Table 2.6 shows the FDI in India during the post reform period. The total foreign investment inflow in 1990-91 was only rupees 185 crores consisting rupees 174 crores direct investment and 11 crores portfolio investment. By 1996-96, total foreign investment reached a peak level of Rs 21, 773 crores and thereafter it showed a declining trend. The decline in foreign investment as well as its year to year fluctuations may be attributed primarily to portfolio investment, which recorded a peak level of Rs 12,007 crores in 1993-94 and declined to -257 in 1998-99.

Table 2.6 Foreign Investment in India (Rs. in Crores)

Year	FDI	PI	Total
1990-91	174	11	185
1991-92	316	10	326
1992-93	965	748	1713
1993-94	1838	11188	13026
1994-95	4126	12007	16133
1995-96	7172	9192	16364
1996-97	10015	11758	21773
1997-98	13220	6696	19916
1998-99	10358	-257	10101

Note: FDI= Foreign Direct Investment, PI= Portfolio investment.
Source: RBI Statistics, (1999)

Foreign direct investment as a percentage of gross fixed capital formation shows an increasing trend during the post reform period (see Fig 2.8). In 1991 foreign direct investment was only 0.14 per cent of the gross fixed capital formation and by 1997-98 it increased to 3.7 per cent. While FDI accounts for only less than 4 per cent Gross Fixed Capital Formation (GFCF) studies have shown that they account for more than 30 per cent of total manufacturing output (Joseph and Jacob 2000).

Figure 2.8 Foreign Investment as Percentage of Gross Fixed Capital Formation.

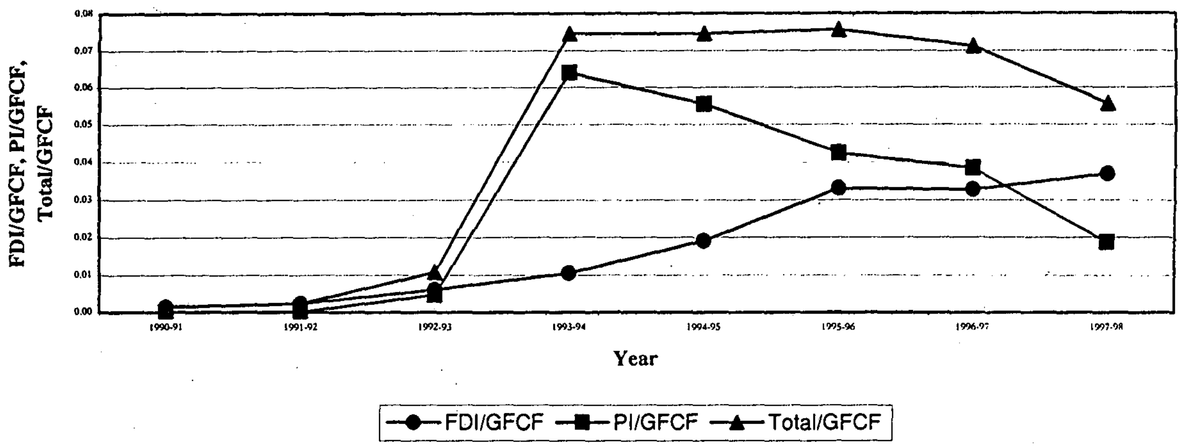


Table 2.7 shows the industry-wise distribution of the FDI. The table shows that among Individual sectors engineering sector, which includes capital goods, received the largest share of FDI followed by chemicals. The share of the computers is high compared to other individual sectors.

Table 2.7 Industry-wise Distribution of FDI (Rs. in crores)

Industrial Sector	1994-95	1995-96	1996-97	1997-98	1998-99
Engineering	413.2 (15.09)	842.5 (17.76)	2592.2 (35.45)	2155.1 (19.62)	1799.1 (21.38)
Chemicals	443.3 (16.19)	423.8 (8.94)	1078.5 (14.75)	956.2 (8.70)	1579.7 (18.77)
Services	293.2 (10.71)	336 (7.08)	53.9 (0.74)	1194.1 (10.87)	1550.3 (18.42)
Electronics & Electrical Equipment	177.1 (6.47)	433.6 (9.14)	545.4 (7.46)	2395.6 (21.81)	960.4 (11.41)
Finance	306.9 (11.21)	903.3 (19.04)	770.4 (10.54)	549.7 (5.00)	777.6 (9.24)
Computers	32 (1.17)	174.3 (3.67)	208.4 (2.85)	517.2 (4.71)	446.7 (5.31)
Pharmaceuticals	31.7 (1.16)	183.2 (3.86)	169 (2.31)	125.6 (1.14)	119.6 (1.42)
Food and Diary Products	191.3 (6.99)	284.2 (5.99)	843.2 (11.53)	417.8 (3.80)	78.1 (0.93)
Others	749 (27.37)	1161.1 (24.48)	1051 (14.37)	2674.6 (24.35)	1102.8 (13.11)
Total	2738 (100)	4743 (100)	7312 (100)	10985.9 (100)	8414.3 (100.00)

Note: column percentages are in the brackets
Source: RBI Annual Reports, various years.

We already found that the new economic policies envisage significant liberalisation in the inflow of foreign technology. Table 2.8 shows the trend in the foreign collaborations from 1985 to 1995. The table shows that from 1991 onwards, the number of foreign collaborations has been increasing at a faster rate. The table also shows that the average lumpsum payment per collaboration is high during the post reform period. This indicates that foreign exchange burden on this account has been increasing during the post reform period. Regarding the industry wise distribution of foreign collaborations, during the period 1992-96, electrical machinery and electronics accounted for 15.21 per cent of the total collaborations. The shares of other industries are, chemical 13.32, mechanical engineering 8.65 per cent, industrial machinery 5.84 per cent and metallurgical 4.31 per cent (Emmanuel, 1999). Thus the data shows that most of the foreign collaborations are in the high technology industries.

Table 2.8 Trends in Foreign Collaborations and Lumpsum Payment Approved

	Number of Foreign Collaborations		Lumpsm Payments (Rs.in million)	
Year	Total	With equity	Total	Average
1985	1041	256(24.6)	4505.3	4.32
1986	960	256(26.7)	5882.3	6.12
1987	903	259(28.7)	4182.6	4.63
1988	957	289(30.2)	5898.7	6.16
1989	639	212(33.2)	6986.9	10.90
1990	703	201(28.6)	5741.4	8.16
1991	976	298(30.5)	9798.2	10.03
1992	1520	736(48.4)	22812.7	15.00
1993	1476	762(51.6)	36900.2	25.00
1994	1854	1054(56.8)	22999.3	12.41
1995	2327	1355(60.0)	71981.5	30.80

Note: Figures in the parenthesis show the percent of the financial collaborations. Source: Government of India (1996), Ministry of Science and Technology A Compilation of Foreign Collaboration Approvals, Department of Science and Industrial Research, New Delhi.

2.8 Summing up

The basic objective of this chapter as outlined in the beginning has been; a) to review the trade policy reforms in India and to empirically examine their macro economic implications, and b) based on the observed trends, select an industrial sector for further analysis of technical efficiency and productivity implications of policy reforms. We found that, the nineties witnessed a significant reduction in the trade barriers as manifested in liberalisation of import licensing, reduction in tariff rates, removal of quantitative restrictions, relaxation in the restrictions on the flow of foreign capital and technology. These measures seem to have their effect in terms increased integration of the Indian economy with rest of the world. With increased import liberalisation, most of the industrial sectors operate in a more competitive environment than before. The empirical evidence shows that the import intensity of different industrial sectors like capital goods and chemicals increased during the post reform period.[9] The evidence on the export behaviour of the different industrial sectors shows that the export intensity of the sectors like, machinery (electrical and non electrical machinery), transport equipment and metal and metal products, although increased, lagged behind other sectors during the post liberalisation period. The liberalisation of the foreign investment and technology import policy increased the foreign investment inflows and technology flows during the nineties. Among the industrial sectors, the data show that engineering sector got higher share of the FDI and among the individual industries, computer sector got a substantial FDI during the nineties.

Based on the empirical evidence presented in this chapter following issues arise; with liberalisation, the capital goods industries have been facing increased competition from imports. Has it generated an environment, which compelled the domestic producers to improve their productivity?

The industry-wise distribution of FDI shows that among the industrial sectors, capital goods sector received a higher share of FDI and foreign technology. What has been the implication of enhanced technology transfer (both embodied and disembodied) on the efficiency and productivity of the capital goods industries? An attempt to provide answers to these questions forms the core of the forthcoming chapter.

[9] The higher import intensity of these sectors will create a competition to the domestic firms only if these imports are substitutes for the domestic production. But there are arguments that in the machinery sub-sector there is a complementary relationship between the import and domestic production. In this case the contraction in market due to import is less than the import of this sector. (see Narayanna, D and S.Sinharoy,1996; Ragarajan,1995)

Chapter III

TECHNICAL EFFICIENCY AND TECHNICAL CHANGE: EVIDENCE FROM THE CAPITAL GOODS INDUSTRIES.

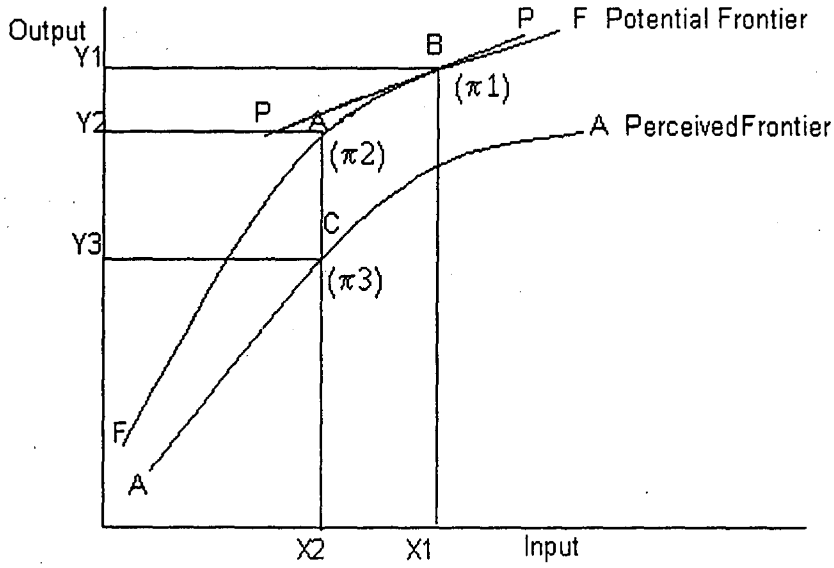
In this chapter, we analyse the performance of Indian capital goods industries in terms of technical efficiency and technical change. More specifically, by using a translog frontier production function, we estimate the extent of technical efficiency and technical change in the four leading capital goods industries, viz. electrical machinery, electronics, nonelectrical machinery and transport equipment and identify the factors influencing the observed inefficiency. A pre and post reform comparison, by taking 1991-92 as the dividing point, is made with a view to make some inference about the effect of policy reforms. Given relaxation in the restrictions on technology import, both embodied and disembodied, envisaged under the trade policy reform of the 1990's on the one hand and the increasing emphasis on in-house R&D on the other, we also analyse the bearing of in-house R&D and technology import on the technical efficiency of firms. The chapter is organised in four sections. Section-I provides the analytical framework for measuring the technical efficiency and technical change. Section-II contains a discussion on the data used for the study. The third section presents the estimation results and its discussion. Final section provides a summary and conclusion of the chapter.

