# TECHNOLOGY BEHAVIOUR AND EXPORT PERFORMANCE:

## A Firm Level Analysis of Indian Electrical Machinery Industry

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I hereby affirm that the research for this dissertation titled ***Technology Behaviour and Export Performance: A Firm Level Analysis of Indian Electrical Machinery Industry,*** being submitted to Jawaharlal Nehru University for the award 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 bona fide work of Jojo Jacob, and has not been considered for the award of any other degree by any other University.

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CHAPTER I

# Introduction

International trade literature has been witnessing significant changes in emphasis on factors influencing the flow of goods across national boundaries in the past few decades. The Hecksher-Ohlin-Samuelson (H-O-S) theorem, which was the dominant paradigm till the mid 1950s, was based on a number of restrictive assumptions, notably the assumption regarding identical production functions across countries. The theoretical developments that have come about in the post 1950 period bore a common characteristic of emphasis given to technology in international trade. While the neo endowment, intra-industry and strategic theories of trade analysed the role of technology manifested in the form of skill content of labour force, as being responsible for product differentiation and economies of scale respectively, the neo technology theories of trade placed technology at the centre of the analysis of international trade.

## Firm Level Technological Capability and Exports

The neo technology theories, particularly the evolutionary approach falling within the former, as well as neo Schumpeterian theories focus on firm specific technological capability and emphasise the importance of firm level competitive advantage as being the most important influence on trade (Rosenberg, 1982). As Lall (1986) puts 'In imperfect markets with widespread oligopoly where the bulk of manufactured exports by most countries is accounted for by a small group of large enterprises, practically all the determinants of an industries comparative advantage are embodied to some extent in firm-level ownership advantages' (Lall, 1986: 81)

The widespread recognition of neo technology theories in explaining international trade has largely been due to the fact that trade flows, of late, have become highly complex with intra industry and inter firm transfers beginning to assume significance.

The tremendous growth achieved by several South East Asian countries[1], through a policy of export led growth and a systematic intervention in the market aimed at improving the technological capability of firms, shifted focus towards the need for developing countries acquiring and improving technological capability to be able to achieve superior export performance in high technology manufactured goods export. This new approach to trade, which is often referred to as the 'capability approach' points to the need for governments in developing countries playing a crucial role of facilitating domestic firms to climb up in the global technological ladder and for attracting the much needed Foreign Direct Investment (FDI)[2] by developing certain capabilities[3]. The new approach thus challenged the linear conception of technological development which considered technological development as synonymous with foreign investment and technology transfer, and reaffirmed the crucial role government has to play in creating the suitable policy environment so as to enable firms to develop their technological capability (Earnst. D., et al, 1998: 6).

## Technological Capability and Trade: The Indian Experience

The inward looking development policy which was the hallmark of development planning in India gave way to a loosening of controls in the seventies, followed by an intensification of reforms in the eighties which culminated in a full fledged program of liberalisation and structural adjustment in the nineties. It involved, among other things, relaxation of controls on production, trade, technology acquisition, foreign investment, etc.

A notable objective of the policy of outward orientation has been to improve the operational efficiency of Indian firms by exposing them to competition from abroad. It is

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[1] Several studies have attempted to explain the crucial role played by the governments, particularly in south East Asia in the technological development of these countries. For a review of literature, see Bruton (1992) and Mytelka (1996).

[2] It may be noted as pointed out in the world Investment report 1987 of UNCTAD, that international capital moves, not so much in search of countries with lower resource cost as in search of destinations which possess certain kind of capabilities.

[3] In the view of, among others, Westpal (1990) and Lall (1990), through the right technological, industrial and external sector policies, governments in developing countries can help domestic firms build up their technological capability. For instance, an export oriented economic policy regime would enable domestic firms to interact with more sophisticated clients abroad which drew forth innovative behaviour.

also expected that firms which have been catering to a large domestic market till recently will be lured by the opportunities existing in foreign markets and hence improve the foreign exchange earnings of the country. This would invariably require an improvement in the technological effort by firms. Given that liberalisation has conferred on firms, greater leeway in acquiring technological knowledge, attempts have been made to examine the technology strategy of firms. Basant (1996) found that firms adopt different technological strategies, by combining in the best possible way the technology that is available for purchase with their own R&D effort.

## Problem of the study

The importance of technology in influencing trade flows is, thus, gaining much importance in recent years. It has also been recognised that firms play a pivotal role in technology development and hence in the creation of competitive advantage within the sector and in the economy as a whole. In the context of developing countries, where, firms lag much behind their counterparts in the north, acquiring technological knowledge can take the shape of in-house R&D, technology import, FDI etc, with the first two playing the most crucial role. As firms operate with a fixed technology budget, they are bound to strike a combination of different technology acquiring options, particularly one involving in-house R&D and technology import. Since a particular technology behaviour is part of the overall strategy of the firm, including export performance, linking technology behaviour with the latter appears to be vital. As the technological options available for firms have increased with the liberalisation of the economy, it becomes relevant to examine the significance of technology behaviour in firm level exports, in the new scenario. Given the policy thrust on export led growth, it is likely that more and more firms are lured to the export markets. In this context, an examination of the role of technology behaviour in the decision to export, along with its importance in affecting export intensity becomes paramount. There are other firm specific factors as well that influence exports, apart from technological capability, whose significance may have changed owing to liberalisation. The present study, therefore, seeks to analyse the role of technology behaviour of firms in the decision to export and export intensity.

The specific objectives of the study are,

I. To examine how the technology behaviour of the firms influence the decision to export as well as export performance.

II. To analyse as to whether the same set of factors influence the decision to export and export performance.

## Data Sources and Period of Analysis

The study makes use of the electronic database, 'Prowess' provided by the Centre for Monitoring Indian Economy (CMIE), Mumbai for firm level data on various variables required. The database provides information covering a sample of firms, and the sample size shows an increasing trend so as to maintain the strength of the sample in relation to the firm population. Since the data in its full form is available only for the period 1988-89 to 1995-96, the analysis is restricted to the same period. Furthermore, 'Market and Market Share' published by CMIE is used to obtain information on market share. To capture the impact of liberalisation, the period of analysis is divided into two; pre-liberalisation period, from 1988-89 (henceforth 89) to 1990-91 (henceforth 91) and post-liberalisation period, from 1991-92 (henceforth 92) to 1995-96 (henceforth 96). The study employs both descriptive statistics and econometric techniques for analysis.

## Chapter Scheme

The study is organised in five chapters including the introduction.

A review of the theoretical and empirical literature on technology and trade with a view to identify certain hypotheses for empirical verification is the subject matter of Chapter 2. Here, the treatment of technology by different theories of international trade along with the empirical studies pertaining to them are discussed. The review points to the emerging emphasis in trade theories on firm level technological capability and exports.

As the data requirement for analysing firm level technological capability and trade can not be met by official statistics alone, an examination of official data sources along with the electronic database provided by the Centre for Monitoring Indian Economy (CMIE), which the present study makes use of, is undertaken at some length in Chapter 3. The discussion on data sources shows that official sources of data are not geared to meet the data requirements in an open economy, particularly for studies of the nature of the present one that require information on a wide range of firm specific variables. It also indicates the need for making effective utilisation of firm level data available with stock exchanges and examines the features of CMIE data, which use stock exchange data.

In Chapter 4, we specify certain hypotheses pertaining to technology behaviour, decision to export, export intensity, and other firm characteristics. On the basis of the hypotheses put forward, we carry out an empirical examination of the hypotheses linking technology behaviour and decision to export and export performance for the Indian Electrical Machinery industry. The analysis reveals the significance of technology behaviour of firms in influencing decision to export and export intensity and also shows that different set of factors influence the two aspects of export.

Chapter 5 summarises the major findings of the study.

CHAPTER II

# The Analytical Framework

## I Introduction

The emergence of firm level technological characteristics as significant factors shaping trade in manufactures is a recent development. Though various theoretical frame works have underlined the role of technology in exports, the actual treatment of technology in empirical studies has differed greatly from the theoretical propositions. In this chapter an attempt is made to bring out the role of technology in influencing exports, as highlighted by different theoretical frame works, and provide a brief review of the empirical studies pertaining to each of them. In Section II, the theoretical literature on export performance and related empirical findings are looked into, with a focus on the technological dimension of trade. Section III provides some concluding observations with a brief note on the implications of the predictions of the theoretical models and empirical studies for Indian firms.

## II The Treatment of Technology in Theories of International Trade

Technological change as a factor affecting trade patterns has been tested in the literature either by incorporating it in the traditional neo-classical frame or by developing a new theoretical frame which explicitly place technology at the centre of analysis. The trade theories have generally been tested in an ad hoc manner with most of the studies incorporating a number of theories in the analysis (Wakelin, 1997: 10). This is because no single theory has so far been able to explain convincingly international trade patterns and the determinants of them. In this section the development of trade theories, with a special emphasis on the treatment of technology by them, along with important empirical works pertaining to different theoretical frame works are discussed.

### The Classical/Neo-Classical Theories of Trade

The international trade literature has been dominated from the late eighteenth century till the first quarter of this century by the classical comparative advantage doctrine. The Ricardian theory of comparative advantage, was basically a theory explaining trade in agricultural products and was based on two restrictive assumptions; only a single factor of

production, labour, and uniform production functions in all countries. These restrictions were addressed by the neo-classical or Hecksher-Ohlin-Samuelson (H-O-S) model, which sought to explain comparative advantage in terms of a country's relative factor endowments. With a two-country, two-commodity, two-factor model, it suggested that it is the relative abundance of factors that determine trade flows between countries. The two factors considered were labour and capital and thus the exports of a country should reflect their relative endowments of capital or labour by being relatively labour intensive or capital intensive. The H-O-S theorem has thus been able to explain not just the pattern of trade but also the sources of that (Perdikis et al, 1998). The model though theoretically appealing is based on a number of restrictive assumptions:

1. As with the classical theory, this theory also assumes static, uniform production functions across countries ruling out technological progress as a motivation for trade.
2. The factor proportions for producing a particular product are assumed to remain constant overtime, thus ruling out the possibility of factor reversals.
3. Perfect competition prevails in both goods and factor markets.
4. Production function exhibits constant returns to scale.
5. Products are homogeneous or in other words, there is no product differentiation.
6. International immobility of factors but perfect mobility within a country.
7. Demand is also assumed to be identical across countries, with consumers maximising an identical homothetic utility function.

It is to be noted that once the assumption of international factor immobility is removed the neo-classical theory becomes a theory explaining trade in factors rather than trade in commodities.

The factor endowments theory was unquestionably the predominant paradigm in the literature on international trade until it was tested empirically. Empirical examination by Leontief (1953) of the trade patterns of the US, a country considered to be the world's most capital-abundant, found that its exports were labour intensive while its imports were capital intensive. This result was contrary to the predictions of factor endowments model

and became one of the foremost paradoxes of modern economics. This finding was reinforced by subsequent studies on the US, which also produced results contrary to theoretical expectations. The H-O-S theory failed to get any support in an empirical study by Bowen et al (1987)[1].

A major reason why the predictions of H-O-S model was disproved by several studies is the stringent assumptions of the theory. Newer theories sprang up relaxing the assumptions of H-O-S one by one. An immediate reaction was to resurrect the traditional line of thought, i.e., the comparative advantage doctrine by incorporating technology variable as a factor of production by modifying the assumption of two factors of production. The newer versions of H-O-S theory, which came about in reaction to the Leontief paradox by incorporating technical knowledge as a factor of production, are collectively known as the neo-endowment theories of trade. Relaxation of identical production function across countries resulted in neo-technology theories; of that of constant returns to scale and perfect competition resulted in scale economy and neo-classical models of imperfect competition; and of that of homogeneous products resulted in theories of product differentiation and intra-industry trade.

**The Neo-Endowment Theories of Trade**

A major refinement of the H-O-S theory of trade was the qualitative division of factors of production, mainly labour and capital. In this new approach, which uphold the predictions of H-O-S, labour is divided into skilled labour and unskilled labour. It was also emphasised that heterogeneity within the existing capital must also be accounted for. Following this view, a number of empirical studies were conducted to examine the neo-endowment approach. The result, however, has been mixed. The importance of skill factors in influencing US exports has been highlighted by the empirical investigation of Stern and Maskus (1981) using both regression analysis and Leontief type input-output techniques for US trade from 1958 to 1976. Another advance in the neo-endowment

[1] It may, however, be noted that Leamer (1980), by introducing an alternative conceptual formulation in which capital-labour ratio in net exports is compared to that in consumption and production, found that Leontief paradox was removed for 1947.

approach was to consider knowledge as an endowment to the economy, which could be used as an input to the production process along with labour and capital, while maintaining the assumption of common production function across countries. Since knowledge is embodied in human capital, in physical capital, as well as being produced through research and development, it becomes endogenous in the long run. This is in contrast to Ricardian factors of land and labour, which are static endowments to the economy.

The early studies such as Gruber et al. (1967) and Keesing (1967) showed the role of R&D expenditure and scientists-engineers in the comparative advantage of the US. Sveikaukus (1983), considering US trade divides technology variable to include personnel employed in research, R&D and actual data on innovations. His findings show that, more than skills or capital intensity, science and technology formed the comparative advantage of the US in 1967. Attempts have been made to extend the unit of analysis of the empirical works of neo-endowment theory from a single country, in most cases the US, to bicountry and multi country analysis. An important steppingstone in this direction was the examination of the bilateral trade flows between Sweden and US both having a high level of development, by Blomstorm et al. (1990). The exports by these countries to each other have been found to be in more technically advanced goods compared to their exports to the rest of the world. In their approach using R&D as an additional factor they found that mutual technological levels may promote trade, with the new basis of specialisation being the different technology levels or R&D intensities of the goods being traded, rather than initial endowments. In a multi-country, multi-commodity analysis, Leamer (1974) used Bayesian techniques to test neo-endowment hypothesis. He found that R&D variable was significant in influencing net exports and concluded that a combination of theories was required in explaining trade, and the use of an appropriate model depends up on the sectoral characteristics.