Section 1

3.1 The Concept of Technical Efficiency.

Firm performance is conventionally judged by the concept of economic efficiency, which is generally assumed to be made up of two components- technical efficiency and allocative efficiency. The former is defined as "the capacity and willingness of an economic unit to produce the maximum possible output from a given bundle of inputs and technology." (Kalirajan and Shand, 1994:3). The latter concept is defined as the "ability and willingness of an economic unit to equate its specific marginal value products with its marginal costs". The pioneering works of Farrel (1957) focused attention on the concept of economic efficiency. We can explain the two concept of efficiency through the figure 3.1.

Figure 3.1 The concepts of Technical Efficiency, Allocative Efficiency and Economic Efficiency.



In neoclassical theory, all the firms operate at potential technical efficiency, along the production frontier FF. Any inefficiency will be solely allocative. Thus if a firm is operating on its frontier FF, its point of economic efficiency is at B, the point of tangency with its price line PP. If it operates at point B with input x_1 and output y_1 there will be maximum profit, π_1 and no allocative or technical inefficiency. On the other hand, if the firm is operating at point A on frontier FF using x_2 inputs and producing y_2 output, its profit may be π_2 and its allocative or economic efficiency will be assumed as π_2/π_1.

On the other hand if the firm is producing y_3 output by operating at point C on its perceived production frontier AA, its economic efficiency would be measured by the ratio π_3/π_1. Where π_3 is the actual profit obtained by the firm by operating at point C of its perceived production frontier and π_1 is potential profit at point B on its potential frontier. Technical efficiency of the firm at point C can be measured by the ratio y_3/y_2 for given input level x_2.

The point B on FF can be considered as the long run equilibrium position for the firm to achieve, given the technology represented by FF. The long run equilibrium point may also shift as new technclogies are introduced in a dynamic situation and new disequilibrium is created. Thus the basic assumption underlying the measurement of the technical efficiency is that a gap normally exists between a firm's actual and potential levels of technical performance.

The most commonly used tool of analysis for measuring technical efficiency is the primal production function. In the neoclassical theory of production, the primal production function defines the maximum possible output of the firm from a given combination of inputs and technology. A simplified version of the theory is discussed below.

Consider a single output y

$$y \leq f(x) \tag{1}$$

Where y is the actual output and f(x) is the maximum possible output. Then, an output based Debreu-Farrel measure of technical efficiency is

$$TE(y,x) = \frac{y}{f(x)} \tag{2}$$

Where TE(y, x) is the technical efficiency in the production of y by using input x. Cross multiplying (2), the relationship for the i^{th} firm is

$$y_i = f(x_i, \beta)TE_i \qquad , i = 1 \ldots N \tag{3}$$

Where $0 < TE(y_i, x_i) \leq 1$, β is a vector of parameters of the production function to be estimated. We can express (3) in log form as follows

$$\ln y_i = \ln f(x_i, \beta) + \ln TE_i \tag{4}$$

$$= \ln f(x_i, \beta) - u_i \tag{5}$$

Where $u_i > 0$ is a measure of the *technical inefficiency*[1]

Equation (5) provides fundamental relationship for any analysis of production. Various methods using different assumptions have been suggested in the literature to measure the technical efficiency of production units. This can be conveniently grouped under two major approaches, namely deterministic frontiers and stochastic frontiers. Frontier functions, in which the deviation of an observation from the theoretical maximum is attributed solely to the inefficiency of the firm, are labelled as 'deterministic frontier functions'. The deterministic frontiers include both the parametric and non-parametric methods. In reality the deviations from the frontier can be due to the random factors like equipment failures or luck etc. So one

[1] Since $0 < TE(y_i, x_i) \leq 1$, logarithm of TE_i, u_i is negative.

defect of the deterministic frontiers is the inclusion of these factors in the inefficiency term. Another defect of the deterministic frontiers is that any error due to misspecification of the model or measurement errors in the constituent variables is lumped together with the inefficiency term.

On the other hand in a stochastic frontier the maximum output that a producer can obtain is assumed to be determined both by the production function and by the random factors such as luck or unexpected disturbances in a related market. Because of above reasons a stochastic frontier production function is considered to be superior to the deterministic production function (Greene, 1996).

Aigner, Lovell and Schmidt (1977) introduced the method of stochastic frontier production function. A stochastic production frontier can be expressed as

$$Y_i = f(x_i) + \upsilon_i - u_i \qquad (6)$$

$$u_i \geq 0$$

Where Y_i is the output, x_i is the input v_i is a symmetric error and u_i is an asymmetric error caused by technical inefficiency. The production frontier is $f(x_i)+v_i$ and by definition it can vary. Of the two components the first v, which is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$, is the pure statistical noise such as measurement and aggregation errors and the random variation of the frontier across the firms; other factors absorbed in to this term include factors which are uncontrollable or unobservable. The term u_i is a measure of technical inefficiency. Initially in the stochastic frontier production functions the term u_i is assumed to follow half normal distribution with zero mode[2]. Stevenson (1980) suggested that the characteristics such as degree of educational training, intelligence, perseverance and other factors that relates to the managerial efficiency are not likely to be distributed over the population with such a monotonically declining density functions. He considered the more general truncated normal distribution, with nonzero mode.

[2] Aigner, Lovell and Schmidt also considered the exponential distribution of u_i also.

To measure the technical efficiency and technical change we employ a stochastic frontier production function of the type developed by Battese and Coelli (1995). This model enables us to measure the time varying, firm specific technical efficiency[3]. "The time varying stochastic frontier approach offers better methodology which is also consistent with production theory to examine the influence of the economic reforms over time on production behaviour" (Kalirajan and Shand, 1994:153). In this model a production frontier is specified, which defines output as function of a given set of inputs, together with technical inefficiency effects, which defines the degree to which firms fail to reach the frontier because of technical inefficiencies of production. Further in this model technical inefficiency effects are modelled in terms of other observable firm specific explanatory variables and all parameters are estimated simultaneously [4]. We assume that frontier technology of the firm is represented by a translog production function. This functional form is chosen because it is flexible and imposes fewer restrictions on the data. A translog stochastic frontier production function with three inputs and the time trend can be written as follows.

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_t t_{it} + \tfrac{1}{2}\beta_{kk} k_{it} k_{it} + \tfrac{1}{2}\beta_{ll} l_{it} l_{it} + \tfrac{1}{2}\beta_{mm} m_{it} m_{it} + \tfrac{1}{2}\beta_{tt} t_{it} t_{it} + \beta_{kl} k_{it} l_{it} + \beta_{km} k_{it} m_{it} + \beta_{kt} k_{it} t_{it} + \beta_{lm} l_{it} m_{it} + \beta_{lt} l_{it} t_{it} + \beta_{mt} m_{it} t_{it} + v_{it} - u_{it} \qquad (7)$$

Where subscripts i and t indicate the observation for i^{th} firm in the t^{th} year

y is the natural logarithm of value of output[5]

k is the natural logarithm of gross capital stock at replacement cost

l is the natural logarithm of labour hours

m is the natural logarithm of material input

t is the time trend; time trend is included in the equation to allow the frontier to shift over time, which is interpreted as technical change.

the v_{it} s are assumed to be independent and identically distributed normal random variables with

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[3] For details about the model see Battese and Coelli (1995)

[4] Regressing the estimated technical efficiency on firm specific factors is considered as useful exercise to identify the factors, which affect the efficiency. But this two stage estimation is inconsistent in it's assumptions regarding the independence of the inefficiency effects in the two estimation stages. (Coelli, 1996:6). Secondly, since the efficiency scores are bounded variables, either by zero and one or below one, it is not suitable to use the OLS to estimate the function, because of the non-normality and bounded range of the error term. (Lovell, 1993: 53). "So it is argued that a single stage estimation is considered to be more superior than a two stage estimation".(Coelli, 1996a:24)

[5] The variables, output, capital stock and raw materials are measured in 1981-82 prices. The details about the construction of variables used in the production function are given in the Appendix-4.

mean zero and variance, σ_v^2 ; and

the u_{it} s are non-negative random variables, which are assumed to be independently distributed, such that u_{it} is the truncation (at zero) of the normal distribution[6] with mean, μ_{it} , and variance σ_u^2.

Where u_{it} is defined as follows

$$u_{it} = f(z_{it},\delta) \quad (8)$$

Where δ is vector of parameters to be estimated and **z** is a vector of variables affecting technical inefficiency The **z** vector includes variables representing the (1) R&D activity of the firm (2) technology import of the firm (3) an interaction variable of R&D and technology import, (4) age of the firm (5) export intensity (6) raw material import intensity (7) a time dummy. The construction of these variables and their possible relationship with the inefficiency are explained below.

(1). Research and Development (R&D)

A firm doing R&D has the advantage that it can easily learn and absorb as well as develop new technology and thereby move towards the frontier technology. In a developing country like India most of the R&D activities are believed to be adaptive or absorption type (Katrak, 1985; Lall, 1983)[7]. Hence it is assumed that firms having in house R&D can easily learn, absorb and adapt the new technology and move towards the higher production frontier. But the relationship between R&D and technical efficiency is not so direct. For example the effect of innovation-product or process- can shift upward the industry's best practise production frontier and increase the measured inefficiency of the business units that have not yet adopted it[8].

[6] Although we are now assuming more generalised truncated normal distribution; in the empirical measurement we test for the half normal distribution also

[7] Developing countries rarely have the experienience, financial resources and human capacities need to develop new industrial technologies. In these countries learning by doing rather than producing knowledge is often more relevant than basic research. Thus R&D activities are likely to take a very different forms in developing countries than in the industrial countries, focusing on reverse engineering and imitative research and development (Pack and Westphal,1986; Levin, Cohen and Mowery,1989)

[8] Caves and Barton (1990) found that industry's research and development expenditure increases the one-sided residuals and inflates the apparent inefficiency. In a half normal; distribution model Torii (1990) derived that in an industry the standard deviation of the technical inefficiency is proportional to the speed of technological progress and inversely proportional to the relative speed of embodiment of the new technology.

Thus a very high rates of innovation or innovations- products or process – that is insulated from imitation can cause inefficiency[9]. However, this link between R&D and efficiency assumes that R&D operates to expand the frontier. If the R&D expenditure enable the firms to move up and catch up with the shifting frontier production technology, then R&D has a negative sign in the inefficiency equation. In a developing country like India most R&D is absorptive or adaptive type so it is quite plausible to expect that R&D has a negative sign in the equation.

Our data on R&D expenditure are flow data and includes both current and capital expenditure. It is quite possible that, a firm started its R&D before the initial year of the data and thus has an accumulated stock of knowledge from the past investments in R&D. It is this stock of knowledge, generated through the continuous investment in R&D has influence on the productivity of the firm. So a binary variable is used to represent the stock of the knowledge accumulated through the continuous investment in R&D. Although this approach has the advantage of relieving us from the difficult task of estimating the knowledge stock generated through R&D, it suffers from the fact that equal weight is attributed to all the firms with varying R&D effort.

(2) Technology Import (IMTECH)

Technology import–both embodied and disembodied–enables the firms to move towards the frontier technology. In this study the variable technology import incorporates both the import of embodied technology through the import of capital goods and disembodied technology through the payment of royalty and/or lumpsm payment[10]. Like R&D, the effect of technology import on technical efficiency of the firms can be either positive or negative. "If the imported

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[9] If the R&D is innovative type it is quit possible that technical inefficiency is positively related to R&D. In this case in the words of Caves (1992) "Innovation can alleviate or offset inefficiency; or it can lift the frontier and make the non innovators appear less efficient"(p-10). Further "The negative association for R&D expenditure in United States suggests that innovative activity as a disturbance. While the positive association for R&D in Japan suggests that absorption of the current technology enhances the level of efficiency" (Torii,1992: 406)

[10] It may be useful to make a distinction between (i) capital goods imports embody advanced technology, and (ii) imports of technology against royalty, technical fees and lumpsum payments, treating them two separate variables. Although these are two major sources of flow of advanced technology in to the firms, the determinants of these variables may not be the same, and their effects on firm performance may differ. This distinction has not been made in this study. Agarwal and Goldar (1999) also constructed the technology import variable by combining the import of embodied and disembodied technology together to analyse the effect of technology import on technical efficiency.

technologies are distributed unequally among the firms according license contracts they can be a source of technical inefficiency". (Caves and Barton, 1990:87). When the access to the imported technology has the effect of mitigating the heterogeneity across firms in an industry, one could expect a negative effect of technology import on the technical inefficiency. On the other hand, if technology import leads to a situation wherein the firm heterogeneity in terms of productivity is widened, one could expect a positive effect of technology import on technical inefficiency. In this study technology import, similar to R&D, is represented by a binary variable. The rationale for treating technology import as a binary variable is that our observations are flow measures of these activities. It is quite possible that firms through its access to the foreign technology have an accumulated stock of knowledge. In the absence of stock measures for this knowledge, we use binary variable to proxy the stock of knowledge accumulated through access to foreign technology.

(3) Interaction of R&D and Import of Technology (IMTECH*R&D)

An interaction variable of R&D and technology import is included in the inefficiency equation. Here our hypothesis is that regardless of the sources of technology, local adaptation efforts are required to achieve higher productivity[11]. Theses efforts are generally manifested in terms of doing in-house R&D by the firms. Hence, it is expected that firms having imported technology along with in-house R&D are likely to record higher productivity levels. The sign of this variable in the inefficiency equation as explained in the case of R&D and import of technology, could be either positive or negative. If the presence of firms having both in-house R&D and technology import increases the productivity disparity among the firms, it will have a positive sign in the inefficiency equation. On the other hand, the presence of such firms in the industry lead to the absorption, adaptation and diffusion of the imported technology, the interaction variable will have a negative sign in the inefficiency equation.

[11] Yan Aw and Batra, (1998), used binary variables for R&D and technology import as well as an interaction variable of these two in a frontier production function framework to test whether firm level efforts to obtain international knowledge may have higher payoffs when accompanied by complementary investments in the development of in-house technological capabilities.

(4) Age of the firm (Age)

Age of the firm is proxy for the experience of the firm. The age of the firm is calculated from the year of incorporation[12]. Logarithm of the age is used because it is assumed that an additional year of experience (learning) of firm is expected to have greater influence on new firms than on older ones. If the age of the firm reflects the accumulated experience of the firm it must have a negative sign in the inefficiency equation. But in some cases age of the firm reflects the age of its capital stock. An older capital stock is technologically inferior to a lesser old capital stock. Hence if the age of the firm reflects the age of the capital stock, then this variable must have a positive effect on technical inefficiency.

(5) Export Intensity (EX-INS)

As we explained in our theoretical chapter, export activity is a source to acquire external technical knowledge and help the firm move toward the higher production frontier. Further, the export activity is also a conduit for conveying the competitive pressure in the foreign market on domestic firms. This compels the firms to move towards the higher production frontier. But the relationship between the measured technical efficiency and export activity of the firms in an industry is not so clear. "Not all firms in an industry participate in export activity. Thus the firms uneven participation in the export activity implies diverse consequences of the export activity on plants productivity levels" (Caves and Barton, 1990)[13]. To the extent that the individual plants participate in global market, each will be exposed to many possible market disturbances, including demand changes, changes in government policies, technological changes and exchange rate fluctuations. Such external disturbances will affect the firms unequally according to their diverse pattern of participation in export market. If the export activity has this kind of influence, then this variable will have a positive effect on technical inefficiency. On the other hand, the technological knowledge accumulated through the export activity and competitive pressures are getting diffused among all firms and lead to an increase in their technical efficiency, the export activity of the domestic firms must

[12] It is possible that in the case of some firms age of the firm may not coincide with the year of incorporation.
[13] Caves and Barton (1990), found that in USA exporting activity affected disproportionately the efficiency of the large and small plants, that it has greater negative impact on the efficiency of the larger plants.

have a negative effect on technical inefficiency. In this study the export activity is measured by the export intensity of the firm i.e. the ratio of the value of the export of the firm to its value of total sale.

(6) Import of Raw materials (IMRW-INS)

As we mentioned in the first chapter, access to better and cheaper rawmaterials is an important source of productivity growth through trade liberalisation. The access to better raw materials also serves as conduit for the transfer of technological progress occurred in other industries in abroad. In our data set all firms are not involved in raw material import Further unlike the R&D, technology import or export activity the possibility of diffusing the productivity gain obtained through firm's access to the better raw materials is less. So a few firms' access to the better-imported rawmaterials can increase the heterogeneity in the productivity levels of domestic firms. So in this case, import of raw materials can have a positive influence on technical inefficiency. On the other hand, if rawmaterials import activity enables the domestic firms to reduce the productivity disparity; it will have a negative sign in the inefficiency equation. In this study raw material import intensity is measured by the ratio of raw material imported to total raw materials used in the production.

(7) Time dummy (TD)

A time dummy is included in the inefficiency equation to capture the effect of policy changes on technical inefficiency. This time dummy takes value zero up to 1991-92 and thereafter one. This time variable is supposed to capture the effect of changes in the enviournment brought in by the policy reforms on technical inefficiency.

The final estimation equations are given as follows

$$y_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \beta_m m_{it} + \beta_t t_{it} + \tfrac{1}{2}\beta_{kk} k_{it} k_{it} + \tfrac{1}{2}\beta_{ll} l_{it} l_{it} + \tfrac{1}{2}\beta_{mm} m_{it} m_{it} + \tfrac{1}{2}\beta_{tt} t_{it} t_{it} + \beta_{kl} k_{it} l_{it} + \beta_{km} k_{it} m_{it} + \beta_{kt} k_{it} t_{it} + \beta_{lm} l_{it} m_{it} + \beta_{lt} l_{it} t_{it} + \beta_{mt} m_{it} t_{it} + v_{it} - u_{it} \quad (9)$$

$$u_{it} = \delta_0 + \delta_1 AGE_{it} + \delta_2 TD_{it} + \delta_3 IMRW\text{-}INS_{it} + \delta_4 EX\text{-}INS_{it} + \delta_5 R\&D_{it} + \delta_6 IMTECH_{it} + \delta_7 R\&D*IMTECH_{it} \quad (10)$$

Section II

3.2 The Data

The study is based on a panel of firms from Indian corporate sector and covers the period 1988-89 to 1997-98. The firm level data are obtained from Centre for Monitoring Indian Economy's (CMIE) computer database PROWESS[14]. The panel is unbalanced. After editing the data by using different rules, 4028 observations on 519 firms were obtained. The data editing rules are given in the appendix-3. The number of firms in each industry are electrical machinery 129, electronics 120, Nonelectrical machinery 140, transport equipment 130. The balanced panel for these industries consists of 48, 42, 56 and 53 firms respectively. More detailed description of the data structure is given in the appendix-2. The cross-section and time dimension of the data can be exploited to separate the economies scale from the technical change (Srivastava, 1996:71; Greene, 1996:464). In the unbalanced panel, strict inter temporal comparison of the technical efficiency and technical change is questionable. Further with unbalanced panel data, it is not clear whether the trend variable for a firm entering in period τ, ($1 < \tau < T$), where T is the maximum time period, should start from τ or be re-scaled to start from unity (Kumbhakar et.al 1999). Because of the above two reasons, the balanced panel results are also presented. In this context it should be noted that, technical efficiency scores obtained from the balanced and unbalanced panel are not comparable; because the two measures may be based on different best practice production frontiers. Because of this, the efficiency score of the same observation can be different in the balanced and unbalanced panel. For this reason as well as due to the differences in the data structure, with respect to the distribution of the variables included in the inefficiency equation in the balanced and unbalanced panel, we cannot expect the same result for the inefficiency equation in the balanced and unbalanced panel.

The details on the construction of variables used in the production are given in the Appendix 4.

[14] This data base is based on the financial statements of the companies. For more details about the merits and drawbacks of this data base see Shanta and Raja Kumar(1999)

Section III

3.3 Preliminary Estimates of Partial Productivity

Single factor productivity measures are calculated to get a preliminary picture about the trends in productivity in the four industry groups. In this the average labour and capital productivity for the entire period as well as for the two sub-periods (1) 1988-89 to 1991-92 and (2) 1992-93 to 1997-98 are calculated both from unbalanced and balanced panel. Two measures of labour productivity are estimated. (1) In the first measure of labour productivity, $(Q/L)_{co}$, output is measured in 1981-82 prices and wage bill in 1981-82 wage rates[15]. (2) In the second measure of labour productivity, $(Q/L)_{cu}$, output is measured in current prices and wage bill is expressed in current wage rates. One measure of capital productivity is computed $(Q/K)_{co}$ In this measure output and gross fixed asset are measured in 1981-82 prices.

The results on preliminary estimates of productivity obtained from the unbalanced are given in the tables 3.1 to 3.4. The corresponding results for the balanced panels are given in the Appendix 1. The tables give the capital labour ratio (K/L) also. The results show that in all industries, the average of the first measure of labour productivity during the second period is higher than that for the first period, indicating an improvement in labour productivity during the post reform period. The second measure of labour productivity shows a decline during the second period in all except in the unbalanced panel of the electrical machinery. This indicates that the wage rate increased at faster rate than the price of the output. The average capital productivity, in all industries is less during the second period compared to that in the first period. Both balanced and unbalanced panel data results confirm it. Generally, there is an inverse relationship between capital intensity and output to capital ratio. The decline in the capital productivity in the second period can be the result of increase in the capital intensity during the same period. The preliminary estimates of productivity thus show an increase in the labour productivity during the post reform period in all four-industry groups. This suggests that total factor productivity growth should be somewhat higher during the post reform period. Only in a leontief production technology, partial productivity measures are

[15] The wage bill is deflated by an index for wage rate constructed from ASI's corresponding industrial classification with base 1981-82 = 100.

equal to the total factor productivity measure. So in a production technology other than leontief, to know the total factor productivity we need to estimate the appropriate production technology, by using the econometric methods.

Table 3.1 Electrical Machinery

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	31.77	16.85	2.467	20.42
1988-89 to 1991-92	24.43	15.06	2.88	14.85
1992-93 to 1997-98	34.4	17.49	2.33	22.41
Change	9.97	2.431	-0.553	7.55

Table 3.2 Electronics

	$(Q/L)_{CO}$	$(Q/L)_{CU}$	$(Q/K)_{CO}$	K/L
Whole Period	40.329	16.044	3.454	18.184
1988-89 to 1991-92	35.829	18.180	3.563	14.310
1992-93 to 1997-98	41.743	15.373	3.419	19.403
Change	5.915	-2.807	-0.144	5.092

Table 3.3 Nonelectrical Machinery

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	16.452	9.9428	1.7533	14.039
1988-89 to 1991-92	14.896	10.024	1.9843	10.42
1992-93 to 1997-98	17.081	9.91	1.6598	15.51
Change	2.185	-0.11	-0.325	5.09

Table 3.4 Transport Equipment

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	22.1	12.664	1.73	16.401
1988-89 to 1991-92	19.34	13.1	1.78	13.74
1992-93 to 1997-98	23.23	12.5	1.7	17.51
Change	3.89	-0.58	-0.084	3.77

3.4 Technical efficiency and Technical Change - Production Function Estimates

Following paragraphs provide estimation results of the frontier production function and the associated inefficiency equation and a discussion of the results. The frontier production function defined by (9) and the inefficacy model defined by (10) are estimated simultaneously[16]. For estimating these equations maximum likelihood method is used. In the calculation of variance parameters the parameterisation of the Battese and Corra (1977) is used, in this σ^2_v and σ^2_u is replaced with $\sigma^2 = \sigma^2_v+\sigma^2_u$, $\gamma = \sigma^2_u/(\sigma^2_v+\sigma^2_u)$ The maximum likelihood estimates of these equations are obtained by using Davidon-Fletcher-Powell Quasi Newton (DFP) iterative method[17]. In this a three-step procedure is used. They are

1. Ordinary Least Squares (OLS) estimates of the function are obtained. All the β estimates with the exception of the intercept will be unbiased.
2. A two–phase grid search of γ is conducted, with the β parameters (excepting β_0) set to the OLS values and the β_0 and σ^2 parameters adjusted according to the corrected ordinary least squares formula presented in Coelli (1995). Any other parameters (μ or δ's) are set to zero in this grid search.
3. The values selected in the grid search are used as starting values in an iterative maximisation procedure using DFP to obtain the final maximum likelihood estimates.