However, neo-endowment approach despite including new variables such as human capital, knowledge endowments etc, could not tackle the fundamental problems associated with the factor proportions theory. Though technology is treated as an additional factor of

production, the coexistence of inferior and superior technical capabilities and the impact this may have on relative productivity and relative growth patterns are not addressed by the neo-endowment approach (Wakelin, 1997). The feature of technological change in altering the comparative advantage, which makes it different from other factors of production, has not been addressed by the neo-endowment theories of trade.

The changing structure of modern industrial organisation led to the development of a new set of theories, which are collectively described as the 'Industrial Organisation' theories of trade (I\O theories of trade). These theories removed such assumptions as constant returns to scale, homogeneous product, perfect competition etc, of H-O-S theorem and emphasised the role of government policies in influencing the sectoral comparative advantage.

**The Industrial Organisation Theories of Trade**

The imperfect features of modern industrial organisation such as product differentiation, economies of scale, monopolistic power etc, as determinants of trade prompted a fresh look at the possibility of attaining comparative advantage in some industries which are characterised by these features. These theories focused on the demand aspects influencing exports on the one hand and supply side factors on the other. It is possible to distinguish between two kinds of theories within this approach, the intra-industry trade and the 'strategic' or 'new' trade theory, both of which emphasise various features of modern I\O structure as capable of affecting trade pattern.

*Differentiated products, Economies of Scale and Intra-Industry Trade*

While the earlier I/O theories of trade focused on the supply side determinants of trade, the role of demand side factors were recognised with the empirical works in the 70's which observed substantial intra-industry trade between developed countries. Following Linder's hypothesis (1961) that trade takes place more between countries with similar income levels and tastes as they are better placed to make products for each other's markets, several studies examined trade between countries with similar income levels. Grubel and Lloyd (1975), among others, found evidence of tremendous increase in the volume of

trade between developed countries in the same products during the post-war period. Krugman (1981) and others have recognised the role of product differentiation and economies of scale for the emergence of such a pattern of trade. While consumers have preferences for variety, economies of scale lead to specialisation by countries resulting in trade between them in differentiated products.

However, the empirical results of economies of scale and intra-industry trade have been mixed. Caves (1981) found a negative relation ship between the two in a study of 13 industrialised countries. A similar result was observed by Greenaway and Milner (1984) for the UK. They attribute the negative relationship between economies of scale and intra-industry trade to the standardisation of products resulting from increased economies of scale. However, the study by Owen (1983) showed a positive relationship between plant size[2] and intra-industry trade for EC countries in 1964. In most of the empirical literature dealing with intra-industry trade, the level and differences in the development of the trading countries, per capita gross domestic product and tariffs have been used as explanations for intra-industry trade. Most of the studies showed a link between the level of income and intra-industry trade, which in turn may be due to differences in factor proportions or similar demands.

*Market Structure and H-O-S Theories*

Another important theoretical development in the eighties has been the synthesis of I\O or market structure theories of trade with the H-O-S model. According to Helpman (1981), intra-industry trade will certainly take place between countries with similar income levels in a continuum of differentiated manufactured products, but the net trade pattern is still explained by the relative factor endowments. The empirical examination of Helpman's model was done by Bergstrand (1990) for 14 major industrialised countries in 1976. He found that intra-industry trade falls as a percentage of bilateral trade given increases in the differences between countries' GDP and GDP per capita and vice versa. He attributes this to both supply reasons, i.e., differences in capital labour ratio (H-O-S) and demand reasons

[2] Plant size captures economies of scale only in production with the notable exclusion of such factors as economies of scale in organisation, R&D facilities, management, etc.

(the Linder hypothesis).

In the theoretical frame work discussed above, trade pattern (particularly intra-industry type) is conceived as resulting mainly from product differentiation and the role of technology is to facilitate product differentiation and hence intra-industry trade.

By removing the assumptions of perfect competition and constant returns to scale a new theory came into existence which underscored the role of government, particularly in developing countries, in enabling domestic firms to transfer monopoly rents from international markets.

*Economies of Scale, Imperfect Competition and Strategic Theories of Trade*

These theories, recognised that technological expenditure or more precisely R&D expenditure, if stimulated by government intervention, in certain sectors characterised by economies of scale and monopolistic competition, can confer firms the first mover advantage, thereby enabling them to transfer monopoly rent from foreign markets to themselves. These theories, which acquired the title 'strategic trade theories', owes its origin to the works of Brander and Spencer (1983), Krugman (1981), etc, among others. In their model Brander and Spencer (1983) placed R&D as the most important variable influencing trade in certain commodities. They considered certain industries as capable of generating monopoly rent. These industries are characterised by such features as economies of scale and imperfect competition, which the traditional theory leaves out. In such industries, if state patronage is provided to domestic firms in terms of R&D subsidies, or tariffs, the monopoly rent may be exploited in imperfectly competitive rent earning industries operating in international markets. In the case of Japan, the empirical examination by Audretsch and Yamawaki (1987) found that R&D expenditure generally promoted Japanese trade although it was more effective in some cases than in others.

Another development within the I\O framework has been the amalgamation of market structure and firm structure, which led to the development of a new theory explaining international capital mobility through multi nationals (MNCs). This theory combines

comparative advantage with product cycle theory of trade. Cantwell (1989), for instance, in his approach considers technology as both firm specific and cumulative and also influenced by the location of the parent company and the subsidiaries.

Market structure or I\O theories of trade though emerged primarily by questioning the wisdom of H-O-S theorem has been successful in adding new dimensions to the neo-endowment theories of trade. However, these theories though emphasised the role of technology, both as a tool for attaining product differentiation and as a weapon for capturing monopoly rents from international markets failed to consider the dynamic aspects of trade by focusing solely on the path dependence and cumulative nature of technological development.

**The Dynamic Comparative Advantage Doctrine**

This theory though perfected in the late eighties draws its inspiration form the stages of comparative advantage argument put forward by Balassa, (1977). He argues that a country's comparative advantage will change as a result of accumulation of physical and human capital. Based on the experiance of post-war Japan and other Asian NICs, he states that with the passage of time, the comparative advantage of more advanced developing countries will be lost in those products that require a relative abundance of cheap, unskilled labour and will shift instead to those products which require more capital and skill input. This, the theory argues, is due to the endogenous nature of technology. In other words, in the lines of strategic trade theories, which focused on the possibility of acquiring comparative advantage through, *inter alia*, R&D subsidies, the new theory perceived that comparative advantage could be created. Among ways to acquire comparative advantage, two are of importance to note. In the model by Grossman and Helpman (1990), comparative advantage is defined as cross-country differences in R&D versus manufacturing. The outcome of this model is that comparative advantage can be acquired through experience in research, which rises relative productivity at R&D, and increases the growth rate of the country through increasing returns to scale. In the model developed by Krugman (1987), comparative advantage is based on differences in learning.

This kind of comparative advantage is essentially static as learning depends on experience in production. However, new comparative advantage can be created by diffusion of technology to foreign partners.

The endogenous comparative advantage based on the endogenous nature of technology makes these models similar to neo-Schumpeterian models of technology that is discussed later in this chapter. For instance, in the neo-Schumpeterian approach Dosi (1988) argues that in the production of new goods, a country can build dynamic competitive advantage. According to him the institutional environment or the technological paradigm existing in a country lead to specific modes of development and technical change which are cumulative in nature. As a result innovation is endogenous, the institutional environment is crucial in influencing the path of technical change. The dynamic competitive advantage can persist over time causing 'virtuous' and 'vicious' cycles of development. However, the theories of dynamic comparative advantage differ from neo-Schumpeterian theories because of their focus on technology spillovers and the resultant creation of comparative advantage.

As pointed out by Wignaraja (1998), there is wider cross-country evidence on the sources of comparative advantage that show that the developed countries losing their comparative advantage first in labour, and then in capital-intensive activities as newly industrialising countries displace them in these areas.

Another group of theories have relaxed the assumptions of H-O-S such as, identical production functions, equal access to knowledge, identical tastes and perfect markets. These theories which place technology at the centre stage are collectively known as neo-technology theories of trade.

**The Neo-Technology Theories of Trade**

The characteristic of technology which questions the analogy between technology and capital is that technological change has the capacity to be a chronic disturber of existing patterns of comparative advantage. This view of knowledge or more precisely R&D as a

factor of production distinguishes neo-endowment theories from neo-technology theories of trade. The role of innovation in creating new markets and conferring cost advantages is emphasised in the latter.

The availability theory proposed by Kravis (1956) was a milestone on the road to incorporating technology on trade patterns. By making trade dependent on the relative as well as the absolute availability of factors, he showed that access to superior technology could endow a country with a comparative advantage. This advantage might only be temporary, however, as other nations learned of and adopted the technology. Later work by Posner (1961) and Hufbauer (1966) formalised and further developed this line of inquiry through their 'Technology Gap' theories of trade.

*(a) Technology Gap Theory of Trade*

There are two major approaches in this, first is the approach developed by Posner and the other, the one by Hufbauer.

*(a.i) Posner's approach*

Posner (1961) put forward a new theory in which he demonstrated the crucial role of technology in determining trade patterns. In his model, he assumed that all industries exist in all countries and factors of production are distributed equally. However, differences in technological knowledge, or know-how, would lead to different processes being adopted or different products being produced between given industries in different countries. Posner also assumed zero tariffs and transport costs, identical tastes, fixed exchange rates, stable growth and full employment.

Posner's model can be summarised in the following way: a firm in one country adopts a new cost cutting method of production or produces a new product. To avoid bankruptcy, other firms in the industry may copy the innovation, but with a lag. This lag has two components. First, there is the time firms take to adjust to the new competitive situation- the reaction lag- and, second, there is the time required to assimilate the new product or

process- the 'learning period'. These two delays taken together give the domestic 'imitation lag. If the innovation is first adopted abroad, the lag increases, giving rise to the foreign 'reaction lag'. Foreign reaction lag will be longer because, firms are less aware of foreign developments. In the interim period, before a country's firm can react to the foreign innovativeness exports come in from abroad. These trade flows need not take place in one direction as no one country has a monopoly on innovation. By further assuming that innovations occur over a period of time and in variety of industries, Posner's model could predict a constant flow of trade between countries. Posner emphasised that dynamic economies of scale measured in terms of the volume of production and experience reinforce the competitiveness of the innovating firm.

*(a.ii) Hufbauer's approach*

A more comprehensive theory of technological trade was put forward by Hufbauer (1966). Hufbauer's approach differs from Posner's on two aspects. First, Hufbauer considered dynamic economies of scale as based on production runs rather than the volume of production. Thus, small countries also could establish and maintain an advantage over larger countries. Second aspect of difference between the two theories is that Hufbauer relaxed the assumption of equal proportions in factor endowments and factor price equalisation. The existence of high and low wage countries gave his model a different focus. Technological improvement and, hence, exports were likely to be concentrated exclusively in high wage economies. Over time, however, firms in low wage countries would produce domestic substitutes for imports. Their lower wage costs would eventually confer a comparative advantage in production and the flow of trade in the particular commodity would be reversed. As there was a technology gap between countries, Hufbauer predicted that new products would dominate the exports of rich countries.

*New Developments in Technology Gap Theory*

A further improvement of technology gap theory was made by Krugman (1979), Cimoli (1988) and others. In his model, Krugman developed a theoretical frame work consisting of an innovative north which produces new products, and a non-innovative South which

can produce the products only after a lag but then at a lower cost. There is only one factor of production (excluding technology), labour, which rules out any factor proportions motivated trade. Within this framework, new industries must constantly emerge in the north as the older industries transfer to the South. The North's higher wages reflect the North's monopoly rent on the new technology. Such a model fits well with inter-industry trade between advanced and developing countries, but in contrast to the original Posner theory, does not provide a rationale for trade between developed countries.

*Technology Gap and Comparative Advantage*

There has been a line of argument, which considered technology gap theory to be compatible with the theory of comparative advantage. As pointed out by Deardorff (1984), in the Posner theory innovations are not immediately produced in countries with a cost advantage in their production, but remain in the innovating country on account of the learning period involved in the diffusion of innovation, and a reaction lag from the imitating country. Thus the theory predicts that countries with innovative capabilities will specialise in technology intensive products, although because of the changing nature of the products, the goods produced in the technology-intensive sectors will change over time.

While neo-endowment theories of trade focused mainly on a single country, the nature of technology gap theory requires testing over a number of countries. This is because, in the latter theory, it is the differences in the technological capability, which are crucial in influencing trade flows. Soete (1981) considers trade flows across countries and within industries, and uses an output from the innovation process (patents) as the technology proxy, in place of the usual input of R&D expenditure. The model was estimated across OECD countries for 40 industrial sectors, including not just manufacturing goods but also a number of resource based industries such as petroleum. The results show the importance of technological differences between countries in explaining trade patterns for a selection of industries. There is great deal of heterogeneity between the different industries, implying that technological factors are of varying importance depending on the characteristic of the industry considered.

The empirical evidence thus, in support of the technology gap theory appears to confirm this hypothesis. However, why the production of new goods should be located in high wage rather than low wage countries was left to Vernon (1966) and Hirsch (1967) to explain through their models of 'product cycle'.

*(b) The Product Cycle Theory of Trade*

As with technology gap theory, two approaches stand out in the theory of Product cycle as well. First one owes its development to Vernon and the second to Hirsch.

*(b.i) Vernon's approach*

Vernon (1966) tried to answer why entrepreneurs with innovations based on technological advances do not locate in low wage countries. He argued that economies with high average per capita income and high wages were the most likely to generate demand for new products and labour-saving processes. During a new product's initial phase, uncertainties surrounding its specifications and application required ease of communication between producer and consumer. This made it advantageous to locate production close to the market. When foreign demand for the product or process first arose it was met by exports from the innovating country. Further increases in demand would subsequently be met by shifting production overseas in order to be nearer new and expanding markets. By locating abroad firms would also be able to avail themselves of lower labour costs. As the product/process matured further and reached a phase of advanced standardisation, competitive pressures made low wage countries even more attractive as centres of production. Eventually, the flow of exports was reversed and the advanced high-wage economy would find itself an importer of the very goods it used to export.