Before estimating the final model various tests of hypotheses are made in the frontier function and in the inefficiency model using generalised likelihood ratio statistic as defined below

$$\lambda = -2\left[\ell(H_0) - \ell(H_1)\right]$$

Where $l(H_0)$ is the log likelihood value of the restricted frontier model as specified by the null hypothesis H_0 and $l(H_1)$ is the log likelihood value of the general frontier model under alternative hypothesis H_1. This test statistic has approximately a chi-square (or a mixed chi-square) distribution with degrees of freedom equal to the difference between the parameters in the null and alternative hypotheses.

The likelihood ratio tests of various hypotheses are conducted by taking equations (9) and (10) as the starting models. The table 3.5 and table 3.6 explain these tests of hypotheses for the production and inefficiency model respectively of the unbalanced panel, and that for the balanced panel are given in the appendix-1, table A1.5 and table A1.6 respectively.

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[16] For estimating this I used Frontier 4.1programme designed by Time Coeli. For more details as well as for merits of this programme compared to other programmes see Drinkwater and Harris (1999).

[17] In the words of Greene (1993) "DFP algorithm is extremely effective and is the most widely used gradient methods". The DFP method is very useful and widely used because it eliminates the use of the second derivative altogether and has excellent convergence properties. Further the DFP was recommended by the Pitt and Lee (1981) for the stochastic frontier production function estimates.

Table 3.5 Tests of Hypotheses: Production function (Unbalanced Panel)

	Electrical Machinery ($\chi 2$)	Electronics ($\chi 2$)	Nonelectrical ($\chi 2$)	Transport Equipment ($\chi 2$)	Critical Value * ($\chi 2$)
Model LLF	564.52	158.77	628.84	749.96	
CobbDougals Functional form	97.04	340.66	66.4	286.42	18.31
No technical Change($\beta_t = 0.5\beta_{tt} = \beta_{ti} = 0$)	22.8	265.1	26.4	315.54	11.67
Half Normal Distribution ($\mu = 0$)	45.24	0.2	0.1	10.68	3.84

* All critical values are at 5 per cent level of significance.

The hypotheses testing results in the unbalanced panel show that translog functional form is the suitable functional form for all industries. The assumption of no technical change is rejected in all industries. The balanced panels also give the same result. Regarding the distributional form of the inefficiency, electrical and transport equipment results show that inefficiency is distributed as truncated normal distribution. In electronics and non-electrical machinery the null hypotheses that inefficiency is distributed half normally is accepted, given the translog specification of the production function. The distributional form of the inefficiency in the unbalanced panel is accepted in the corresponding balanced panel also, so no separate testing is made on the distributional form of inefficiency in the balanced panel

In testing of the inefficiency model, the null hypothesis of no inefficiency is rejected in all industries, both in the unbalanced and balanced panel. (Note that, the test statistic in this case follows a mixed chi-square distribution, so critical values for the generalised likelihood ratio test are obtained from Table-1 in Kodde and Palm (1986))[18]. If this null hypothesis is true, then production function is equivalent to the traditional average response function, which can be efficiently estimated using ordinary least-squares regression.

In the unbalanced panel, the significance of the variables in the inefficiency model are tested by taking three variables together and the significance of age variable is tested by taking it alone. The LR test of the age variable in the unbalanced panels of the nonelectrical machinery and transport equipment rejected the null hypotheses that its coefficient is equal to zero. But age variable is not statistically significant at 5 per cent level in the unbalanced panels of electrical machinery and electronics. The unbalanced panel result shows that raw material

[18] "Any likelihood ratio test statistic involving a null hypothesis which includes the restriction that γ is zero does not have a chi-square distribution because the restriction defines a point on the boundary of the parameter space. In this case likelihood ratio statistic has been shown to have a mixed chi-square distribution".(Coelli, 1996: 6)

import intensity; export intensity and time dummy, as a group are significant at 5 per cent level in all industries except in electronics. The variables R&D, import of technology and the interaction variable, as a group are statistically significant at 5 per cent level in the unbalanced panel of all industries.

In the balanced panel also, the null hypothesis of no technical inefficiency is rejected in all industries at 5 per cent level of significance. Further, the likelihood ratio test in the balanced panel shows that variables time dummy, raw material import intensity, export intensity, R&D, technology import and the interaction variable as a group are statistically significant at 5 per cent level in the inefficiency equation of all industries[19].

Table 3.6 Testing of Hypothesis-Inefficiency Model (Unbalanced Panel)

	Electrical Machinery ($\chi2$)	Electronics ($\chi2$)	Nonelectrical Mach: ($\chi2$)	Transport Equipment ($\chi2$)	Critical Value* ($\chi2$)
No technical inefficiency ($\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$)	299.70	64.03	67.90	429.57	14.85
$\delta_{AGE} = 0$	0.21	0.20	11.24	26	3.84
$\delta_{IMRW\text{-}INS} = \delta_{EX\text{-}INS} = \delta_{TIME\text{-}DUMMY} = 0$	26.80	0.65	8.46	20	6.25
$\delta_{R\&D} = \delta_{IMTECH} = \delta_{IMTECH*R\&D} = 0$	39.86	30.48	44.20	113.44	6.25
Model LLF	564.40	158.80	628.80	749.96	

* Critical Values are at 5% level of significance.

The coefficients of the production function and the associated inefficiency equation estimated from the unbalanced panel are given in the table. 3.7 The corresponding estimates obtained from the balanced panel are given in the Appendix-1, table A 1.7.

[19] In the testing of the inefficiency model in the balanced panel, these six variables in the inefficiency equation are taken as group. This is because we are interested in these variables and the statistical significance of these variables is already tested in the unbalanced panel. So the objective in the balanced panel is simply to check the statistical significance of these variables as group.

Table 3.7 Maximum Likelihood Estimates of the Production Function (Unbalanced Panel)
(t values are given in the parentheses)

	Electrical Machinery	Electronics	Nonelectrical Machinery	Transport Equipment
Production function				
Constant	2.7357* (4.59)	4.5852* (6.39)	0.6438 (1.11)	2.7946* (5.83)
β_k	-0.0015 (-0.02)	0.1018 (0.69)	0.2086* (2.29)	-0.0433 (-0.44)
β_l	0.5395* (7.50)	0.7567* (6.69)	0.3533* (3.34)	0.5329* (6.91)
β_m	0.4095* (4.09)	0.0017 (0.02)	0.5775* (6.58)	0.4444* (6.33)
β_t	-0.0406* (-1.65)	-0.0723* (1.77)	-0.0346 (-1.39)	0.0033 (0.18)
$0.5\beta_{kk}$	0.0319* (2.67)	0.0299 (1.45)	0.0257* (1.56)	0.1303* (9.44)
$0.5\beta_{ll}$	0.0327* (3.14)	0.1295* (6.45)	0.0554* (3.11)	0.0988* (7.59)
$0.5\beta_{mm}$	0.1084* (7.06)	0.1971* (16.22)	0.0871* (6.49)	0.1500* (15.04)
$0.5\beta_{tt}$	0.0033* (2.33)	0.0025 (1.01)	0.0026* (1.94)	0.0055* (4.69)
β_{kl}	0.0157* (1.85)	0.0175 (1.18)	0.0013 (0.09)	-0.0410* (-3.85)
β_{km}	-0.0384* (-3.79)	-0.0462* (-3.48)	-0.0336* (-2.75)	-0.0891* (-9.96)
β_{kt}	-0.0033 (-1.35)	-0.0001 (0.03)	-0.003 (-1.14)	-0.0037 (-1.49)
β_{lm}	-0.0648* (-6.64)	-0.1471* (-13.35)	-0.0564* (-4.34)	-0.0586* (-6.78)
β_{lt}	0.0060* (2.91)	-0.0076* (-2.09)	-0.0003 (-0.11)	0.0045* (2.25)
β_{mt}	-0.0001 (-0.019)	0.0112* (3.18)	0.0048* (1.92)	-0.0003 (-0.16)
Inefficiency model				
Constant	-2.9733* (-10.72)	**	**	0.38* (4.88)
Age	0.0418 (0.54)	0.0723* (4.95)	0.0364* (5.50)	-0.4743* (19.912)
Time Dummy	0.7904* (3.51)	-0.0027 (-0.06)	0.027 (1.16)	0.5096* (12.14)
IMRW-INS	1.2789* (1.87)	-0.0946 (-0.81)	-0.090 (-1.29)	-0.9349* (-13.55)
EX-INS	0.9641 (1.10)	0.1994* (1.94)	-0.2586* (-2.27)	-0.0794* (-26.36)
R&D	-0.864* (-6.77)	-0.0415 (-0.89)	-0.0211 (-0.89)	0.0837* (1.59)
IMTECH	-1.8782* (-10.01)	-0.1588* (-3.33)	-0.0992* (-5.77)	-1.0364* (-13.25)

Table Continued ....

IMTECH*R&D	0.8304* (6.86)	-0.0486 (-0.52)	-0.0992 (-0.81)	-0.754* (-9.91)
Sigma $(\sigma^2_v+\sigma^2_u)$	0.3480* (7.78)	0.0447* (16.07)	0.0204* (21.31)	0.1667* (13.46)
Gamma $\gamma= (\sigma^2/\sigma^2_v+\sigma^2_u)$	0.9724* (215.14)	0.178* (4.33)	0.1613* (2.56)	0.9636* (268.98)
LLF	564.52	158.77	628.84	749.96
Number of Observations	984	882	1106	1056

* Significant at least ten per cent level.

** Constant of the inefficiency model is the mean of the truncated normal distribution. Half normal distribution implies that the mean of the inefficiency distribution is zero. As revealed from the hypothesis testing results, half normal distribution for inefficiency is accepted in electronics and non-electrical machinery.

In the following paragraphs we discuss results obtained from the estimation of production function and the associated inefficiency equation.

3.4.1 Elasticity of Output

Due to the squared and interaction terms on the right-hand side of the translog stochastic frontier production function, the elasticity of output with respect to inputs are functions of the levels of inputs. The general expression for the input elasticity of the output (ε_k) with respect to k^{th} input (k = k, l, m, t) for i^{th} firm in the t^{th} year is given below.

$$\frac{\partial y_{it}}{\partial x_{kit}} = \beta_k + \beta_{kk} x_{kit} + \sum_{j\neq k}^{3} \beta_{kj} x_{jit}$$

Technical change is defined as the partial derivative of y_{it} with respect to the time variable. Returns to scale (RTS) is defined as the sum of the mean output elasticity with respect to all inputs. The elasticities are estimated for all the observations and average elasticity is reported.

The input elasticity of output estimated form the unbalanced and balanced panels are given in the table 3.8 and table 3.9 respectively.

Table 3.8 Elasticity Estimates (Unbalanced Panel)

	Electrical Machinery	Electronics	Non Electrical Machinery	Transport Equipment.
Capital	0.0786	0.0608	0.0773	0.1395
Labour	0.1374	0.2075	0.1646	0.1480
Raw materials	0.7801	0.7026	0.7384	0.6840
Returns to Scale	0.9961	0.9708	0.9803	0.9715

Table 3.9 Elasticity Estimates (Balanced Panel)

	Electrical Machinery	Electronics	Non Electrical Machinery	Transport Equipment.
Capital	0.0523	0.0349	0.0711	0.1237
Labour	0.1285	0.2443	0.2126	0.1655
Raw materials	0.8217	0.7033	0.7284	0.7049
Returns to Scale	1.002	0.9826	1.0122	0.9942

The elasticity measures obtained are as expected. The elasticity of the output with respect to materials is high and that of capital is low. The low value of elasticity of output with respect to capital seems to be reasonable in Indian context (Ahluwalia, 1991; Srivastava, 1996:83). The difference between the elasticity measures obtained from the balanced and unbalanced panel is not much different. The estimates of returns to scale shows that it is close to unity, indicating that the firms are operating at constant returns to scale.

3.4.2 Technical Change

As we mentioned above, elasticity of output with respect to time variable (ε_t) is defined as technical change. The estimates of average technical change are reported for the whole period as well as for the pre and post reform periods. The table 3.10 and table 3.11 give the estimates of technical change obtained from the unbalanced and balanced panel respectively.

Table 3.10 Estimates of Technical Change (Unbalanced Panel)

	Electrical Machinery	Electronics	Non Electrical Machinery	Transport Equipment.
ε_t (Entire period)	0.002824	0.035744	0.00821	0.027668
ε_{t1} (1988-89 to 1991-92)	-0.007011	0.028305	0.00008	0.009573
ε_{t2} (1992-93 to 1997-98)	0.006319	0.038083	0.011549	0.035222
Change	0.01333 (24.89)	0.009778 (10.79)	0.011469 (34.89)	0.02565 (50.55)

Note: t values of the change are given in the parentheses.

Table 3.11 Estimates of Technical Change (Balanced Panel)

	Electrical Machinery	Electronics	Non ElectricalMachinery	Transport Equipment.
ε_t (Entire period)	0.005498	0.029665	0.004102	0.02113
ε_{t1} (1988-89 to 1991-92)	-0.000076	0.013387	-0.00913	0.004975
ε_{t2} (1992-93 to 1997-98)	0.009230	0.040000	0.012885	0.031902
Change	0.009303 (13.84)	0.026614 (12.63)	0.02216 (34.38)	0.02693 (30.49)

Note: t values of the change are given in the parentheses

The unbalanced panel estimates of average technical change in the electrical machinery show that, it is 0.282 per cent per annum for the entire period and –0.7 per cent and 0.548 per cent for the first and second period respectively. Both the balanced and unbalanced panel results show that technical change is negative during the first period. This result is quite possible in the context of a lower, especially negative in 1991-92, output growth rate, which this industry experienced during the first period. A decline in output in the face of a fixed capital input resulted in under utilisation of the capacity[20]. This decline in output could be due to the disturbances in the economy, like import compression, domestic demand shrinkage etc. experienced by the economy during that period. In the electrical machinery, both balanced and unbalanced panel results show a statistically significant improvement in technical change during the post reform period.

The estimates of average technical change in the unbalanced panel of electronics show that it is higher during the second period than that in the first period, and this improvement is statistically significant. The corresponding balanced panel estimates also give the same result.

In non electrical machinery, unbalanced panel estimate of average technical change is near to zero in the first period. The corresponding estimate in the balanced panel is negative. Like electrical machinery, the growth rate of output of this industry was lower during the first period and experienced a decline in output of 3.57 per cent in 1991-92. This can be the reason behind the technological stagnation in this industry during the first period. The estimates of

[20] A decline in capacity utilisation means that firms are using the same level of input for producing lower level of output. The data on capacity utilisation in this industry show that it is lower in 1990-91 and 1991-92 compared to other years. (see Azeez, 1999). Further, labour input is also considered as quasi fixed. See Appendix 5 for the growth rate of the capital goods industries.

average technical change in the second period shows a statistically significant improvement in it over that in the first period. Both balanced and unbalanced panel results confirm it.

The estimates of average technical change in the transport equipment industry shows that, this industry experienced positive technical change of 2.8 percent (unbalanced panel estimate) per annum through the entire period. The rate of technical change in the second period is higher than that for the first period In respect of improvement in the technical change in the second period balanced and unbalanced panel gives the same result. The unbalanced panel estimate of average technical change is 3.5 per cent per annum in the second period, making a difference of 2.567 points over that in the first period.

3.4.3 Technical Efficiency:

Technical efficiency of the i^{th} firm in the t^{th} year is defined by

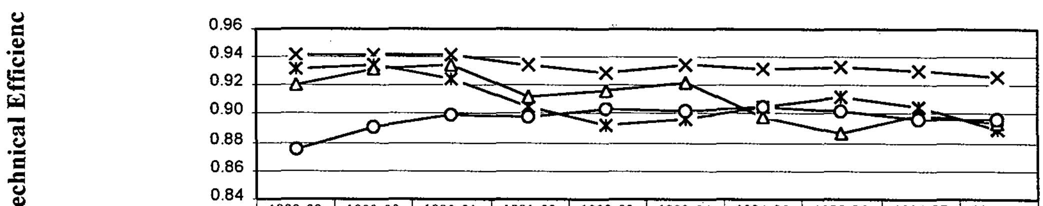
$$TE_{it} = \exp(-u_{it})$$

This is the ratio of the observed output to the stochastic frontier output, which has no technical inefficiency. So technical efficiency equals one only if a firm has inefficiency equals to zero other wise it is less than one[21]. Although, technical efficiency scores for each firm in each year is estimated, mean technical efficiency scores for each year is reported. The mean technical efficiency scores for balanced and unbalanced panel data are reported separately. The estimates show that in all industries the mean technical efficiency is high and it is more than 85 per cent.

The mean technical efficiency score estimated from the unbalanced panel of electrical machinery, non-electrical machinery and transport equipment show that it is lower during the second period compared to that in the first period (see figure 3.2).

[21] The frontier production function, which is used as a benchmark in the measurement of the technical efficiency, is the best practice frontier function. (Forsund et.al, 1980:20; Torii, 1992:32).

Figure 3.2 Trends in Mean Technical Efficiency (Unbalanced Panel)

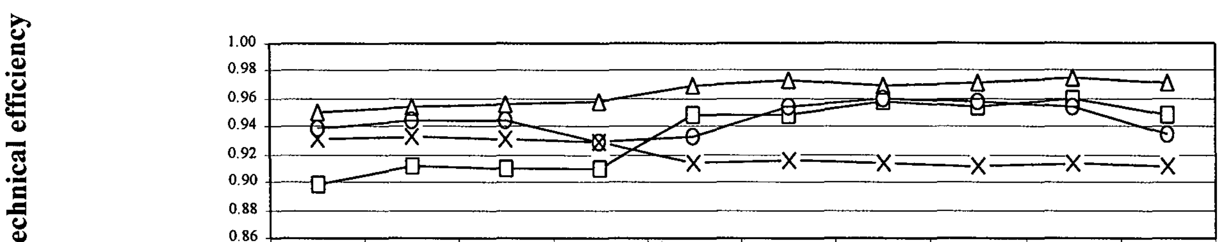


	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98
—x— Electrical Machinery	0.9423	0.9419	0.9419	0.9349	0.9283	0.9346	0.9312	0.9331	0.93	0.9265
—x— Transport Equipment	0.9319	0.9349	0.9241	0.9055	0.8924	0.8965	0.9049	0.9125	0.9052	0.8897
—Δ— Electrical Machinery	0.9211	0.9321	0.9345	0.9115	0.9158	0.9224	0.8982	0.8872	0.8996	0.8938
—o— Electronics	0.8754	0.8905	0.8999	0.8981	0.903	0.9019	0.9047	0.9028	0.8965	0.8964

Year

The positive sign of the time dummy variable in the inefficiency equation (unbalanced panel) also confirms a drop in the technical efficiency during the second period in these industries. The balanced panel estimate of mean technical efficiency scores in the electrical machinery also gives a similar trend as in the unbalanced panel (see figure 3.2).

Figure 3.3 Trends in Mean Technical Efficiency (Balanced Panel)



	1988-89	1989-90	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98
—x— Electrical Machinery	0.9313	0.9322	0.9301	0.9296	0.9135	0.9154	0.9136	0.9123	0.9136	0.9112
—□— Electronics	0.8989	0.911	0.9091	0.909	0.9476	0.9483	0.9574	0.9541	0.9592	0.9486
—Δ— Non electrical Machinery	0.9499	0.9539	0.95513	0.9575	0.9701	0.973	0.9696	0.9705	0.975	0.9705
—θ— Transport Equipment	0.9385	0.9452	0.9444	0.9283	0.9325	0.9544	0.9604	0.9586	0.9534	0.9357

Year

The mean technical efficiency scores estimated from the balanced panel of the transport equipment shows a fluctuating trend in the second period. But the positive sign of time dummy in the inefficiency equation indicates a drop in the technical efficiency during the second period. In the balanced panel of non electrical machinery mean technical efficiency is higher in the second period compared to that in the first period. This result is different from the corresponding result of the unbalanced panel.

The result obtained from the electronics show that both in the unbalanced and balanced panel mean technical efficiency is high in the second period compared to that in the first period.

The estimation results shows that in electrical machinery, nonelectrical machinery and transport equipment mean technical efficiency declined in the second period. We found that, in these industries, both balanced and unbalanced panel estimates show a positive growth rate of technology in the post reform period. One plausible explanation for the decline in technical efficiency of these industries during the second period can be this technical progress. "High technical progress can coexist with declining technical efficiency- perhaps due to the failure in achieving technological mastery or due to the short run cost minimising behaviour in the face of the quasi-fixed vintage capital" (Nishimizu and Page, 1982:924). When the frontier production function shifts upward because of technical change some firms are unable to catch up with the shifting frontier, resulting in an increase in their measured technical inefficiency[22]. Statistical evidence for this possibility can be obtained from the nonelectrical and transport equipment industries. In these two industries the time dummy variable has a negative sign in the inefficiency equation when we do not allow the frontier to shift upward by assuming no technical change. This time dummy is getting a positive sign when we allow the frontier to shift upward by assuming technical change. It is particularly the small firms, which face so many constraints in moving up the technology frontier[23]. One of the major constraints the small firms face is the financial constraint. This is true in Indian post liberalisation scenario. Analysing the effects of financial sector reforms on the Industrial sector, Khanna (1999) says "small and medium firms began to find it difficult to tap the liberalised financial markets" (p-3236). Further the access to the credit is being now shaped by the evaluation of the credit rating agencies, which adversely affects the small and medium size firms. Moreover small firms may not have the infrastructure, like own R&D to rapidly absorb the new technology and keep up with the shifting frontier. This inability of small firms to catch up with the shifting production frontier can be the reason behind the different results with respect to the movement of mean technical efficiency, in the balanced and unbalanced panel of the

[22] Rapid technical progress makes the older plants obsolete and this obsolescence can also be due to the optimal conduct of the agent. When there is technological progress, the optimal conduct of an agent is to replace equipment at a finite rate, if the embodiment of technology is not costless. The agent would choose the optimal point in the trade off between the cost reduction effects of new technology and the costs of replacement investment. So if the technological progress increases the measured technical inefficiency of a firm, it can also be due to the rational behaviour on the part of the agent. Further the results show that in most cases the decline in mean technical efficiency is only marginal. So we cannot refute the possibility of the decline in technical efficiency due to the rationale behaviour on the part of the firms.