*(b.ii) Hirsch's approach*

Hirsch (1967) proposed a product cycle theory consisting of new, growth and mature

phases. But whereas Vernon (1966) stressed information factors as the main determinant of the location of new products in their first phase of production, Hirsch emphasised the availability of skilled labour; labour qualified in the sciences, engineering and technology. The flexibility of the skilled labour is the principal reason for the location of new industries in advanced countries. In the early phases of production before a product or process is standardised, frequent changes are needed that require the use of highly skilled labour. As large quantities of skilled labour are found only in the advanced countries, Hirsch concluded that the production of new goods and the adoption new processes would be concentrated in these countries. As a product or process was refined, its production would follow the usual pattern and gravitate to low wage countries over time. Trade patterns would reflect this evolutionary cycle in the location of production.

*New Developments in Product Cycle Theory*

Refinements to product cycle theory were subsequently made among others, by Rapp (1975), McGee (1977), Finger (1975) etc.

McGee (1977) proposed the *appropriability theory* to account for the high incidence of new product development and technology transfer between and within multi national firms. According to him, during the development of a new product the most important information developed by the market is the information concerning the extent to which the originator of an idea could expect to acquire the value society places on the idea. This he called the *appropriability*. Since this kind of information can be generated only by large firms it has the features of a public good. This in turn makes the transfer of such information intra-firm in nature rather than inter-firm.

Rapp (1975) provided a new definition of newness. According to him the relocation of industry from developed to developing will not require the transfer of whole industries to other countries. Citing the example of textile industry, he argued that the nature of the product itself might change in response to competitive factors. The new product is still

produced in the developed country and industrial decline and relocation of industry are not observed.

Finger (1975) tried to remove an apparent conflict between the Hirsch's and Vernon's definitions of product cycle. Hirsch's (1967) definition of newness required that a new technological process be used to produce a good. Vernon's (1966) definition requires not just new technique but also the ability of the product to satisfy new wants. Finger tried to develop a theory incorporating the definitions of newness given by both Hirsch and Vernon. Finger suggested that firms attempt to develop products at an optimal rate over time-a rate that does not add more to a firm's costs than to its revenues. Competition between firms through product development can take place irrespective of technology. He cited annual model changes in automobiles and appliances as well as new fashions in the garment industry. Further, product development does not necessarily lead to the satisfaction of new wants. It occurs, Finger suggested, to keep interest in the product alive. The higher the rate of product development, the more likely a country was able to maintain its exports in a particular line of production.

The product cycle theory was criticised by Walker (1979) for its emphasis on technical stability and the standardisation of production. The product cycle theory envisaged that with the diffusion of technology over time, production returns to normality with standardised products unaffected by innovation. Thus the product cycle theory points to technical stability with products following a well-defined technical pattern. With the help of a number of case studies he found that nature of innovation and diffusion cannot be generalised and only a few industries follow what is termed as product cycle. In other industries such as textile machinery, innovation plays a crucial role in improving competitiveness. In other words, innovation confers monopoly advantages to firms in such industries, and hence the process of standardisation never takes place as suggested by the 'product cycle theory'.

*Reconciling Technology Gap and Product Cycle Theories of Trade*

An attempt to distinguish between technology gap and product cycle theories empirically has been made by Hufbauer (1970), with a sample of 24 countries. He identified time as the crucial factor in the technology gap model and used the 'first trade date' of a product as an indication of the age of the product. For the product cycle theory, he used the variance of the standard deviation of export unit values in each product as an indication of the standardisation of the product. He found both the first trade date of exports and the index of price variability for exports to be significantly correlated with per capita GDP, indicating that rich countries have an advantage both in new and non-standardised products. An indicator for a new product that is often used is R&D; high R&D reflecting the production of a new product. As has already been pointed out, the study by Keesing (1967) for the USA showed a strong relation ship between R&D expenditure and exports. This indicates that US have a comparative advantage in new products.

The dynamic propositions of the product cycle theory such as the association between new product and high R&D has been a subject of much empirical investigation. For instance, Audretsch (1987) tested the hypothesis of whether new products are R&D intensive. He split sectors into growing, mature and declining based on the trend in real sales in each sector and then looked at the relative inputs of R&D expenditure, skilled labour and capital intensity. He found that growing industries are R&D intensive and are intensive in skilled and unskilled labour. The elasticity of trade to technology endowments has been tested by Aquino (1981) by estimating comparative advantage in each sector on country characteristics for a selection of countries including newly industrialised countries (NICs) from 1961-74. It has been observed in a majority of sectors, a decline in the elasticity of technology variable over time. Bowen (1980) used the rate at which the price of a good declines as an indication of its level of maturity. He found little evidence for the product cycle, with the location of production not being clearly related to the price index.

Of late, new variants of neo-technology theories are paying attention more to the

characteristic of firm level technological capability as being responsible for stimulating sector level and country level comparative advantage. The neo-Schumpeterian approach is a pioneering one in this line of enquiry.

*The Neo-Schumpeterian Approach*

A very recent development in the neo–technology theories has been the recognition of micro level aspects of technology. This has been achieved through incorporating the Schumpeterian[3] theory of innovation into technology gap theory, notably by Dosi et al (1988, 1990) . This approach tried to rectify two major lacunae in the neo-technology theories. First, an insufficient treatment of technology and second, the failure to account for the dynamic implications of different technological capabilities across countries. In this context, it should be noted that neo-technology theories fail to explain as to why innovation remained in the innovating country even in the short run, and why it was not transferred to the least cost location. The neo-Schumpeterian approach views technology as embodying specific, local, often tacit, that is, non-codifiable, and only partly appropriable knowledge. This approach stresses the importance of firm level technological capabilities, much within the evolutionary tradition of technical change[4]. At the micro economic level most innovations are influenced by past experience of innovation. This depends on firm level skills and knowledge. At the macro economic level these firm specific advantages translate into a competitive advantage for the country. The national system of innovation is thus the innovation experience of a country, which is the aggregation of innovation experience of firms, as well as through complementarities between different innovations and inter-industry relationships based on the use and production of innovations (Perdikis et al, 1998).

The neo-Schumpeterian approach, however, cautions that technology theories of trade alone may not be sufficient in explaining all trade flows and that it has to be combined

[3] See, for example, Schumpeter, 1934, 1939, 1943.

[4] The evolutionary theories of technological trade are discussed later in this chapter.

with cost based explanations of trade[5].

Before we examine the overwhelming importance attached to firm specific technological capabilities by recent literature on technological trade, the importance of sector specific factors in influencing export performance is discussed.

**The Sectoral Variations in Comparative Advantage: A Brief Note**

The environment in which a firm is situated influences its innovative character in more than one way. At the sector level, the limitations of science and of the specific technology act as one constraint of firms (some things just cannot be invented), and each technology is characterised by the technological opportunity, which it presents. Together both of these factors vary with the sector in which the firm is located, and the technology up on which it is based. Some sectors such as mechanical engineering have a high level of technical opportunity as a result of the production process, while others, such as footwear and clothing, offer a much lower level of technological opportunity. The probability of a firm being an innovator is much higher in some sectors because of the higher level of technological opportunity in those sectors (Wakelin, 1997). In the Indian case, Kumar (1990) has shown that conduct of firms differs depending on the organisational form involved.

Apart from management, skills and innovation, which are the firm specific characteristics, firms' competitiveness is also influenced by the general economic structure in which they are located. According to Chesnais (1992), the strength and efficiency of a national economy's productive structure, its technical infrastructure and other factors determining the externalities on which the firms can build, influence the competitiveness of the firms.

Chesnais goes on to point out that a country's structural competitiveness, including the

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[5] See, for instance, Dosi and Soete, 1983, Dosi et al, 1990, and Johnson, 1975.

size of the domestic market, the structure of domestic relations between different sectors and the size distribution of firms can be affected by a variety of factors. The increasing importance of generic technologies such as micro electronics, means that the interrelations between different sectors in terms of transfers of technology is of increasing importance to the structure of the economy. Together these technological characteristics make up the national system of innovation of that country. The importance of institutions and the cumulative nature of innovations emphasise that a country's culture and history shape its subsequent innovation profile, that is, technological development is path dependent at the macroeconomic as well as at the microeconomic level (David 1975, Arthur, 1989).

Although sector specific and country specific factors are important determinants of trade, even in sectors which are highly export oriented, bulk of the export of manufactured products are accounted for by a small group of large enterprises. Thus, '....practically all the determinants of an industry's comparative advantage are embodied to some extent in firm-level ownership advantages' (Lall, 1986: 81). This aspect of firm level characteristics influencing export has been subject to much deliberations in recent theoretical and empirical research. In the following section the importance of firm specific capabilities, more importantly technological capabilities and their significance in affecting exports are discussed.

**Firm Level Technological Capability and Export Performance**

The above discussion of theoretical and empirical literature on export performance reveals the inadequate attention paid to the importance of firm specific technological characteristics and the subsequent firm specific competitive advantages. This was influenced partly by the comparative advantage doctrine, which emphasised inter-country variations in resource endowments as responsible for international trade and the neo-classical assumption of perfect competition, which assumed away among other things, any firm specific differentials in technology. It is to be noted that some of the earlier theories of technical change and trade had implicitly acknowledged the importance of firm in the process of innovation. Posner (1961) in his technology-gap model of trade, considered that

the temporary advantage in knowledge, which gave rise to trade advantage, was industry specific. Nevertheless, Posner considered dynamic economies of scale, resulting from learning, as occurring at the level of the firm and being firm specific. Firms in particular countries produce innovations, which other domestic firms in the industry are assumed to be able to react to faster than firms abroad; foreign firms experience a learning lag. As a result, the benefits of innovation are felt by the domestic sector of the innovating firm, before the same sector in foreign countries. Thus the benefits of innovation are felt not just by the innovating firm, but by the whole domestic industry.

From the early eighties onwards, with the development of what is generally described as '*the evolutionary approach*' to economic growth, the significance of firms in determining the national comparative advantage has been attached greater importance. A pioneering study was done by Nelson and Winter (1982) followed by Dosi, 1988; Dosi et al., 1988 and others, in which they place firms at the centre of their analysis of technical change as an evolutionary process. To them, technological change is a dynamic force repeatedly changing the environment in which firms are located and this acts as a dynamic selection mechanism for firms. Secondly, firms are heterogeneous, and may vary considerably in terms of production methods, efficiency and their approach to innovation. Within the evolutionary tradition innovation is considered to be of central importance. Certain features of innovation highlighted by, among others Dosi (1984, 1988) and Freeman (1982), lead to the accumulation of innovation at the level of the firm. It then becomes a cumulative process (Rosenberg 1976, 1982) which is specific to firm. Technology is thus embodied both in people and in firms (Teece, 1986). Because of the general level of uncertainty and in particular uncertainty in relation to innovation, firms are unaware of the alternatives that are available to them (Freeman, 1982); they search for new innovations locally which, combined with the cumulative nature of innovation, leads to the importance of past experience. The result is that technological change at the level of the firm is path dependent with past experience affecting present innovation potential. One outcome from these firm specific innovation patterns is that asymmetries exist between firms in terms of their technological capabilities and their general economic performance, including their

trade performance. Firms have differentiated learning patterns, which alter their ability to perceive and exploit innovation opportunities (Silverberg et al., 1988); the benefits of innovation are at least partly appropriable, and as a result innovation gives an ownership advantage to the firm. Through the process of innovation some firms become more competitive relative to others, providing an incentive for other firms to follow the innovator; this leads to technical progress at the level of the sector and the economy over time (Wakelin, 1997).

In the following section, the important empirical investigations at the firm level pertaining to developing countries, particularly India are discussed.

*Technology and Trade: Studies at the Firm Level*

There have been quite a few studies probing into the innovative character of firms and their export performance. Many of them also look at other firm specific characteristics as well. These include firm size, advertising and marketing, industrial concentration, product differentiation, location and foreign subsidiaries, with the use of them varying from one study to another.

In one of the earliest studies, Hirsch and Adar (1974) examined the importance of firm size as a determinant of exports. They hypothesised that larger firms have the capacity to bear higher risks and larger investments associated with exporting and hence they will export a higher proportion of their output than smaller firms. They ran a linear regression equations of exports to sales ratios on firm size proxied by total sales. The firm size influenced exporting positively at 5 per cent level in the case of Holland and Israel.

In a study that attempted to broaden the definition of economies of scale by considering exports as one that can add to the economies of scale enjoyed by firms, Glejser et al., (1980) found a significant negative relationship between firm size and export intensity for a sample of Belgian firms. However, significant multicollinearity between several independent variables such as firm size, industrial concentration, product differentiation

and foreign subsidiaries rendered the results unreliable. Furthermore, the study by Auquier (1980) rejected the firm size hypothesis for French firms. His study showed that firm size coefficients were not significant at the 5 per cent level. However, product differentiation positively and competitive conditions negatively influenced export intensity.

In their study of 111 Israeli firms all of which had undertaken R&D expenditure Hirsch and Bijaoui (1985) found that the export propensity of these firms are much higher than the average export propensity of each sector. They also examined the rate of change in exports of 1979-81 relative to 1975-77 as the dependent variable and found R&D expenditure in 1977 to be a significant explanatory variable (at the 1 per cent level) along with the change in firm sales, taken as an indicator of 'other firm characteristics'. The firm size variable (the logarithm of sales in 1981) was not found to affect the rate of change in exports, having an elasticity of approximately one. Thus they concluded that innovation is an important variable in determining firm level export performance while beyond a level, firm size is not a major factor.

In a study pooling both time series and cross section, Hirsch et al. (1988) found a positive relationship between export performance and R&D across firms in the electronics industry. He found a 1 per cent significance for R&D and marketing expenses on export performance. However, this study has the serious weakness of considering only 14 firms.