[23] In analysing the determinants of technical efficiency of small and large plants in Japanese industries the result shows that "productivity growth represents a disturbance, and small plants lagging behind frontier technology will exhibit impaired efficiency" (Torii,1992:408)

nonelectrical machinery. The proportion of observations on small firms is more in the unbalanced panel than in the balanced panel. The large number of observations on small firms in the unbalanced panel may have reduced the mean technical efficiency in the second period[24]. (See appendix-2, tableA2.2 for the size distribution of observations).

3.4.4 Determinants of Technical Inefficiency.

In the inefficiency equation we included the variables, age, time dummy, raw material import intensity, export intensity, R&D, technology import and an interaction of technology import and R&D. As we mentioned earlier, we cannot expect the same result for the inefficiency equations estimated from the balanced and unbalanced panel. So in this context a discussion focusing on the results obtained from the unbalanced panel data seems more suitable. So the following discussion is mainly based on the result obtained from the unbalanced data.

In electrical machinery, electronics and non-electrical machinery the age variable has a positive effect on technical inefficiency. Indicating that age variable is reflecting the age of the capital stock rather than the experience of the firm. But in electrical machinery, both the LR test and t ratio show that age is not significant in the unbalanced panel and it is significant in the balanced panel. This difference in the statistical significance can be due to the following reason. In the unbalanced panel, the number of observations on small firms is higher than that in the balanced panel. The data show that small firms are less older than the large firms. In the case of small firms the age variable may reflects the experience or learning than the age of the capital stock, so age may have a negative influence on technical inefficiency. But in the case of large firms, which are more older, the age variable may reflects the age of the capital stock, so in the case of large firms the age variable may have positive influence on technical inefficiency[25]. The presence of large and small firms in the unbalanced panel can result in the mutual cancellation of the opposite forces and thereby the

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[24] . Further it is also found that the correlation between the technical efficiency and firm size is positive. Regressing the technical efficiency on size, measured in terms of raw material consumed, shows that large firms are more efficient.

[25] . An important empirical regularity suggested by various industry level studies is the existence of strong diminishing returns in the "learning by doing" (Young, 1991). Although there is an ongoing discussion on whether gains in technical efficiency from experience are eventually entirely exhausted, most researchers seems to agree that these gains become smaller over time. (Lundvall K. and Battese G.E, 1998:5)

insignificant coefficient of this variable. In the balanced panel the large firms are more, so the negative sign of the coefficient is significant in the balanced panel.

The unbalanced panel result shows that raw material import intensity has a positive significant effect on technical inefficiency in the electrical machinery and it has a negative significant effect on technical inefficiency in transport equipment industries. The positive effect of raw material import intensity on technical inefficiency shows that its effect is unequally distributed among the firms included in the sample and results in more productivity disparity among the firms.

The evidence on the effect of export intensity on technical inefficiency indicates that it has a significant positive effect on technical inefficiency in electronics and a significant negative effect in nonelectrical and transport equipment.

As we found earlier, the LR tests shows that variables R&D, technology import and interaction variable as a group have significant effect on technical inefficiency in all industries. The variable R&D has a negative effect on technical inefficiency in electrical machinery, electronics and non-electrical machinery. But R&D does not have significant t value in electronics and nonelectrical machinery. This may be due to the presence of multicollinearity among the variables of R&D and its interaction with technology import, which inflates the standard error and reduce the t values[26]. The negative association between R&D and inefficiency can be interpreted as consistent with its role of preserving the maximum efficiency. In transport equipment R&D has a significant positive sign indicating that R&D activities results in the upward shift of the production frontier and thereby increase the measured inefficiency of the non-innovators.

In all industries technology import has a negative significant sign. In balanced panel also technology import variable has a negative sign in all industries. This indicates that the firms are using the access to modern technology, both embodied and disembodied, to move towards the potential production frontier. The negative sign can also be the result of the diffusion of

[26] The correlation between the R&D and its interaction with technology import is 0.85, and their VIF are 3.84 and 4.44 respectively in electronics. In nonelectrical machinery the correlation between the R&D and its interaction with technology import is 0.861 and their VIF values are 4.27 and 4.84 respectively.

the imported technology among other firms and thereby enable them also to increase the production efficiency.

The variable, interaction of R&D and technology import, has a significant positive sign in the electrical machinery industry. This result shows that increased productivity, accruing from the imported technology along with its adaptation to the domestic conditions through the in-house R&D is confined only to a few firms in the industry. The presence of such firms in the industry results in the shift of the best practice production frontier and reduce the relative productivity of other firms in the industry. In electronics, non-electrical machinery and transport equipment the interaction variable has a negative sign. But in the electronics and nonelectrical the t value of the coefficient is not significant. This, as we already mentioned earlier, can be due to the presence of multicollinearity among R&D and the interaction variable. The negative sign of the interaction variable indicates that presence of the firms having both in-house R&D and imported technology, although a few in numbers, has the effect of increasing technical efficiency. These firms import technology, and by using the in-house R&D; they adapt the technology to the domestic conditions and ultimately this technology is getting diffused among other firms, so they also become more efficient. Thus, the result shows that in-house R&D enables the firms to use the imported technology in its maximum potential.

3.5 Summing up

In this chapter we analysed the productivity performance of the four capital goods industries: electrical machinery, electronics, non-electrical machinery and transport equipment. Specifically, we measured the technical efficiency and technical change of these four capital goods industries. For measuring the technical efficiency and technical change, we used a translog stochastic frontier production function and an associated inefficiency equation. We used firm level panel data for the period 1988-89 to 1997-98 and estimated these two equations simultaneously. The empirical evidence shows that all industries experienced a significant improvement in technical change during the post reform period compared to the pre reform period.

The empirical evidence on technical efficiency shows that the estimates of mean technical efficiency is lower in the post reform period in all the industries studied except electronics. The observed decline in mean technical efficiency in a general context of positive technical change calls for explanation. Our explanation for the drop in technical efficiency during the second period in these industries is in term of the nature of technical progress, which these industries experienced in the post reform period. It appears that with trade liberalisation a few firms have been successful in bringing about efficiency enhancing innovations while a large number of firms were devoid of any such attempts. The net result has been that, while frontier technology has been moving up, the gap between the leaders in technical progress and laggards has increased during the second period resulting in a reduction in mean technical efficiency.

The results obtained from the associated inefficacy equation highlights the importance of the firm level effort on the front of developing in-house R&D and technology import in exploiting the avenues open through trade liberalisation. It is found that technology import in general has had the effect of reducing the technical inefficiency. Viewed thus, the removal of restrictions on technology import seems to have yielded positive returns. The results also shows that technology import has a higher productivity enhancing effect, when it is supplemented with in-house R&D effort. It indicates that imported technology, which is developed in the context of other economies needs to be supplemented with domestic R&D effort, to reap the full benefits of imported technology. On the whole if trade liberalisation were to achieve its declared objective of attaining efficiency gains, the policy enviournment should be the one, which induces the firms to supplement technology import with significant doses of in-house R&D effort.

Chapter IV

SUMMARY AND CONCLUSIONS

The last two decades witnessed unprecedented changes in the focus of development policy in the developing world. Essentially, the changes implied a shift away from the earlier import substitution regime to globalisation with greater role for market forces. In this bandwagon India has not been left much behind as is evident from the wide ranging reforms initiated in the trade and industrial policy regimes. The move towards liberalisation, which had its beginning in the eighties achieved momentum in the 1990s with the initiation of structural adjustment policies. The underlying objective of the policy reforms, especially the trade and industrial policy reforms has been, to quote from the Industrial policy statement of 1991...to build on the gains already made, correct the distortions or weaknesses that may have crept in, maintain a sustained growth in productivity and gainful employment and attain international competitiveness. Although economic reform is often considered as a process yet to be completed, it may be appropriate to examine the implications of the policy reforms in terms of their declared objectives. The present study has been an attempt in this direction with focus on technical efficiency and productivity improvement. The study derives its importance from the conspicuous absence of conclusive evidence, both theoretical and empirical, on the relationship between the trade liberalisation and improvement in technical efficiency. To quote Pack, "to date there is no clear confirmation of the hypothesis that countries with external orientation benefit from greater growth in technical efficiency in component sectors of manufacturing".

The theoretical literature highlights a number of channels through which trade liberalisation improve the technical efficiency of the manufacturing sector. These include reduction in x-inefficiency, creation of favourable conditions for investment in technological progress, liberal access to technology-both embodied and disembodied, and better exploitation of scale economies. But regarding the productivity growth through the access to better technology, the theoretical literature stress the importance of the firm level R&D, especially in a developing country, to utilise the imported technology in its maximum productivity. Important implication of this argument is that having access to better technology is not enough, but complementary domestic effort is a precondition for utilising the benefit made available by the trade liberalisation.

The study began with an examination of the changes in the trade policy reforms especially in the 1990s. The objective has been two folds; first to discern the macroeconomic implications of trade policy reform and secondly, based on sectoral experience, to identify the sector/industries for detailed analysis. The review of trade policy reforms and its empirical implications shows that nineties witnessed significant reduction in trade barriers, as revealed from the liberalisation of import licensing, reduction in tariff rates, removal of quantitative restrictions and relaxation in the flow of foreign capital and technology. The empirical evidence shows that openness of the Indian economy, measured in terms of the trade intensity of the economy, has increased in the post reform period. The import intensity of the various industrial sectors indicates that the import intensity of the sectors like food products, chemicals, leather and leather products, capital goods (including electrical and non electrical machinery and transport equipment) has increased during the post liberalisation period. The import intensity of chemical and capital goods sector registered a higher increase compared to other sectors. The trends in the export intensity of various industrial sectors show a significant increase in export intensity of the sectors like food products, chemicals and textile products in the post reform period. The export intensity of the capital goods industries although increased in the post reform period, lagged much behind that of other sectors. The industry wise distribution of the FDI inflows shows that the engineering sector received a substantial share of FDI and among the individual industries, computer sector got a significant share of FDI during the post reform period.

On the basis of the review of the trade policy reforms and its effects in terms of changes in the import and export intensity, foreign investment and foreign collaborations during the post reform period, capital goods sector is selected for further analysis of technical change and technical efficiency. For the purpose of analysis, capital goods sector is divided into four sub groups, (1) Electrical machinery, (2) Electronics (3) Non electrical machinery and (4) Transport Equipment.

For measuring technical efficiency and technical change, we used a time varying stochastic frontier production function method, developed in a panel data framework. In this model technical inefficiencies are modelled in terms of firm specific explanatory variables and all parameters are estimated simultaneously. Hence this model avoids the problems of two-stage estimation. In the inefficiency model we have included the variables, R&D of the firm, technology import, an interaction of R&D and technology import, export intensity, raw material import intensity, age of the firm and a time dummy. The creation of variables representing the R&D and technology import and the measurement of capital stock variable used in the production function need further improvement. To measure technical efficiency and technical change the study used firm level panel data for the period 1988-89 to 1997-98. The entire period of study is divided in to two-sub periods, pre and post reform period. The pre reform period is up to 1991-92. The empirical results show a significant improvement in technical change during the post reform period compared to the pre reform period in all industries studied.

The estimate of mean technical efficiency, however, declined in the post reform period in all industries studied except electronics. The observed decline in technical efficiency in a context of positive technical change calls for explanation. The explanation could be in terms of the nature of the technical progress, which these industries experienced during the post reform period. It appears that with trade liberalisation a few firms have been successful in bringing about efficiency enhancing technological progress, a large number of firms lagged behind them. The net result has been that while the frontier technology moving up, the gap between the leaders in technical progress and the laggards has increased during the second period resulting in a reduction in mean technical efficiency. This inability of some firms to catch up with shifting frontier can be either due to the short run profit maximisation behaviour of the firms or because of the constraints like financial, lack of R&D infrastructure, which make them unable to master the new technology at a faster rate.

The results obtained from the associated inefficiency equation highlights the importance of the firm level effort on the front of developing in-house R&D and technology import in exploiting the avenues open through the trade liberalisation. It is found that technology import in general has had the effect of reducing the technical inefficiency. Viewed thus the removal of restrictions on technology import seems to have yielded positive returns. Further, the results also show that technology import has a higher productivity enhancing effect when it is accompanied by in-house R&D effort. This indicates that imported technology, which is developed in the context of other economies, need to be supplemented with domestic R&D effort, to reap the full benefits of imported technology. On the whole if trade liberalisation were to achieve its declared objective of attaining productivity improvement, the policy enviournment should be the one, which induces the firms to supplement technology import with significant doses of in-hose R&D effort.

Appendix 1

Balanced Panel Results

Table A1.1 Electrical Machinery

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	23	12.78	2.59	14
1988-89 to 1991-92	21.81	13.46	2.97	12.11
1992-93 to 1997-98	24.20	12.33	2.34	15.23
Change	2.39	-1.13	-0.63	3.12

Table A1.2 Electronics

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	33.912	14.315	3.374	14.06
1988-89 to 1991-92	32.331	16.443	3.578	13.322
1992-93 to 1997-98	34.929	12.946	3.243	14.535
Change	2.598	-3.497	-0.3351	1.213

Table A1.3 Non Electrical Machinery

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	14.62	9.03	1.71	11.69
1988-89 to 1991-92	13.52	9.11	1.97	9.73
1992-93 to 1997-98	15.35	8.99	1.53	12.99
Change	1.83	-0.1184	-0.44	3.262

Table A1.4 Transport Equipment

	$(Q/L)_{co}$	$(Q/L)_{cu}$	$(Q/K)_{co}$	K/L
Whole Period	23.24	12.78	2.58	13.57
1988-89 to 1991-92	21.81	13.45	2.96	12.92
1992-93 to 1997-98	24.21	12.33	2.33	13.99
Change	2.39	-1.27	-063	1.07

Table A1.5 Hypotheses Testing: Balanced Panel (Production Function)

	Electrical Machinery (χ^2)	Electronics (χ^2)	Non electrical Machinery (χ^2)	Transport Equipment (χ^2)	Critical Value* (χ^2)
Model LLF	433.6	134	416.86	552.8	
CobbDougals Functional form	34.4	267.16	150.56	231.91	18.31
No technical Change ($\beta_t = 0.5\beta_{tt} = \beta_{ti} = 0$)	28	64.06	84.32	39.14	11.07

* Critical values are at 5 per cent level of significance

Table A1.6 Hypotheses testing Balanced Panel (Inefficiency Model)

	Electrical Machinery (χ^2)	Electronics (χ^2)	Nonelectrical Machinery (χ^2)	Transport Equipment (χ^2)	Critical Value (χ^2)*
Model LLF	433.6	134.52	416.86	552.8	
No technical inefficiency ($\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$)	65.32	30.88	16.10	120.43	14.853
$\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$	20	26.04	14.52	14.8	12.592
$\delta_{Age} = 0$	30	0.052	12.128	12.34	3.84

* Critical values are 5 per cent level of significance.

Table A1.7 Maximum Likelihood estimates of the Production function (Balanced Panel)

	Electrical Machinery	Electronics	Nonelectrical Machinery	Transport Equipment
Production function				
Constant	1.8447* (1.87)	2.9413* (2.48)	-2.4522* (-2.35)	1.1703* (1.88)
β_k	-0.2080* (-1.64)	0.021 (0.10)	-0.0705 (-0.49)	0.1677 (1.35)
β_l	0.3154* (2.28)	0.9208* (5.09)	-0.2808 (-1.26)	0.6894* (6.92)
β_m	0.8774* (4.18)	0.1098 (0.64)	1.6769* (8.27)	0.2749* (2.44)
β_t	-0.0767* (-2.73)	-0.0596 (-1.40)	-0.0532* (-1.58)	-0.0375* (-2.10)
$0.5\beta_{kk}$	0.0486* (2.83)	0.0239 (0.87)	0.0678* (3.09)	0.1874* (9.12)
$0.5\beta_{ll}$	0.0206 (1.15)	0.227* (9.29)	0.2424* (8.08)	0.1138* (5.77)
$0.5\beta_{mm}$	0.02* (1.95)	0.1929* (11.76)	0.1479* (5.37)	0.1958* (11.06)
$0.5\beta_{tt}$	0.002 (1.46)	0.0064* (2.31)	0.0046* (3.04)	0.0054* (5.09)
β_{kl}	0.0102 (0.78)	-0.0145 (-0.79)	0.0001 (0.01)	-0.0705* (-4.52)
β_{km}	-0.0412* (-2.23)	-0.0078 (-0.39)	-0.0604* (-2.92)	-0.1337* (-8.02)

Table Continued ...

β_{kt}	-0.0054* (-2.155)	-0.0129* (-2.68)	-0.0042 (-1.31)	-0.0063* (-2.31)
β_{lm}	-0.0349* (-1.89)	-0.2004* (14.09)	-0.1709* (-7.98)	-0.0489* (-4.098)
β_{lt}	-0.0049* (-1.88)	-0.0104* (-2.57)	0.0010 (0.25)	0.0083* (3.33)
β_{mt}	0.013* (3.80)	0.0242* (5.75)	0.0052 (1.52)	0.0013 (0.5921)
Inefficiency Model				
Constant	-0.1213* (-1.84)			0.516* (6.11)
Age	0.0657* (4.17)	0.0681* (5.36)	0.0237* (2.34)	-0.4311* (-4.03)
Time Dummy	0.0325 (1.30)	-0.0343 (-0.82)	-0.0061 (-0.21)	0.1261* (2.73)
IMRW-INS	-0.0654 (-0.80)	-0.2602* (-2.22)	-0.1441 (-1.35)	0.6827* (3.20)
EX-INS	-0.2289 (-1.42)	0.0501 (0.27)	-0.1362 (-1.23)	0.0176* (1.93)
R&D	-0.0587 (-1.42)	-0.0855 (-1.11)	-0.0149 (-0.36)	0.2124* (2.39)
IMTECH-B	-0.0114 (-0.551)	-0.1079* (-2.536)	-0.0170 (-0.808)	-0.5084* (-4.3782)
IMTECH*R&D-B	0.0461 (1.35)	-0.1367 (-1.40)	-0.0777 (-1.35)	-0.7425* (-3.24)
Sigma ($\sigma^2_v+\sigma^2_u$)	0.0096* (11.55)	0.0328* (10.91)	0.0135* (12.10)	0.0759* (4.19)
Gamma $\gamma= (\sigma^2/\sigma^2_v+\sigma^2_u)$	0.0163 (0.13)	0.0612 (0.69)	0.0435 (0.38)	0.9447* (67.31)
LLF	433.6	134.53	416.87	552.81
No. of Observations	480	420	560	530

Note: t values are given in brackets
* Significant at least 10 per cent

Appendix 2

Data Structure

Table A2.1 Number of Firms in each Industry

Year	Electrical Machinery	Electronics	Nonelectrical Machinery	Transport Equipment	Total
1988-89	51	37	59	56	203
1989-90	59	46	71	67	243
1990-91	68	59	93	90	310
1991-92	80	69	99	98	346
1992-93	94	90	111	108	403
1993-94	121	110	125	119	475
1994-95	129	120	140	130	519
1995-96	129	120	137	130	516
1996-97	128	119	136	130	513
1997-98	125	112	135	128	500
Total	984	882	1106	1056	4028

The observations are divided in to three categories on the basis of size, small, medium and large firms[1]. The size classification is on the basis of the output of the firm. The output is measured in 1981-82 prices. All observations having output less than 10 crores are included in the category of small firms. Firms having output more than ten crores but less than hundred crores are classified as medium size firms and firms having output more than hundred crores are classified as large firms. Table A5 gives the size distribution of observations.

Table A2.2 Size Distribution of Observations

	Unbalanced panel				Balanced panel			
	Electrical machinery	Electronics	Non-electrical Machinery	Transport Equipment	Electrical machinery	Electronics	Non-electrical Machinery	Transport Equipment
Small	362 (36.79)	345 (39.12)	468 (42.31)	359 (34)	82 (17.12)	124 (29.59)	134 (23.97)	106 (20)
Medium	511 (51.93)	417 (47.28)	543 (49.10)	547 (51.8)	313 (65.34)	220 (52.51)	365 (66.30)	306 (57.74)
Large	111 (11.28)	120 (13.61)	95 (8.54)	150 (14.2)	85 (17.54)	78 (17.90)	60 (10.73)	118 (22.26)
Total	984 (100)	882 (100)	1106 (100)	1056 (100)	480 (100)	420 (100)	560 (100)	530 (100)

Note: Column percentages are in brackets.

[1] The size classification of the firms is purely arbitrary. The objective is to give an idea about the size structure f the observations in the data.

Appendix 3

Data Editing rules

A sensitive question for the estimation of frontier production function and technical efficiency is the quality of the underlying data on individual manufacturing establishments. (Caves and Barton,1990: 34). One reason for the preferring stochastic frontier production functions to other methods for inferring efficiency frontier is that the stochastic frontier makes allowance for random errors in the measurement of output. But it is immune to such errors only if they are in fact random, and measurement errors in input variables are a source of trouble in any case.

Therefore it is imperative to correct or remove observations that seem with high probability to involve data errors. On the other hand, the loss involved from removing a correct but outlying observation on the presumption of a data error is very large. It is important that firms that are actually very efficient carry their weight in determining the estimated efficiency frontier. It is equally important that estimated average inefficiency reflects the performance of any plants that are extremely inefficient. Following rules are used for editing the data in this study.

Zero Values for key variables.

One obvious reason for excluding observations from the analysis was the reporting of zero values for gross output or principle inputs; gross fixed assets, wages, raw materials and energy consumed.

Presumptive data errors.

Various consistency checks are also imposed, in which, if the values of variables presented by the firm exceed a credible range, then it is presumed to have errors. The ratio of gross output (Q) to capital (K), wages (L) and raw materials (M) and ratio of capital to labour are taken. It is seems unplausible that such raw measures of labour productivity or input structure could differ among comparable and competing plants by a hundred folds. So observations having these values beyond a range is removed from the data set. The range is mean of the ratio plus 4.5 of standard deviations of the ratio.

For example observations having values Q/L above Mean (Q/L) +4/5*Standard deviation of (Q/L) have been removed from the analysis. The same rule is applied for Q/K, Q/M and K/L.

Further in order to calculate gross fixed capital stock at replacement costs, it is necessary to have a continuous time series of the observations on each firm. Since we adopted 1994-95 as the base year in the capital stock estimation it is necessary that observations on all firms should present in that year. Hence firms neither having continuous time series nor observations in the year 1994-95 are deleted from the sample.