Willmore (1992) in his study of Brazil's transnationals examined the factors that influence exports and imports. He found no significant role for R&D expenditure as a determinant of exports, although R&D appeared to play a small negative role with respect to imports, indicating that technological effort led to increased domestic inputs and less reliance on imports. His study, however found that foreign ownership (at the 1 per cent level), firm size etc, were significant with a positive sign. Also, capital intensity was found to be an insignificant determinant of export performance.

Wignaraja (1998) explored the effects of liberalisation measures undertaken during the

late 1970s, and examined the export performance of Sri Lankan manufacturing firms. He employed the principle of parsimony in his analysis. First a general model was constructed including all probable variables. After estimating the parameters, variables with low explanatory powers were excluded and a specific model was constructed. In this way, from the original model, variables such as capital, R&D, foreign share, and size were excluded and in the specific model only wage and the quality control variable were included. The model explains a large proportion of the variation in firm level export performance in the sample and compares well with the results obtained by Hirsch et al, (1985).

The importance of firm size was confirmed by the study of Lall and Kumar (1981). Using data on Indian engineering firms, they found a highly significant (at the 1 per cent level) and positive firm size coefficient. However, the quadratic term of firm size was found to be exerting a negative impact on export performance. They attribute this to a tendency to manipulate monopoly advantages conferred by size in domestic markets by lower exports. Since reliable information on R&D was absent, they used a dummy[6] to capture the effect of R&D investment by firms. R&D turned out to be significant at the 5 per cent level with a negative sign. However, they treated the result to be tentative because of the low explanatory power of the model.

In yet another study on Indian firms, Lall (1986) tested export propensities of Indian engineering and chemical firms against a number of technological variables - age of the firm, skills, royalties, licenses, foreign equity and R&D. He found a higher statistical significance for chemicals (at the 1 per cent level) than the engineering. Among the technology variables, R&D was found significant negatively and licenses positively in both industries. However, other technology variables such as age of the firm, skills and royalties were not significant in either industry, while foreign equity was insignificant in engineering and weakly significant (at the 10 per cent level) in chemicals.

[6] Dummy variable took the value 1 if firm has a registered R&D unit and 0 otherwise.

Kumar and Siddharthan (1993) examined the relationship between R&D expenditure and export performance of 640 firms for the period 1988 to 1990. Industries were classified into three, viz.; low technology, medium technology and high technology industries based on the UNCTAD classification. They found that R&D expenditure is an important determinant of export in medium and low technology industries where as it is not, in the case of high technology industries.

Several of the studies mentioned above have used mainly R&D expenditure by firms as a proxy for innovation. In addition, variables such as license fees, royalty and technical fees to capture the extent of imported technology and, age of the firm, skills etc, have been used by different studies. The use of R&D expenditure as a proxy for domestic innovative efforts has its defects. This is because the innovating characteristics of firms may not be fully captured by R&D at least in some sectors. For instance, in sectors such as engineering and instrumentation many innovations are produced as part of the production process rather than through formal R&D (Wakelin, 1997)[7]. This aspect would be discussed in greater detail in the next chapter.

## Government Policies, Multinational Firms and Export Capability: Theoretical Predictions

A very discernible feature of comparative advantage theories of trade has been the insignificant role attached to government policies to influence shifts in comparative advantage. Though strategic trade theories do provide a role for government intervention, these theories seem to suggest that an economy should still optimise its trading position by free market policies and by allowing free inflows of technology that suits its national factor endowments and are assumed to be costlessly absorbed. Even the neo-technology

[7] In her study on UK firms, she classified firms into innovating firms and non-innovating firms based on an innovation survey. In the sample of firms some of the non-innovating firms have been found to have R&D where as for some innovating firms R&D was nil. So the use of actual innovations produced a different classification from that based on R&D expenditure. However, her finding that firm level R&D is highest for innovating firms indicates that, R&D can still be used as a good proxy for the innovation intensity of a firm.

theories of trade provided little scope for government intervention. These theories argued that a developing country should encourage free trade and technology transfer via the entry of foreign direct investment.

However, the newer variants of neo-technology theory, falling within the evolutionary tradition which is sometimes referred to as belonging to the 'capability approach 'has recognised the role of government in improving the technological capability of firms in developing countries.

Firms in developing countries, in this approach, require policy interventions by the government, or foreign collaboration and the subsequent inflow of foreign capital and technology, or both to improve their technological and export capability. The government policies such as subsidies and tariffs are vital because of the risk involved in investments in technological capability building, partial appropriability of technology, i.e., the public good nature of technology, etc. Also, a well-trained and skilled labour force is vital for undertaking research in high technology industries as well as to operate advanced machinery. As pointed out by Lall (1993, 1994), government intervention is required more in difficult and complex technologies, where market failures are more likely to occur. Even in countries like Japan and US during the early stages of development domestic market was protected from foreign competition to enable domestic firms to develop their technological capability. Furthermore, in several South East Asian countries, including Japan and South Korea, direct interventions in the allocation of resources were also widely used (World Bank, 1993)[8].

Within this approach, multinational investment in developing countries is viewed as a means to attain shifts in comparative advantage in favour of developing countries. Since these countries lag very much behind the global technology frontier, export success in

[8] Direct interventions in the allocation of resources takes the form of restricting the number of firms in certain industries to confer them monopoly advantages, as well as subsidies, directed credit etc, to channel investment into selected enterprises and industries.

manufacturing would require acquisition of advanced technology from developed countries, where such technology is not locally available. This in turn calls for liberal technological and investment policies. Further, it has been highlighted of late that international investment moves not so much in search of destinations with lower resource cost, but those which possess certain capabilities (UNCTAD, 1987). These capabilities, among others, skilled labour and technology infrastructure, which are often referred to as 'complementary factors' (see Dunning, 1988; Lall, 1991), require public investment for their development.

Thus, theories of firm specific technological capability and exports, falling within the 'capability approach' place great importance on government intervention for attaining firm level and the subsequent sector level technological capability. This can occur in two ways. First, by enabling domestic firms to develop their technological capability thorough fiscal incentives and tariff protection, thereby encouraging domestic investment in capability building. Second, by establishing a technological infrastructure conducive for attracting foreign investment through public investment in education and training and by liberal technology and foreign investment policies.

## III Concluding Observations

In the forgoing discussion, major trade theories starting from the Ricardian comparative advantage to neo-technology and 'capability approach' have been examined along with empirical studies pertaining to them. It must be noted that the empirical verifications of trade theories have generally been done in a manner with most of the studies incorporating a number of theories in the analysis. Certain general predictions about the importance of different factors in trade relevant in the context of India can be drawn from the preceding discussion.

The classical and neo-classical theories of trade have been the subject of much empirical

investigation. The H-O-S model, which is based on a number of restrictive assumptions, predict that countries will specialise in the production and export of those goods that use more of their relatively abundant factors of production. Viewed thus, firms in a large developing economy like India, relatively well endowed with labour, can have a comparative advantage in the export of labour intensive goods.

The new variant of H-O-S theorem, that is the neo-endowment theorem, incorporated a third factor of production viz., the skill content of the work force. This theory predicts that a country with a large endowment of skilled labour will have a comparative advantage in the production and export of skill-intensive goods. Operating in a country relatively well endowed with skilled labour force, Indian firms can be assumed to have a comparative advantage in the export of skill intensive goods.

The I\O theories of trade, which removed such assumptions as constant returns to scale, homogeneous product, perfect competition etc, of H-O-S theorem, emphasised the role of government policies in influencing the sectoral competitive advantage. To be more specific, the market structure theory of trade, which is a variant of I\O theory, predicts that scale economies are instrumental in improving the export competitiveness. The strategic trade theories place emphasis on government intervention in industries characterised by scale economies and imperfect competition. In general, in developing countries where markets are small, there is little that these countries can gain by strategic intervention of the government. However, from the point of view of economies of scale, large Indian firms, which have been enjoying a relatively big domestic market and that too a protected one, till recently, in all likelihood would enjoy a comparative advantage over small firms in improving their export share.

The neo-technology theories treat developed countries as leaders in new technology[9]. These theories depart from many of the assumptions of H-O-S theorem such as identical

[9] Neo-technology theories, however, recognise that it is individual firms, rather than industries, that invest in technology creation.

production functions, equal access to knowledge, identical tastes and perfect markets and focus on technological and taste differences in imperfect markets as the basis for international trade between countries. They further argue that developing countries should follow an open approach towards technology and investment as they are not in a position to develop the needed technology on their own. The incorporation of Schumpeter's views on innovation in neo-technology trade theories, which later came to know as neo-Schumpeterian theories, shifted to some extent the focus of technology-trade studies from sector and country levels to firm level analysis. This is not withstanding the fact that neo-Schumpeterian theories have emphasised the role of technological paradigm and institutional factors to be crucial in influencing the path of technical change.

The importance of an effective government policy that would develop certain capabilities in developing countries as a pre-requisite for improving firm level technological knowledge has been highlighted in the so called 'capability approach'. This approach differs from the neo-technology theories in that while the latter considers technological capability to be specific to firm and easily appropriable, the former focuses on imperfections in the market that would stand in the way of firms in developing countries catching up with those in north. The capability building in developing countries would require active intervention of government in such areas as education, training and a suitable tariff, technology and investment policies, to name a few. As firms in developing countries like India lag much behind technologically advanced firms in developed countries, apart from investment in R&D, they need to acquire technological knowledge from the latter, wherever it is possible, rather than trying to develop all necessary technology on their own. In other words, the particular technological situation in developing countries requires firms to follow a judicious programme of domestic R&D and technology import[10].

[10] In the words of Subrahmanian, 'What is perhaps needed is a relatively free environment of the market for technology import but accompanied by positive intervention of the state toensure that the import is backed up with domestic R&D effort for firms/industry to move along a dependence-independence' continuum of technical change' (Subrahmanian, 1991)

Having developed an analytical framework, we are now in a position to undertake an empirical verification of some of the predictions from the literature. This forms the focus of Chapter 4 wherein the role of technology vis-à-vis other firm specific characteristics in trade behaviour is analysed by taking the case of Indian Electrical Machinery Industry. Before getting into the analysis *per se* it is appropriate that we deal with the database of the empirical analysis. This is the focus of the next chapter.

CHAPTER III

# The Database

## 1 Introduction

The analytical review in the previous chapter leads us to the broad conclusion that an analysis involving technology and trade would require data on a wide range of variables, both technological and otherwise. It may be noted that studies in the Indian context examining firm level characteristics and exports have failed to incorporate all necessary variables into their framework. This undoubtedly is due to the absence of a comprehensive database with both public and private sector. The present study seeks to overcome this problem to some extent by making use of a recently developed electronic database 'Prowess' provided by the private agency Centre for Monitoring Indian Economy (CMIE). In the present chapter we undertake a critical assessment of this database from the perspective of the current study, by comparing it with the official statistics on production, trade and technology.

In Section II, we examine the importance of a comprehensive database not just in a regulated economic regime but also in a liberalised one, keeping in mind the reform measures undertaken as part of liberalisation. Section III discusses the data available on production. Section IV reviews the data sources pertaining to trade. Section V briefly points at the need for harmonising production and trade data. Section VI gives a brief description of the computer-based database of CMIE (Prowess) and Section VII presents the concluding observations.

## II The Need for a Comprehensive Database

The need for a comprehensive data system in a planned economy has been well documented in the literature (see for example, Rao, 1972). The policy regime in India till recently was characterised by a host of regulations on production and trade as manifested in restrictions on entry and exit, capacity, pricing, tariff and non-tariff barriers, exchange rate and so on. The effective implementation of these regulations called for a data system which generated timely data on the different aspects of production, trade and related economic

activities. The economic reforms initiated in the early nineties marked the beginning of the move towards a liberalised policy environment wherein government regulations are being replaced by the market forces and import substitution is giving way to outward orientation. Implicit in these policy changes is the greater integration of the Indian economy with the world market and greater linkage between domestic and external sectors of the economy.

The importance of an extensive database on the various sectors of the economy is no less important in an economic regime where government control over the economic activities is on the decline. However, the nature and content of the data requirement appears to be different. To begin with, the data on production and trade need to be integrated incorporating new variables such as technological payments, foreign equity participation etc. Relaxation of government control over production has called for new sets of information to suit the needs of policy makers as well as the market forces which has replaced, partially, if not fully, the official regulatory mechanism.

An important characteristic of the trade liberalisation has been the transition from a non-tariff regime, characterised by quantitative restrictions, to a tariff regime. Such a transition demands detailed information on what is traded, by whom, produced under what conditions, at what cost etc. An effective implementation of the export orientation policy requires information on what is exported, by whom, to which market and so on. This is important for the analysis of the impact of trade sector reforms on the growth performance of various sectors of the economy as well as on the balance of payments. This kind of a data is all the more important to make any forecast about the future course of exports and to make suitable policy changes in the domestic as well as external sector.

As we have already seen in Chapter II, in an open economy, technology (through domestic R&D, joint venture and technology transfer from developed to developing countries) plays a crucial role in augmenting international competitiveness. Any analysis of the link between technology and trade therefore needs data on different aspects of technology transfer as well as domestic technological effort and other related variables.

In the new scenario, though the firms are rather free from government controls, their

behaviour, right from the mobilisation of capital to successful marketing, is governed in more than one way by the market. To illustrate, while in the earlier regime industries raised most of their capital from banking institutions, in the new regime the capital market has emerged as an important source of funds. This points to the fact that it is the market that determines the capital mobilising capacity of the industry which in turn *inter alia* depends on their performance. It may be noted that company reports such as profit and loss accounts and balance sheet incorporate important information to help assess their current performance and future prospects. These data, pertaining to listed companies are available in the stock exchanges. This data source, if properly made use of, could far outweigh the official statistics on trade and production in terms of the coverage and go a long way towards an integrated database. An attempt in this direction has been made by a private agency (Centre for Monitoring Indian Economy, CMIE) and has come forward with an electronic database (Prowess).

It may be noted that no serious attempt has been made in recent years to assess the usefulness of various official statistics as well as data offered by private agencies on analysing the different sectors of the economy operating under globalisation[1].