Appendix 4

Construction of Variables used in the Production Function

All variables available in the database are the figures reported in the financial statement of the companies. I have made adjustments to some of these variables to make them suitable for the estimation of production function. The construction of output, capital, labour and material input used in this study is discussed below.

Output.

In the database the value of output of a firm is reported. This is the sum of sales (net of indirect taxes) and the change in stocks of final commodities. To get real values for output, nominal value of out put is deflated by the corresponding whole sale price index[2] with base 1981-82 = 100.

Capital.

In this study for measuring the capital stock I used Srivastava's (1996) method. The capital variable in the production function is the gross fixed asset at 1981-82 prices. As Ahluwalia, (1991), stated there is no universally accepted method of measuring capital stock. Ideally, if it was possible to devise a measure of the true economic depreciation, we can use the estimate

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[2] The price index is obtained from Index Numbers of Whole Sale Prices in India, published by the Office of the Economic Adviser Ministry of Industry, Government of India.

of net capital stock. But the available estimates of depreciation are either tax based accounting concepts or based on a certain rules of thumb. It is therefore, preferable to work with the estimate of gross capital stock. In the database the variable relating to capital is gross fixed asset (GFA) at historical costs. This is gross of depreciation. Further this includes capital asset under construction. In the case of some firms, gross fixed capital is revalued and the reported gross fixed asset includes this revaluation portion also. This revaluation portion is reported separately in the database. First I subtracted the value of capital under construction and the revaluation portion from the reported GFA. The remaining portion of the GFA is used in the measurement of capital stock.

The value of capital stock at replacement cost is obtained and then this is deflated to obtain a series for the real capital stock, using the 1981-82 as the base year. For deflating the capital stock, I used the wholesale price index for machinery and machine tools provided by the Whole Sale Price Index of India. The procedures for obtaining this series and the assumptions made in this regard are described below.

Capital Stock Series

In this study 1994-95 is used as the base year in the measurement of capital stock [3]. Let us denote k_t be the real gross fixed capital stock at the base year t. Then the capital stock for other years can be calculated as follows.

$$k_{t+1} = k_t + I_{t+1}$$

$$k_{t-1} = k_t - I_t$$

$$k_{t-2} = k_t - I_t - I_{t-1}$$

and so on

Where I_{t+s} is the real investment at time t+s

Replacement Cost in the base year.

As noted earlier, we do not have a capital stock at replacement cost in the base year. The base year capital stock needs to be revalued so as to obtain its value at replacement cost in the base

[3] The rationale for using 1994-95 as the base year is that in order to construct capital stock a continuous time series of the observations is necessary. So I used that year as the base year or bench mark year in which the maximum number of the observations are available

year. There is no perfect way of doing this and any method used is undoubtedly an approximation. The method that I have used is based on the following assumptions.

1. No firm has any capital stock in the base year (1994-95) of a vintage earlier than 1975-76. For firms incorporated before 1975-76 it is assumed that the earliest vintage capital in their capital mix dates back to the year of incorporation. Clearly as stated by Srivastava (1996) the year of incorporation and the vintage of the oldest capital in the firms asset mix may not coincide for some firms, but the assumption is made for want of a better alternative.
2. The price of capital has changed at constant rate

$$\pi = \frac{P_t}{P_{t-1}} - 1$$

   from 1975-76 or from the date of incorporation of the firm (which ever is later) up to 1994-95 (base year). Values for π were obtained by constructing capital formation price indices from the series for gross fixed capital formation in manufacturing obtained from National Account Statistics. The constant inflation rate π is not firm specific but it varies with the year of incorporation, provided the firm was incorporated after 1975-76.
3. Investment has increased at a constant rate for all firms and the rate of growth of investment (g) is

$$g = \frac{I_t}{I_{t-1}} - 1$$

   Here the rate of growth of gross fixed capital formation in manufacturing at 1980-81 prices is assumed to apply to all firms. Again different average annual growth rates are obtained for firms established after 1975-76.

Making these assumptions the revaluation factor R^G for the base year gross fixed capital stock can be obtained as described below. The balance sheet value of assets in the base year is scaled up by the revaluation factor to obtain an estimate of the value of capital stock at replacement costs.

Replacement Cost of Capital = R^G x [Value of Capital Stock at Historic Cost]

The revaluation factors can be obtained as follows

Revaluation Factor for Gross Fixed assets (R^G)

Let us denote GFA_t^h and GFA_t^r are gross fixed asset at historical costs and replacement costs respectively and I_t is the real investment at time t . By definition and making the assumptions noted above.

$$GFA_t^h = P_t I_t + P_{t-1} I_{t-1} + P_{t-2} I_{t-2} + \dots$$

$$= P_t I_t \left(\frac{(1+g)(1+\pi)}{(1+g)(1+\pi)-1} \right)$$

And

$$GFA_t^r = P_t I_t + P_t I_{t-1} + P_t I_{t-2} + \dots$$

$$= P_t I_t \left(\frac{(1+g)}{g} \right)$$

Let us define

$$R^G = \frac{GFA_t^r}{GFA_t^h}$$

Then

$$R^G = \frac{(1+g)(1+\pi)-1}{g(1+\pi)}$$

If it is assumed more realistically that the capital stock does not dates back infinitely, but that the capital stock of the earliest vintage is t period old then we can derive the revaluation factor as follows.

$$GFA_t^h = P_t I_t + P_t I_t \frac{1}{(1+g)} \frac{1}{(1+\pi)} + \dots$$

The sum of this geometric series is equal to

$$= P_t I_t \left(\frac{(1+g)^{t+1}(1+\pi)^{t+1} - 1}{[(1+g)^t (1+\pi)^t][(1+g)(1+\pi)-1]} \right)$$

Similarly

$$GFA_t^r = P_t I_t + P_t I_t \frac{1}{(1+g)} + \ldots$$

$$= P_t I_t \left(\frac{(1+g)^{t+1} - 1}{(1+g)^t g} \right)$$

$$R^G = \frac{[(1+g)^{t+1} - 1](1+\pi)^t [(1+g)(1+\pi) - 1]}{g[(1+g)(1+\pi)]^{t+1} - 1}$$

If the reliable data on the economic rate of depreciation is available then we can use the net fixed asset. The revaluation factor for the net fixed asset can be derived similarly. The table A4.1 gives the calculated revaluation factors for the gross fixed asset with base year. 1994-95.

Labour

In productivity analysis, the measurement of labour inputs poses both conceptual and empirical difficulties because of the heterogeneity of the labour input to production. For example, labour inputs vary according to quality; type of work; hours worked and above all, age and sex, across firms and even within firms. In PROWESS the data relating to the labour variable is the total wages paid to the employees. The category of employees includes production workers and employees in the managerial and supervisory cadre. In the production function the labour variable is measured in terms of labour hours.[4] For obtaining it, the wage rate per hour is constructed from ASI's corresponding industrial classification[5].

[4] In Basant and Fikkert (1996) study the labour variable is measured in labour hours. Further Denison (1961) found better results using man-hours worked as an argument in the production function.
[5] In the case of electrical machinery, non-electrical machinery and electronics, to get wage data, three digit level of ASI classification is appropriately aggregated.

Raw materials

The variable raw materials include all intermediate inputs and energy consumed in the process of production. The total raw materials expense is deflated by a raw materials price index with base 1981-82. The raw material price index is constructed by taking weights from the input-Output Transaction Matrix-1989-90. The weights are given in the tableA4.2.

Table A4.1 Revaluation Factor.

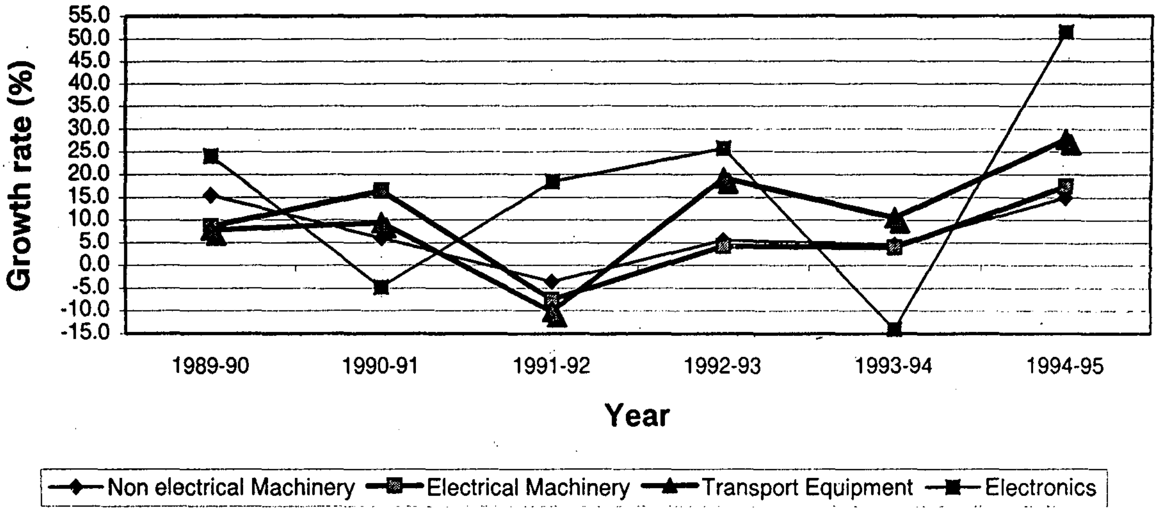
Year	Revaluation Factor
1975-76	1.609474
1976-77	1.565792
1977-78	1.526182
1978-79	1.539297
1979-80	1.571392
1980-81	1.498515
1981-82	1.405357
1982-83	1.427282
1983-84	1.403089
1984-85	1.350995
1985-86	1.322036
1986-87	1.246692
1987-88	1.211605
1988-89	1.240086
1989-90	1.250696
1990-91	1.168105
1991-92	1.133263
1992-93	1.064078
1993-94	1.042297
1994-95	1.000000

Table A4.2 Weights for the Construction of Raw Material Price Index.

Industry ⇒ Commodity ⇓	Non Electrical machinery	Electrical machinery	Electronics	Transport Equipment
Food Articles	0.00000	0.00000	0.00000	0.00000
Non Food Articles	0.00000	0.00002	0.00000	0.00000
Metallic minerals	0.00001	0.00000	0.00006	0.00000
Non-metallic minerals	0.00025	0.00000	0.00000	0.00000
Food Products	0.0000	0.0000	0.0000	0.0000
Beverages, Tobacco	0.0000	000000	0.0000	0.0000
Cotton Textiles	0.00116	0.00191	0.00095	0.00044
Wool	0.00000	0.00000	0.00000	0.00000
Jute, hemp, mesta, textiles	0.00049	0.00008	0.00000	0.00033
Textiles(misc)	0.00244	0.00053	0.00132	0.00546
Wood & Wood Products	0.01623	0.01737	0.01649	0.01543
Paper & Paper Products	0.00760	0.02538	0.08305	0.01642
Leather Products	0.00066	0.00016	0.00045	0.00085
Rubber, Plastic products etc	0.05789	0.04526	0.07801	0.15445
Chemicals	0.03667	0.16195	0.10384	0.12493
Non metallic mineral products	0.00493	0.02376	0.01008	0.00597
Basic Metals	0.64572	0.60137	0.18794	0.43375
Metal Products	0.14390	0.06448	0.43644	0.15038
Coal and lignite	0.00479	0.00095	0.00002	0.00279
Crude petroleum	0.00268	0.00284	0.00000	0.00000
Electricity	0.07456	0.05392	0.08135	0.08881
Total	1.00000	1.00000	1.00000	1.00000

Appendix 5

Figure A 5.1 Growth Rate of the Capital Goods Industries



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