## III Data on Production

The Annual Survey of Industries is the only database on the production statistics of the entire factory sector[2]. It is a detailed report on the performance of the industrial sector in India brought out every year by the government agency, the Central Statistical Organisation (CSO). It replaced both the Census of Manufacturing Industries (CMI) and the Sample

[1] Two possible exceptions in recent years are the seminars organised by the econometric society (Manglore, 1998 and Jaipur, 1999), which discussed about the existing data sources and the need for reorienting them in the light of liberalised economic environment.

[2] All the factories registered under section 2m(i) and 2m(ii) of the Indian Factories Act 1948,employing 10 or more workers using power and those employing 20 or more workers but not using power on any day of the preceding 12 months, fall under its investigation. Also comes under its purview are Bidi and Cigar manufacturing establishments with the above mentioned features, electricity undertakings registered with the Central Electricity Authority and certain activities such as cold storage, water supply, repairing activities (motor vehicle....)Etc. Though it covers servicing industries like motion picture production, personal services like laundry, job dyeing, etc, data are not tabulated as these do not fall under the scope of industrial sector defined by UN. It excludes defence establishments, cold storage and distribution depots, hotels, restaurants, cafes and computer services and technical training institutes.

Survey of Manufacturing Industries (SSMI) with effect from the year 1959. The primary unit of enumeration is the factory and the survey relates to a calendar year for most of the industries. The Collection of Statistics Act, 1953, empowers the Centre and the State governments to call for statistical information on the prescribed form from the owners of factories. Particulars about installed capacity, output, employment, earnings and raw materials consumed, and reasons for spare capacity etc. are collected under the survey. The frame is being revised once in three years from 1989-90, during which the names of de-registered companies are removed and registered, added. The survey covers (a) the census sector, which include factories employing on any day 100 or more workers, and, (b) the sample sector, which includes factories employing less than 100 workers. The sample sector is covered on the basis of probability sample. Once a factory is classified into census or sample sector, its status is not altered for a period of three years, i.e., till the frame is revised; though change in employment might warrant it. The Field Operation Division (FOD) of the National Sample Survey Organisation (NSSO) carries out the fieldwork of the survey through its network of zonal, regional and sub-regional offices located in different parts of the country. While the direction and supervision for the timely execution of the field survey rest with the FOD of NSSO, processing of data and publication of reports there on, are the responsibilities of CSO[3]. The ASI data on industries cover the whole of India except the states of Arunachal Pradesh, Mizoram and Sikkim and the union territory of Lakshwa Dweep.

In ASI, The National Industrial Classification (NIC) 1987 is being followed from 1989-90. All the factories in the ASI frame are accordingly classified in their appropriate industry groups on the value of the principal product manufactured by them. Therefore a unit gets classified in one and only one industry group even though it might be manufacturing products belonging to different industries. This classification is used to represent industries at the two and three digit levels in ASI.

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[3] The Annual Survey of Industries has 15 volumes including the summary results of the factory sector. Volume I of the report give the summary tables by states and by industries, among other things. The form of return, concepts and definition and the classification of industries are also given in this volume. The other volumes provide detailed data relating to various industries and industry groups at the two and three digit level. It however does not give data at the firm level.

As pointed out by Krishna (1972), ASI is capable of providing extremely valuable data for the purpose of national income estimation and for the investigation of problems in the field of industrial economics. But the utility of ASI data is considerably diminished as a result of long delays in the processing and publication of data. As of now detailed data are not available for any of the years beginning with 1995. This is a serious shortcoming of the ASI data. ASI has been collecting data on capacity and reasons for the under utilisation of capacity right from the year 1959. But the figures of capacity and the data on reasons for under utilisation have never been published. Such acts of omission are, to say the least, deplorable (Krishna, 1972). In ASI, the census sector has a larger coverage than the sample sector. This results in the under representation of the manufacturing sector[4]. Such a bias is coupled with the difficulty of intertemporal comparisons arising out of the changes in the survey, its coverage and the classification. Again, as ASI leaves out a large unregistered manufacturing segment, making any meaningful empirical analysis is rather difficult (Sinharoy, 1998).

However, it is to be noted that ASI is a rich source of data on output, capital, labour, and raw material inputs, wages and salaries at the factory level. In its coverage and scope, it is comparable to the Annual Survey of Manufactures in the US, the census of manufactures in Canada and the Census of Manufacturing Establishments in Norway. The information from the establishments was collected under non-disclosure provisions, as in ASI. However, research workers were provided, on request, the matrices of sums of squares and products of relevant variables so as to enable them to estimate production relationships. Though there have been arguments in favour of making the ASI data also available for researchers on similar lines, no effort has been made in that direction.

## IV Data on Trade

As pointed out earlier, the trade data is provided by the DGCI&S[5], Calcutta, and the RBI.

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[4] The census accounted for about four fifth of the total output of the two sectors taken together in the early seventies.

[5] It has three different volumes. While the first gives country wise compositions of India's foreign trade, the other two volumes give industry wise composition of the trade between India and the Rest of the World with the one on exports and re-exports and the other on imports and re-imports. The data relate to the transaction of all merchandise through all the recognised seaports, air ports, lands customs stations and inland container ports, and in the case of exports, export processing zones of India as well.

The DGCI&S statistics is based on customs clearance of merchandise transactions at major ports in the country, where exports are based on the basis of shipment of goods and imports on the basis of arrival of goods and their clearance by the customs. The RBI statistics is based on merchandise transactions taking place in the economy which are valued at the actual price paid through the banking channel, where exports figures are on the basis of declarations and imports are on the basis of realisations rather than on landed merchandise. It is to be noted that there is discrepancy in data from the two sources because of the differences in the timing of recording by RBI and customs sources[6]. The important need to correct the lack of correspondence between the RBI and the DGCI&S statistics has been voiced almost three decades back (V. R. Panchamukhy, 1972).

While DGCI&S provides data at a fairly disaggregate level, RBI data is obtained only at the aggregate as its purpose is solely to provide information on the balance of payments situation in the country. Unlike the production statistics, the trade statistics of the DGCI&S has undergone systematic changes over the years. A new system of commodity classification known as Indian Trade Classification (Based on Harmonised Commodity Description and Coding System (ITC (HS), has been adopted from April, 1987 replacing Indian Trade Classification, Revision-2 (ITC-Rev-2). The ITC (HS) is an extended version of the International Classification System called 'Harmonised Commodity Description and Coding System' evolved by Customs Co-operation council, Brussels. The ITC (HS) has undergone two revisions, one w.e.f. April'91 and next w.e.f. April'92[7].

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[6] As pointed out by Sinharoy (1998), the divergence between the two is not just due to the timing of recording but also due to the nature of coverage and valuation of transactions. His study shows that divergence has been widening over the years with RBI figures vastly exceeding the DGCI&S figures, more so in the case of imports. Also, while RBI covers defence related items, DGCI&S does not cover them for security reasons. These apart, there are differences, which are specific to imports such as lead in payment, imports of mobile equipments such as ships and aircrafts and imports under external assistance and commercial borrowing. In addition there are certain imported items which are not covered by the DGCI&S as they do not require customs clearance but are compiled in the RBI database.

[7] The classification consists of 99 product groups represented by two digit codes, with 77 representing products reserved for future use, 1253 H.S. headings represented by 4-digit codes and 5063 HS Sub-headings represented by 6 digit codes. The 8 digit codes of ITC (HS) nearly 10,980 in number have been derived by further sub division of the 5063 HS sub headings to capture data on commodities of national importance.

In spite of the 8-digit level of disaggregation, one often confronts the non-availability of data on volume of trade in DGCI&S[8]. It has been pointed out that the 8-digit level of disaggregation is not sufficient to arrive at product specific inference. Further, the trade statistics in India has undergone changes very frequently creating the very serious problem of unequal totals across revisions. This makes it difficult to obtain information on a meaningful set of products at the disaggregated level and arrive at a comparable time series for individual items. Therefore one has to limit the analysis of time series, for broad aggregates like metals and manufactures, leather and manufactures or machinery and transport equipments (Sinharoy 1998). Again, under HS, products are classified in increasing degree of value addition of the basic input. As a result, meaningful aggregation is barely possible for end group categories such as basics, intermediaries, capital goods and consumer goods.

## V The Need for Harmonising Production and Trade Data

In a liberalised economic regime, the need for the synchronisation of trade and production data is paramount[9]. This is because, in such a system, international trade plays a key role in influencing the level of output of various sectors of the economy. In India, it has been well illustrated that, the measures of export intensity, which is an indicator of the openness of the economy, and import intensity are underestimates. This is due to the fact that, in the export to GDP ratio or import to GDP ratio, the numerators and denominators do not represent the same categories. Merchandise trade covers only the productive sectors of the economy while GDP includes services also. Sector wise measures of import intensity and export intensity have been found to be overestimates. This is because production data available from ASI at three-digit level covers only the registered segment. Production data covering the registered and unregistered sectors are available only up to the two-digit level. Thus, a calculation of export intensities at 3 digit level leaves out a large chunk of small scale sector which is often found to be more export intensive.

The analysis by Sinharoy (1998), shows that though at the aggregate level export to GDP

[8] For instance, in the case of petroleum and related products and drugs and pharmaceuticals, the volumes of trade are not available. While the latter is emerging as an important tradable, the former accounts for the bulk of import payments.

[9] Sinharoy (1998) illustrates the need for harmonising production and trade data in an open economy.

ratio has been increasing from the mid eighties through 90s, when the data was adjusted for unregistered production the increase was more pronounced[10]. At the disaggregate level, when a similar exercise was done, it was found that, the export intensities were overestimates. It has further been noticed that, the ratios for non-traditional manufactures such as machinery and transport equipments, chemicals and metal and manufactures have a lower bias than those for traditional items due to the rather modest existence of the small scale segment in these sectors. Thus, information of small-scale production would scale down the intensity ratios, especially for traditional sectors. Several studies have tried to compare ASI data at the two digit with the DGCI&S data at various levels[11]. Suggestions have been made in recent years to harmonise the production and trade data. This requires the unification of system of classification and the sample coverage of data sources[12].

Another suggestion has been to calculate export indices at the firm level, which are not compiled by either ASI or DGCI&S. Yet another solution for the problems discussed above is to increase the coverage of sample sector in ASI and to enlarge its scope by including the foreign exchange transactions of firms which include the export and import of finished goods, intermediaries and raw materials.

**VI The Prowess Database**

The computerised database of the CMIE (Prowess) makes an attempt towards overcoming some of the problems raised above. Though based on a sample, it remedies the problem of non-harmonisation between the production data and trade data to some extent, by providing information on most of the economic activities at the firm level including production, trade, R&D, technology import and other foreign exchange transactions. In Prowess, data is collected from original and secondary sources. An important advantage of Prowess is that it gives data at the firm level much more comprehensively than data sources such as Bombay Stock Exchange Directory, which also gives information at the firm level. It covers many of the variables needed in social science research, such as sales, exports, imports, technical payments made abroad, R&D, wages and so on. It needs, however, to be pointed out that it

[10] The reader of the paper, however, is kept in dark regarding the method of adjustment.
[11] Deberoy and Santhanam, 1993, quoted in Sinharoy, 1998.
[12] Panchamukhi (1972) has pointed out that, the diversity of code numbers in Indian Statistical System should be removed and a common body should be set out to devise appropriate correspondence between several code numbers.

does not give information on such important variables as mandays, number of workers etc.

Industrial classification is based on the overall distribution of companies amongst industries and the distribution of sales turn over of companies. Selection of a set of industry groups is based on a 'reasonable' representation of companies. In some cases, companies belonging to a group of industries have been clubbed together, if they are closely related to each other. Regarding the sales turn over, as a general rule, if a company derives more than half of its sales from one of the industry classification heads, it gets classified under the particular industry, else it is classified as a diversified industry. Business activities of companies are tracked on an ongoing basis and it is possible that a non-diversified company may tomorrow become a diversified company or vice versa.

To have better understanding of the prowess data we have made some preliminary comparison with other official sources mentioned above. The Net Value Added (NVA) of Prowess sample is compared with that of ASI and imports and exports data in Prowess are compared with those of DGCI&S at the two digit levels of ASI and DGCI&S respectively. It is found that for the year 1989, the NVA of the Prowess sample of the manufacturing sector constituted nearly 70 per cent of the NVA of the manufacturing sector reported in ASI. More importantly this share is found more or less the same in almost all industry groups. The Prowess data on exports and imports for the years 1988-89 and 1994-95 show a reasonable representation of those of DGCI&S data. In terms of the volume of exports, the share of Prowess data has increased from 15% to 28% during the period. The Prowess sample for imports shows an increase in the share from 12% to 18% during the period. This may be viewed against the earlier findings that the Indian exports is contributed more by the small scale sector which may not be represented in the listed companies. However the Prowess share for both import and export shows wide differences across industries. For exports, the Prowess data on metal and metal products accounted for more than 70% in both the years. Share of Prowess for chemicals and Transport equipment increased to 60 and 63 per cents respectively from 54 and 46 per cents. For the machinery the share increased from 32 per cent to 44 per cent. As pointed out else where in the chapter, in traditional industries like textiles, small firms are major exporters and because of this reason their share in the Prowess sample is rather low. In the case of imports, the Prowess

data on imports show a more than 50% representation for industries like Textiles, Chemicals, Transport Equipment and Metal and Metal products, and; for Machinery, it gives a representation of around 20%. However, before making any judgement about the representation of the manufacturing sector in Prowess, one must notice that the sample is selected from companies listed in the stock exchanges. As a result though it gives a good representation of large and medium sized firms it excludes a majority of small firms.

### Coverage of Variables

In terms of the coverage of variables and industries, Prowess is the most comprehensive database available in the country. Any research requiring many of these variables require a review of a number of data sources such as ASI, DGCI&S, Foreign Collaborations Data, R&D statistics and Bombay Stock Exchange Directory. ASI, as already pointed out does not give data on, number of firms belonging to each industry, sales, R&D, technological payments, exports, imports, marketing and selling costs, tax payments, profits, share holding pattern etc. DGCI&S, gives data only on the exports and imports at the industry level (up to eight-digit level). Foreign Collaborations data, published by the Department of Scientific and Industrial Research (DSIR) gives data on the technology purchase at the firm level and shows only whether firms resort to import of technology without showing the absolute amount spent on such transactions. R&D Statistics brought out by the Department of Science and Technology (DST) gives information on R&D at the industrial level but the firm level information is provided only for those firms having a registered R&D unit. Bombay stock exchange directory provides data at the firm level but the variables covered are less with the significant omission of exports and imports, expenditure on R&D and foreign technology etc. Even if one attempts to make use of the different data sources mentioned above, such a task entails numerous problems of comparison. In these circumstances the usefulness of Prowess as a database for analysing issues under a globalised setting appears overwhelming.

### Limitations

The Prowess database has some weaknesses due to the voluntary nature of data collection. Since firms retain the option of not providing information, it may not always be possible to collect data from all firms from which data is sought. In addition to this, it has been found

that though data is available for the latest year, it cannot be used for any analysis. This is because the data collection for any year is completed only after a period of one or two years. For instance, though the number of firms in Prowess are increasing gradually, it shows a sudden dip from 1996-97 onwards indicating that data collection is not complete for the years following 1997. However, the database is silent regarding whether data for any year is complete or not, and hence it is left to the subjectivity of individual researcher to choose the final year for the purpose of analysis. Another problem in running time series analysis pertains to the fact that a firm belonging to one group of industry in one year may become represented in another group in the following year. There are other handicaps as well, due to the reason that firms may not always provide information about some variables. However, as has been found often, it is not possible to figure out whether a particular variable has zero value or it is not reported as both gets a zero value in the dataset. As a result such firms which may have to be left out of any analysis, still retains its place in the dataset. As with Annual Survey of Industries, Prowess also has the serious handicap of not including a vast chunk of non-listed companies, many of which are prominent players in the export market, at least in traditional industries. Furthermore, with the recognition of technology behaviour of firms as involving not just R&D and technology import, but also royalty payments and lumpsum fees, an analysis of that nature would require information on these two variables as well.

## VII Summing Up

The present chapter has been aimed at delineating the data constraints one often confronts in economic analysis in an open economy, with a special focus on the data requirements for a study like the present one. We have examined the features of official and private data sources on production, trade and technology and discovered the usefulness of employing Prowess data. One major problem associated with the official statistics is the lack of harmonisation between production and trade data. A database on production and trade based on a uniform industrial classification can make economic analysis in an open economy much more reliable and easy. Adding to this, the official data sources on technology transfers fail to show the magnitude of such transactions. It has also been pointed out that stock exchanges have emerged as an important source of firm level data. The balance sheet data with the stock exchanges are superior in that, production and trade

data are provided at the firm level and hence, the problem of non-harmonisation between production and trade data are taken care of. On the other hand, the effective utilisation of Prowess data is hampered mainly by the fact that they come with a lag along with non-information on certain variables in some years, owing mainly to the irregular reporting of balance sheet data by some firms.

CHAPTER IV

# Technology and Trade: A Firm Level Analysis of Indian Electrical Machinery Industry

## I Introduction

Having seen the importance of technology factor in international trade in chapter II, the present chapter examines the role of firm level technology behaviour in exports in the Indian Electrical Machinery industry. The development of engineering industry, to which electrical machinery belongs, was one of the leading objectives of development planning in India. This was because, to quote Saha '.... engineering industry, which includes the manufacture of steel and a wide range of heavy and light machinery is probably the most crucial enabling component of a national economy to get on to an upward trajectory of endogenously driven and sustainable process of development', (Saha, 1993: m149). The United Nations Industrial Development Organisation (UNIDO) underscored the importance of engineering sector, particularly for developing countries, when it, in its 1988 report picked up metal products, machinery and equipment as the most important constituent of core technology sector. It also warned developing countries that, unless they took active steps to create this sector as an essential part of their domestic production capabilities, they would be forever locked up in the trap of technological backwardness and poverty, feeding each other (UNIDO, 1998). It must be noted that India is one of a very small number of developing countries in the world, which has had a strong presence of this sector in its industrial structure. Another unique aspect of the Indian engineering industry has been the dominance of public sector and the insignificant role of foreign capital. With the relaxation of controls on industry from the mid 1980s, the Indian machinery industry has undergone substantial transformation with private sector emerging as an important force to reckon with. The outward orientation of the economy has led to the emergence of this industry as a leading foreign exchange earner as well.

Prior to liberalisation, exports from this sector had been dominated by small and medium sized industries (Patibandla, 1988a). This could largely be owing to the domestic monopoly enjoyed by large firms, which provided them little inducement to export. It would be of some interest to look at the size composition of firms and export intensity, as

large firms are likely to increase their outward orientation with the liberalisation of the economy.

As the outward orientation of firms are expected to go up with the liberalisation of the economy, it is reasonable to assume that firms increase their technological effort through increased in-house R&D, technological import[1], Foreign Direct Investment (FDI) and such other means. As the share of machinery in the total export earnings remained at a substantially high level of around 12% throughout the 90s, and it being a highly technology intensive industry, a study on the role of technology in export intensity of firms in this sector appears to be of much significance.

The present chapter is organized in the following way. Drawing from the analytical framework presented in Chapter II, the following section presents the various hypotheses to be tested and the econometric models for estimation. Section III deals with the sample frame and the construction of variables used in the analysis. Estimation results are provided in Section IV, followed by some concluding observations in Section V.

## II Hypotheses

### The Decision to Export and Export Intensity

It has of late been recognised that factors that influence the decision to export may not be the same as those that determine the intensity of export. The study by Willmore (1992) on Brazilian manufacturing firms found that while factors such as size and quadratic term of the size were significant (with positive and negative signs respectively) in explaining the export decision, an opposite result was obtained for the export intensity. A similar result is obtained by Athukorala et al (1995) in their study of the link between foreign ownership and export by firms in Sri Lanka. While ownership, efficiency, firm size etc, have been proved to be significant in explaining the decision to export by firms, they have been found to be insignificant in influencing the export intensity. The study by Wakelin (1997) on the link between firm level technological characteristics and export intensity for British manufacturing firms also found that there are significant differences between the factors

[1] As part of new technology policy, royalty payments have been considerably liberalised (Ahluwalia, 1996). Technology imports obtain automatic approval for royalty payment up to five per cent of domestic sales and eight per cent of export sales (both net of tax), with or without lump sum payment up to Rs. 10 million.

that influence the decision to export and export intensity. Her study showed that though firm size is insignificant in the probability of exporting it is significant in the intensity of export. However, capital intensity has been found to be important in influencing both export intensity and decision to export. In the context of India, earlier studies found a close association between decision to export and export intensity (Pant, 1993, Subrahmanian et al, 1996). A recent study by Joseph (1999) on the export intensity of multi national enterprises also confirms this result.

The present study examines the influence of technology behavior of firms, rather than the accumulated technical knowledge, on exports. The following section deals with this aspect of firm level technology behaviour.

**Technology Behaviour**

Studies examining the role of technology in firm level exports have used different proxies to capture the level of innovative activities by firms. In most of the studies pertaining to developed countries patent data has been used to capture the extent of technological capability of firms. Studies on developing countries on the other hand, have used several input proxies of innovation such as R&D expenditure, foreign technology purchase etc. It must be noted that since firms in the developing countries lag much behind the world technological frontier, the technological options available are many.

The two most important sources of acquiring technological capability by firms in developing countries are in house R&D and technology Import.

Given these two factors, an ideal approach would be to examine the link between firm level technology strategy and exports[2]. These strategies may include, a. R&D only, b. technology import only, c. both R&D and technology import, and d. neither R&D nor technology import. An analysis in this direction could be econometrically carried out using a multinomial logit model. The scope of the present study, owing to the limited time available, is limited to an examination of the technology behaviour of firms (with respect

[2] Studies in the Indian context which examined the determinants of technology strategy by firms reveal that various firm specific characteristics influence the technology strategy of firms (see, for instance Basant, 1996).

to R&D and Technology Import) and its impact on export decision and export intensity.

*R&D and Exports*

The studies analysing the influence of R&D on firm level exports provide mixed results. R&D's[3] role in influencing the decision to export has not been found significant in a study on Brazilian firms by Willmore (1992), while in some of the studies pertaining to developed countries (Pavitt et al, 1980, Wakelin, 1997), its role has been found to be significant. A few Indian studies did not find any credible evidence for the link between R&D and the export intensity of firms (Lall, 1986, Kumar, 1990, and Kumar and Siddharthan, 1993).

Since an initial technological capability is a prerequisite for acquiring advanced technology and improving technological capability, we hypothesise that, R&D is significant in influencing the decision to export, while not important in influencing the export intensity.

*Technology Import and Exports*

While there have not been any major study in the Indian context that examined the role of technology import in the decision to export, the studies by Lall (1986) on the engineering industry and Kumar and Siddharthan (1993) on high technology industries have found that foreign technology import has a significant influence on the export intensity of firms. As technology import is a prerequisite for improving the technological capability of firms in a developing country like India, it could be hypothesised that it has a positive influence on export intensity. However, since a firm, which is yet to make its presence in developed country markets may not have adequate knowledge or bargaining power to acquire foreign technology, it is assumed that technology import does not have a positive impact on the decision to export.

We have thus hypothesised that R&D and technology import would have a differential

[3] Following, Arrow, 1962, there have been arguments that imperfect appropriability of the benefits of R&D may lead to increase in spending on R&D as firms with a higher technological capability will be able to appropriate the innovation spillovers from other firms (Cohen and Levinthal, 1989).

influence on decision to export and export intensity. While the former is assumed to influence the decision to export, the latter is assumed to be affecting the intensity of export.

**Other Firm Specific Factors**

Apart from the technological characteristics, there are other significant firm specific characteristics as well, which are found to be influencing the export decision and export intensity. The major variables included in the existing literature are; firm size, foreign equity participation, market share, profitability, selling cost including advertisement, marketing and distribution costs, fiscal benefits, skill intensity, capital intensity, vertical integration and the import of capital. Let us examine the hypotheses pertaining to them in the ensuing discussion.

*Firm size*

Firm size is expected to have a positive relationship with exports as larger firms have more resources with which to enter foreign markets. This may be the case if there are high fixed costs to exporting, such as gathering information or covering the uncertainty of a foreign market. There may also be economies of production and marketing, which benefit large firms. The importance of firm size can be expected to vary with the characteristics of the sector, such as economies of scale in the sector. The empirical evidence on the relationship between firm size and export intensity is mixed. Lall (1986) has found that firm size is significant in the case of engineering firms. However, the findings of Patibandla (1988a) in the case of Indian engineering industry, and Bonaccorsi (1992) in the case of Italian industry point out the dominance of small and medium sized firms in export.

In addition to firm size, the quadratic term of firm size is used to test for non-linearities in the relation ship between size and exports. It is possible that a minimum size is required to overcome additional costs of exporting, beyond which increase in size has no impact on export intensity. The argument is that, although size is an advantage in exporting, this may not apply to very large firms, which may be orientated towards the domestic market because of, say, monopoly in the domestic market (Siddharthan, 1994, Willmore, 1992). A firm faced with domestic monopoly can exploit domestic demand; a foreign market would typically have a higher elasticity of demand, and would involve the domestic firm

becoming a price taker. Thus, the quadratic term of size is expected to have a negative coefficient.

For similar reasons, the market power of the firms is also expected to have a negative impact on export. There have been arguments that a concentrated domestic market would be a disincentive for firms to export (Kumar, 1990, Evenson and Joseph, 1997).

*Foreign Equity Participation*

The role of Foreign Direct Investment (FDI) in the export intensity of firms has been the subject of much debate. The vast body of literature pertaining to FDI and its impact on trade is well illustrated in Joseph (1999). There is no unanimity among studies regarding the role of foreign investment in promoting the export intensity of firms. On the one hand, there are studies, which present a strong case for foreign investment based on the better export intensity by the foreign firms[4]. At the same time, there are studies, which underscore scepticism of either superior performance of domestic or no significant difference between them in their export performance[5]. The differential influence of foreign investment on decision to export and export intensity is another aspect that needs to be analysed. Joseph (1999) found that while the foreign ownership has no statistically significant effect on the decision to export, it has a negative effect on export intensity. This reaffirms the general apprehension that foreign firms are interested more in exploiting the domestic market than exporting their products from India. It is, therefore, expected that foreign investment is significant in influencing the decision to export but is insignificant in affecting the export intensity of firms.

*Selling Cost*

Expenditure on advertisement and marketing can improve the quality of the products and hence the non-price competitiveness (Kumar and Siddharthan, 1993). This is because in the process of building brand and trade names Indian enterprises are likely to become

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[4] For a review of literature on studies which underscored the export propensity of foreign controlled/owned firms, see, Cohen, 1975, Willmore, 1976, 1986, Lall and Mohammed, 1983, Willmore, 1992 etc.

[5] For a review of studies which are skeptical on foreign controlled/owned firms' export propensity, see Jenkins, 1979, Subrahmanian and Pillai, 1979, Newfarmer and Marsh, 1981, Lall, 1986, Kumar and Siddharthan, 1993, Pant, 1993, Subrahmanian and Joseph, 1994, Subrahmanian et al, 1996, Athukorala et al, 1995.

conscious of the need to improve quality. Hence a positive relationship is expected between advertisement intensity and export intensity as well as decision to export.

*Capital Intensity*

It is legitimate to argue that in a labour abundant country like India, comparative advantage[6] may arise from a higher proportion of labour relative to capital in the production process. At the same time, a higher capital intensity is symptomatic of a better technology at least in high technology industries. We, therefore, hypothesise that a higher capital intensity will indeed positively influence the decision to export and export intensity.

*Vertical integration*

Vertical integration enables a firm to achieve cost competitiveness through sourcing most of the inputs from the firm itself[7]. However, the opening up of the economy is likely to enable firms to acquire inputs from abroad, which can substitute in house production. It is, thus, possible that vertical integration can have a positive or negative influence on the decision to export and export intensity.

*Import Intensity*

It is only to be expected that firms resort to purchase of inputs from abroad to improve the quality and reduce cost and hence the competitiveness. It is thus assumed that a positive relationship exists between import intensity and exports[8]. The increased intensity of intra industry trade in the case of India (Veeramani, 1998), lends support to the assumption that a higher import intensity is associated with a higher export intensity. Furthermore, as superior quality of the exportables is a prerequisite for them to be accepted in developed foreign markets, it is assumed that import intensity is positively associated with the

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[6] While earlier studies such as Pant, 1993 and Subrahmanian and Joseph, 1994, found the existence of a Hecksher-Ohlin kind of situation in the export of Indian manufactures, Kumar and Siddharthan, 1993, have found a significant positive relationship between capital intensity and export intensity in high technology industries.

[7] Joseph, 1999, argues that vertical integration is important in influencing the decision to export and export intensity of firms catering to certain markets where, cost competitiveness is important.

[8] While Joseph (1999) finds import intensity to be a significant factor in influencing the decision to as well as intensity of export, the study by Kumar and Siddharthan (1993) does not indicate any such relation ship.

decision to export.

*Profitability*

A higher profit[9] can obviously enable a firm to tide over the risks associated with breaking into foreign markets. It can also capture to some degree, the extent of tax concessions and other incentives provided by the government. It may positively influence the export intensity as well, because firms with a higher profit would be able to overcome temporary fluctuation in export prices and exchange rates than those with a lower profit. Because of the reasons cited above a positive relationship is presumed to exist between profitability and both export decision and export intensity. It may, however, be noted that, the study by Kumar and Siddharthan (1993) found profit to be significant only in four out of the 13 industries examined.

*Fiscal Benefits*

The governmental effort[10] in facilitating exports particularly in a liberalised economic regime can partially be captured by the extent of fiscal incentives rendered to firms by way of tax concession and subsidies. It is, however, to be noted that the liberalisation bestows a different kind of incentive for firms in the form of a liberalised exchange rate. Like the profitability variable, this variable is also expected to have a positive impact on both the aspects of export.

*Skill Intensity*

The skill content of the labour force has been a traditional explanation for many of those empirical results, which questioned the validity of comparative advantage doctrine. It is argued that, goods with a higher skill content embody a higher technology and hence have a comparative advantage over goods with a lower skill content[11]. It is hypothesised that skill intensity exerts a positive influence on exports.

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[9] While profitability has been found to be a significant influence on the export intensity by firms in the studies of Pant, 1993, Subrahmanian and Joseph, 1994, and Subrahmanian et al, 1996, an opposite result has been obtained by Kumar and Siddharthan, 1993, and Joseph, 1999.

[10] In their pre liberalisation period analysis, both Lall, 1986 and Kumar and Siddharthan, 1993, have found government's role to be crucial in augmenting exports.

[11] While Kumar and Siddharthan, 1993 in the Indian context and Wignaraja, 1998, in the context of Sri Lanka have found skill intensity to be a significant determinant of export intensity, the study by Lall, 1986 shows that skill intensity is insignificant in engineering industry.

The above hypotheses may be translated into the two following models.

The decision to export may be expressed as,

Prob (Exporting)= $f$ (R&D expenditure, Technology Import, Import Intensity, Vertical Integration, Sales, Square of sales, Market Share, Fiscal Benefits, Selling Cost, Profitability, Skill Intensity, Capital Intensity, Foreign Share, Period Dummy)

Export intensity may be modelled in the following way,

Export Intensity = $f$ (R&D expenditure, Technology Import, Import Intensity, Vertical Integration, Sales, Square of sales, Market Share, Fiscal Benefits, Selling Cost, Profitability, Skill Intensity, Capital Intensity, Foreign Share, Period Dummy)

## III The Sample and the Construction of Variables

The sample of firms in the electrical machinery industry used in the study is classified into exporting and non-exporting firms. Since not all firms have been exporters through out the period of analysis we define an exporting firm for a particular period (pre or post liberalisation) as one that has reported exports at least once during that period. Thus a firm which is an exporter in one particular period may become a non-exporter in the other.

The sample frame has 710 observations with 91 exporting and 65 non-exporting firms for the period 1988-89 to 1995-96. During the pre liberalisation period (1989-92) there are only 53 non-exporting firms as against 61 exporting firms. In the post-liberalisation period (1993-96) the number of firms in the former has declined to 43 and the latter increased to 84.

### Construction of Variables

Among the several variables used, R&D and technology import need special mention. The data provide information regarding two kinds of R&D viz., R&D capital as well as R&D current. The two are added up to get the total R&D expenditure by firms. The technology import variable has two components, namely royalty payments and lumpsum payments.

While royalty payments represent the regular stream of income flowing out of the country as remuneration to technology transfer, lumpsum payments are the fees paid for a technology once and for all. In the data, however, royalty and lumpsum payments are clubbed together as a single variable representing most of the disembodied technology transfer.

Since, all the variables have been standardised by dividing them with sales, no attempt has been made to deflate the variables. However, we have deflated gross sales with the Whole Sale Price Index of Electrical Machinery industry for the period 1988-89 to 1995-96, with 1980-81 as the base year. For convenience, variables have been renamed using different codes. The definitions as well as the coding of the variables are given in Table 4.1.

To further delineate the nature of variables used and inter firm variability during each period, the summary statistics for each period has been constructed (see Table 4.2).

Table 4.1: *Variable Construction and Coding*

| Variable | Code | Definition |
|---|---|---|
| Export Intensity | EXPINT | Ratio of Exports to sales |
| R&D Intensity | RD | Ratio of R&D to sales |
| Technology Import Intensity | TECHIMP | Ratio of technology import to sales |
| Import Intensity | IMPINT | Ratio of total imports to sales |
| Vertical Integration | VINT | Ratio of gross value added to sales |
| Gross Sales | SALES | Value of sales in Rs. Crores deflated by the whole sale price index of electrical Machinery Industry for the period 1988-89 to 1995-96. |
| Square of Sales | SALES2 | Square of Sales |
| Market Share | MSHARE | Market share of each firm belonging to different industry groups as defined in 'Market and Market Share' of CMIE. |
| Fiscal Benefits | FBEN | Ratio of fiscal incentives to sales |
| Selling Cost | SCOST | Ratio of selling cost to sales |
| Profit | PROF | Ratio of retained profit to sales |
| Skill Intensity | SINT | Ratio of total emoluments paid to employees to the value of output |
| Capital Intensity | CAPINT | Ratio of Gross Fixed Assets to sales |
| Foreign Share | FSHARE | Percentage share of foreign equity in a firm's total equity |
| Period Dummy | PDUM | It takes a value 1 for post liberalisation period and 0 for pre-liberalisation period |
| Probability of Exporting | EXP | It takes a value 1 for exporting firms and 0 for non-exporting firms |

In table 4.2, high standard deviations of different variables indicate, despite the removal of several outlier variables, the high inter-firm differences in the sample. This may be more evident from the large difference between the minimum and maximum values of different variables. The table also shows that in the case of variables like export intensity, R&D, technology import etc, for instance, an increase in the mean value between the periods, with the increase quite substantial in the case of R&D.

Table 4.2 *Summary Statistics of Variables Used in the Model*

| | Pre-Liberalisation | | | | Post-Liberalisation | | | |
|---|---|---|---|---|---|---|---|---|
| | MEAN | SD | MIN | MAX | MEAN | SD | MIN | MAX |
| EXPINT | 3.11 | 5.37 | 0.00 | 28.10 | 3.77 | 6.69 | 0.00 | 30.17 |
| RD | 0.02 | 0.14 | 0.00 | 1.53 | 0.35 | 1.03 | 0.00 | 13.16 |
| TECHIMP | 0.21 | 0.54 | 0.00 | 6.02 | 0.21 | 0.67 | 0.00 | 8.11 |
| IMPINT | 7.33 | 7.60 | 0.00 | 46.11 | 8.69 | 8.19 | 0.00 | 35.20 |
| VINT | 21.27 | 8.00 | -0.46 | 55.06 | 21.11 | 7.88 | -3.53 | 53.25 |
| SALES | 43.82 | 57.35 | 0.37 | 374.35 | 44.63 | 4.19 | 0.55 | 531.75 |
| MSHARE | 14.58 | 20.19 | 0.00 | 92.00 | 11.50 | 5.47 | 0.00 | 76.00 |
| FBEN | 0.46 | 1.27 | 0.00 | 16.55 | 0.33 | 1.19 | 0.00 | 13.41 |
| SCOST | 3.35 | 2.97 | 0.00 | 18.25 | 3.49 | 3.34 | 0.00 | 20.35 |
| PROF | 2.44 | 5.67 | -48.60 | 19.30 | 3.07 | 6.98 | 48.68 | 40.15 |
| SINT | 10.17 | 6.05 | 0.35 | 31.25 | 9.16 | 6.13 | 0.70 | 34.83 |
| CAPINT | 89.26 | 52.73 | 25.50 | 471.43 | 97.83 | 2.81 | 33.17 | 630 |
| FSHARE | 11.87 | 20.34 | 0.00 | 78.10 | 10.44 | 8.66 | 0.00 | 78.10 |

A notable exception to this general trend has been the reduction in average fiscal benefits between the periods. This may, however, be interpreted as a shift in the nature of government support to exporters from direct subsidies and tax concessions to liberalisation of exchange rate.

With a view to examine the presence of multicollinearity, a correlation matrix (Table 4.3) has been constructed. The correlation matrix shows the absence of a high degree of correlation between different variables. To avoid hetroscedasticity, as has already been noted, variables have been standardised by dividing them with sales. Having stated the data and variables, let us now proceed with the empirical estimation.

Since only a select number of firms are found to be exporters, and the dependent variable takes a binary form, the export decision has been estimated with a probit model of the following type,

Prob (EXP)= $\alpha 0 + \alpha 1$ RD + $\alpha 2$ TECHIMP + $\alpha 3$ IMPINT + $\alpha 4$ VINT + $\alpha 5$ SALES + $\alpha 6$ SALES2 + $\alpha 7$ MSHARE + $\alpha 8$ FBEN + $\alpha 9$ SCOST + $\alpha 10$ PROF + $\alpha 11$ SINT + $\alpha 12$ CAPINT + $\alpha 13$ FSHARE + $\alpha 14$ PDUM

where

Prob (EXP) = $e^{xb} / 1 + e^{xb}$

The issue of export intensity has been analysed with an Ordinary Least Square Equation (OLS) of the following type,

EXPINT = $\beta 0 + \beta 1$ RD + $\beta 2$ TECHIMP + $\beta 3$ IMPINT + $\beta 4$ VINT + $\beta 5$ SALES + $\beta 6$ SALES2 + $\beta 7$ MSHARE + $\beta 8$ FBEN + $\beta 9$ SCOST + $\beta 10$ PROF + $\beta 11$ SINT + $\beta 12$ CAPINT + $\beta 13$ FSHARE + $\beta 14$ PDUM

Table 4.3 *The Correlation Matrix of Variables*

| | EXP | EXPINT | RD | TECHIMP | SALES | SALES2 | MSHARE | FBEN | SINT | PROF | SCOST | VINT | CAPINT | IMPINT | FSHARE | PDUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXP | 1.0 | | | | | | | | | | | | | | | |
| EXPINT | 0.4 | 1.0 | | | | | | | | | | | | | | |
| RD | 0.1 | 0.1 | 1.0 | | | | | | | | | | | | | |
| TECHIMP | 0.0 | 0.1 | 0.1 | 1.0 | | | | | | | | | | | | |
| SALES | 0.3 | 0.1 | 0.1 | 0.0 | 1.0 | | | | | | | | | | | |
| SALES2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.9 | 1.0 | | | | | | | | | | |
| MSHARE | 0.3 | 0.1 | 0.0 | 0.1 | 0.3 | 0.1 | 1.0 | | | | | | | | | |
| FBEN | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | | | | | | | | |
| SINT | 0.1 | 0.0 | 0.1 | -0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 1.0 | | | | | | | |
| PROF | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | -0.1 | -0.3 | 1.0 | | | | | | |
| SCOST | 0.2 | 0.2 | 0.0 | -0.1 | 0.0 | -0.1 | 0.3 | 0.0 | 0.1 | -0.2 | 1.0 | | | | | |
| VINT | 0.0 | 0.2 | 0.2 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.3 | -0.1 | 1.0 | | | | |
| CAPINT | -0.1 | 0.1 | 0.0 | 0.1 | -0.1 | 0.0 | -0.2 | 0.1 | 0.0 | -0.2 | 0.0 | 0.4 | 1.0 | | | |
| IMPINT | 0.1 | 0.2 | 0.0 | 0.2 | 0.1 | 0.1 | 0.0 | 0.1 | -0.3 | 0.1 | -0.1 | 0.0 | 0.1 | 1.0 | | |
| FSHARE | 0.2 | 0.1 | 0.0 | 0.3 | 0.4 | 0.3 | 0.3 | -0.1 | 0.0 | 0.1 | 0.1 | 0.0 | -0.1 | 0.1 | 1.0 | |
| PDUM | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | -0.1 | -0.1 | -0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.0 | 1.0 |

## IV Empirical Results

### Export Decision

The estimation results of probit and OLS models are given in Table 4.4. Let us begin with the results of the probit model. The estimation of the model shows that while R&D is a highly significant determinant of the decision to export, technology import does not show any influence on firms' decision to export. In other words, to be able to export, a firm needs to develop a certain amount of in-house technological capability. The insignificance of technology import in the probability of exporting may imply that firms, which intend to explore foreign markets, are placed at a disadvantage in terms of access to and cost of technology. The fact that technology import is not an important determinant of decision to export may indicate that foreign technology comes with restrictions on the export of goods produced using imported technology[12].

The significance of the existence of a particular kind of technology behaviour with respect to decision to export and export intensity would be more clear after our analysis of export intensity.

Other firm specific factors that have been found significant in export decision are sales, square of sales, market share, import intensity, fiscal benefits, selling cost, and skill intensity. All these variables, except square of sales, are found to have a positive influence on the export decision.

[12] In this context, it is interesting to note that in their study, Evenson and Joseph (1997) attributed the reluctance of firms to resort to technology import, to the fact that technology import in Indian machinery industry may be associated with restrictions on exports or higher payments for technology where exporting is involved

Table 4.4: *Probit estimate on the factors influencing the decision to export and the OLS estimate on the intensity of export*

| Variables | Probit | OLS Estimate |
|---|---|---|
| No. of Observations | 710 | 509 |
| Intercept | -0.84*<br>(-4.22) | -0.02***<br>(-1.72) |
| RD | 28.54**<br>(2.13) | -0.62<br>(-1.35) |
| TECHIMP | -10.63<br>(-0.88) | 2.53*<br>(2.96) |
| IMPINT | 1.88*<br>(2.54) | 0.13*<br>(3.13) |
| VINT | -1.34<br>(-1.07) | 0.26*<br>(3.52) |
| SALES | 0.014*<br>(5.48) | -0.00006<br>(-0.62) |
| SALES2 | -0.00003*<br>(-3.1) | 4.18e-07<br>(1.46) |
| MSHARE | 1.43*<br>(3.28) | 0.003<br>(0.20) |
| FBEN | 16.46*<br>(3.16) | 0.91*<br>(4.12) |
| SCOST | 10.50*<br>(5.10) | 0.34*<br>(3.69) |
| PROF | 2.12<br>(1.54) | 0.08<br>(0.97) |
| SINT | 3.36**<br>(2.30) | -0.14<br>(-1.58) |
| CAPINT | -0.11<br>(-0.70) | -0.01<br>(-0.74) |
| FSHARE | 0.04<br>(0.12) | 0.002<br>(0.12) |
| PDUM | 0.16<br>(1.37) | 0.001<br>(0.12) |
| F statistics | -- | 8.80* |
| $R^2$ | 0.21 | 0.21 |
| Log Likelihood | -359.62 | -- |
| Chi2 | 218.38* | -- |

Note:

1. *Significant at 1% level, **Significant at 5% level, ***Significant at 10% level.
2. $R^2$ for the probit model is pseudo R2.

Regarding firm size, the results indicate that firms, which enjoy certain scale economies, are better positioned to break into world markets than those, which possess a lower sales turn over. This may suggest that a certain amount of scale economies is desirable in becoming an exporter. The negative influence of the square of size variable indicates, as with the predictions of several other studies that, there exists an inverted U-shaped relation ship between firm size and the decision to export. In other words, while a minimum firm size is required for facilitating export, after a certain limit, firm size is a disincentive on the decision to export by firms.

Our results reveal that market power exerts a positive influence on the firms' ability to find markets for their products abroad. This is in line with the arguments one often confronts in the new or strategic trade literature that if domestic firms are given certain amount of protection in home markets from foreign competition, they can reap the benefits of economies of scale and would be better positioned to penetrate into imperfect markets abroad.

Fiscal incentives in the form of tax concessions and subsidies appear to have exerted a significant influence on the decision to export by firms. The insignificance of period dummy indicates that the returns to policy reforms of the 1990s in the form of enhanced incidence of exports is yet to be realised. The significance of skill intensity in the decision to export suggests that the skill content of the work force is enabling firms to export, presumably more technically advanced goods. This in turn affirms the neo-endowment predictions that skill intensity is an important influence on comparative advantage. It is, however, to be noted that the role of skill intensity depends much on the destination of export[14].

The significance of selling cost variable points to the present day reality that developing a good brand image through advertisement, marketing and other sales promotion schemes is as important as improving the quality of the product through technological up gradation to

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[14] For instance, Indian exports with a high skill intensity may have a comparative advantage in markets where they compete with goods from other developing countries than those coming from developed countries.

attract the attention of consumers. This may also be a manifestation of the greater preparedness of Indian firms to take on global giants in foreign markets. Another interesting finding of the present study is the positive influence of import intensity on the probability of exporting by firms. With the liberalisation of imports of inputs and greater incidence of intra-industry trade it is likely that its influence goes up in the near future. The higher import intensity may also be partly responsible for R&D becoming significant in the export decision, as a higher R&D may be required to adapt imported inputs to domestic market conditions.

**Export Intensity**

In tune with our hypothesis on technology behaviour of firms, the results indicate that while the role of R&D is confined mainly to enable firms to export, it is technology import that is decisive in improving the export performance. This reflects the fact that, in improving external competitiveness, firms take greater recourse to import of technology for upgrading the production process and product quality, while it is imperative that a certain amount of technological know through in-house R&D is developed in order for a firm to export. This aspect of technology behaviour of firms indicates, as against the predictions of some earlier studies[15], that the import of technology exerts a larger influence on the export intensity of firms than in-house R&D in the electrical machinery industry.

Other factors with significant bearing on export intensity are import intensity, vertical integration, fiscal benefits, selling cost, with the notable exceptions being sales and market share.

The insignificance of size, size2 and market share variables may suggest that scale economies as well as domestic monopoly may not always be an advantage in improving export performance. These findings are partly in agreement with the argument that if firms operate in a concentrated market and enjoy market power at home, they may prefer the relatively easier life of selling domestically to the more troublesome one of exporting[16].

The significance of fiscal benefits in augmenting export intensity points to the important

[15] See, for instance, Kumar, 1990, Evenson and Joseph, 1997 etc.
[16] Glejser et al, 1980, for instance, hold such a view.

role played by the government in augmenting exports even in the context of liberalisation and the subsequent marketisation of economic activities. The important feature of selling cost by firms as having a significant impact on export intensity substantiates our argument that building up a good brand image is vital in improving the export competitiveness.

While vertical integration is not a significant factor in influencing the decision to export, it has assumed significance in the realm of export intensity. Also significant is the import intensity variable suggesting that firms, which strive to improve the export competitiveness, follow a two pronged strategy of improving product improvement on the one hand and cost competitiveness on the other. The former, it can be inferred, is achieved by importing inputs and components and technology from abroad, and the latter by doing away with the traditional habit of ancillarisation and subcontracting.

## V Concluding Observations

Our examination of technological behaviour of firms shows that while R&D is significant in influencing the decision to export, technology import exerts influence on the intensity of export. This is indicative of the technological spending pattern of firms as being guided by a judicious combination of in-house R&D and Technology Import. Given the constraints imposed by a fixed technology budget, firms resort to in house R&D effort sufficient enough to generate certain basic capabilities and supplement it by a wide range of technological opportunities available elsewhere through technology import. Our results on the role of technology import in influencing the intensity of export, is consistent with the results of Lall (1986) -where license fees is used as the proxy- Kumar and Siddharthan (1993), and is not in agreement with the findings of Kumar (1990), Evenson and Joseph (1997). The findings on R&D in the case of decision to export do not agree with the results of Willmore (1992). The insignificant role of R&D in influencing export intensity, is in line with the results of Lall (1986), Kumar (1990), Willmore (1992) and Wignaraja (1998) and does not tally with the those of Pavitt et al (1980) and Wakelin (1997). Though liberalisation measures initiated in the nineties are yet to make an impact on firm level exports as indicated by the lack of significance of period dummy, it can be inferred from the significance of technology import and import intensity that the liberal import and technology policies implemented as part of reforms are enabling firms to acquire modern technology from abroad.

The results of the present study also show that the decision to export and export intensity are not shaped by the same set of factors. The only factors found significant in the both equations are import intensity, fiscal benefits and selling cost. This finding is in contrast to the earlier studies carried out under the controlled policy regime. However, our results are in agreement with the studies by Willmore (1992), for Brazil, Athukorala et al (1995), for Sri Lanka, and Wakeline (1997), for British manufacturing firms, all of which found that it is not the same set of factors that influence the decision to export and export intensity. It may be noted that apart from technology import, a factor that is significant in influencing only the intensity of export is vertical integration. The lack of significance of FDI may be viewed from the point of view of ongoing campaign for attracting FDI, which leaves much to be desired. The insignificance of FDI is in agreement with the finding of, for instance, Lall (1986), Kumar and Sddharthan (1993), Subrahmanian and Joseph (1994), Subrahmanian et al (1996) etc. The significance of fiscal incentives points towards the role of government incentives even in a liberalised economic regime.

In conclusion it can be stated that technological factors are significant in influencing the trade behaviour of firms in a high technology industry like electrical machinery. The technology behaviour of firms, given the technological options available, mainly R&D and technology import, has been found to be crucial in influencing the decision to export and export intensity. While the former is an important determinant of the decision to export, the latter exerts influence on the intensity of export. Finally, our analysis reveals that in the context of Indian electrical machinery, the decision to export and export intensity are shaped by different set of factors.

CHAPTER V

# Summary and Conclusion

The focus of the present study has been an analysis of the role of technology behaviour of firms in the decision to export and export intensity. The study has also analysed whether the same set of factors, technological and otherwise, influence the decision to export and export intensity. In order to maintain homogeneity of firms the study has been confined to that of Indian Electrical Machinery Industry.

With a view to focus the issue of firm level technological capability and export, an examination of the theoretical and empirical literature on technology and trade has been carried out. It has been observed that the treatment of technology by different theories of international trade has been different. The neo-technology theories of trade differed from others by placing technology at the centre stage. A new approach within the neo-technology frame work focussed on the role of governments in developing countries building up certain capabilities for firms to acquire technological capability, and hence influencing the comparative advantage of the sector and the country as a whole. This approach, viz., the 'capability approach' evolved mainly to bridge the missing links in neo-technology theories when applied to developing countries. These theories also recognised the imperfections in markets and called for government intervention in developing certain capabilities which are a prerequisite for the economy to attract foreign technology and investment as well as for firms to develop their own technological capability.

Given the data requirement of our analysis, we have undertaken an examination of the kind of data on such aspects as production, trade, technology etc, available in official as well as a private source of data. It has been found that official statistics on production and trade are plagued with a number of problems such as non-harmonisation owing to different codes of classification, inadequate representation of certain key variables like technology and the lack of sufficient degree of disaggregation. The official statistics on technology lacks information on the magnitude of technology transfer, inadequate information on firm level R&D and so on. The private data source, Prowess, which the

current study has made use of, overcomes some of the problems faced by the official statistics owing mainly to the fact that it provides firm level information. It, however, has the shortcoming of being a sample and hence, non-representative in the case of some industries which are dominated by non-listed firms. Furthermore, the data also has the deficiency of inconsistent reporting of some variables.

As is well known, an important objective of the opening up of the economy has been to improve the efficiency of Indian firms as well as to integrate them with international markets through removal of restrictions on the import of inputs, technology, foreign direct investment etc. This implied that firms which were content with their own in-house R&D effort in improving technical knowledge are now having the prospects of acquiring technology from abroad, which could substitute or complement their in-house R&D effort. Given that firms operate with a limited technology budget, this opens up the possibilities for firms to strike a particular combination of R&D and technology import. Our analysis has shown that the technology behaviour of firms with respect to R&D and technology import is of much significance in influencing the decision to export and export intensity. While R&D has been found significant in the decision to export, technology import is significant in influencing the intensity of export. This may suggest that firms require a certain amount of in-house technological effort before they can aspire to export, and to improve their performance they need technological upgradation through import of technology. This points to the fact that liberal technology policies that are being pursued today are of paramount importance as regards the trade performance of firms. It also underscores the need for initiating policy measures towards enhancing in-house R&D activities within firms. Another variable that has been found significant positively in influencing both export decision and export intensity is import intensity. The important role played by the technology variables in influencing both aspects of export underscores the predictions of neo technology theories of trade, which considered technology as an important determinant of trade flows.

While it is generally assumed that in a large country like India, the same set of factors influence the decision to export and intensity of export, we have found that except three variables, the factors influencing these two aspects are different. This may indicate that to be able to export is one thing and to improve export performance is another. For instance, though vertical integration has been found significant positively in influencing the intensity of export, it is insignificant in the decision to export. This could be due to, firms, while trying to break into foreign markets, go in for import of inputs with very little attention paid to cost competitiveness (less insourcing). However, it may be the case that cost competitiveness assumes importance, through greater vertical integration by way of a reduction in domestic ancillarisation and subcontracting, when firms need to improve their export performance.

The firm size variable has been found positively significant in influencing the decision to export alone, without any significant impact on the intensity of export, pointing to the fact that while scale economies are important in penetrating into foreign markets, its role is insignificant in improving export performance. A similar result has been obtained in the case of market share as well.

Fiscal incentives and selling cost are the two other variables, apart from import intensity, that has been found positively influencing both decision to and intensity of export. The significant influence of fiscal incentives goes contrary to the popular notion about government's minimal role in a liberalised market economy, and augurs well for greater outward orientation of the economy. The significance of advertisement, in the decision to and intensity of export, implies that along with product quality and price competitiveness, developing a good brand image is also a prerequisite for being successful in international markets.

To sum up, our analysis of the technology-trade behaviour of firms show that the two components of technology, viz., R&D and technology import, exert a differential influence on decision to export and export intensity. While R&D is significant in influencing the former, technology import is significant in affecting the latter. This

result, which underscores the importance of technology import and in-house R&D, is in conformity with the predictions of capability approach in the neo-technology trade theories. The second aspect of our analysis has been to examine whether the same set of factors influence decision to as well as intensity of export. The results show that the factors influencing these two aspects are different, except for import intensity, fiscal benefits and selling cost. Apart from the above three factors, the decision to export is influenced by R&D, sales, market share and skill intensity positively as well as quadratic term of sales negatively; and factors like technology import, vertical integration are found playing important role in determining the observed export intensity of firms. Finally, the lack of significance of period dummy may suggest that the trade liberalisation measures initiated are yet to give their returns in terms of influencing the firm level decision to export and export intensity.

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