CHAPTER 7

SUMMARY, CONCLUSIONS AND AVENUES FOR FURTHER RESEARCH
The present chapter seeks to make a summary of the study and identify the conclusions that may be derived from the findings of the study. The chapter also points out the avenues for future research in this field/domain. It has been divided into three sections. Section 7.1 contains the summary, conclusions are presented in Section 7.2 and 7.3 is concerned with the avenues for future research.

7.1 Summary of the study

Chapter 1 was introductory albeit it unveiled how globalisation resulted in structural transformation of the manufacturing sector across the globe, thereby, invoking the consideration of the concept of ‘technological regime’. When agriculture based economy embraces the strategy of industrialisation and while treading, gradually, along that path, suddenly experiences a surge in the contribution of the service sector in its GDP more than in comparison with that of the manufacturing sector it needs a serious reappraisal of the transformation. In this chapter in course of delineating the multidimensional role played by the manufacturing sector for sustenance of an economy the study reexamined the status of Indian manufacturing.

The issue of technology is closely associated with manufacturing but the qualitative improvement of the manufacturing cannot be properly explained in terms of production function approach pertaining to technology as was done by the Neoclassicists- this critique comes from the evolutionary theorising of economic principles of which Nelson and Winter (1982) was the main proponents. This study, following the evolutionary approach, invoked the idea of technology regime and explored how globalisation was responsible for changing perspective of the structure of manufacturing across the globe which, in turn, called for rethinking about the concept of technology regime. In this chapter the role of India’s manufacturing sector was analysed and the nature of India’s technology regime was explored in the context of India’s manufacturing sector. The trend of the variables representing the elements of technology regime of an economy, namely, R&D expenditure incurred, technology import-embodied and disembodied- measured by the import of capital goods and payment of royalty and technical fees by the country abroad respectively and the exports of technology intensive goods were analysed in the chapter.
Chapter 2 was concerned with the survey of the existing literature. It also pointed out the importance and limitations of the relevant literature and finally indicated the research gap which the present study sought to cover.

Chapter 3 contained the objectives, data source, research methodology, significance and limitations of the study.

The principal objective of the present study was to examine the impact of globalisation ushered thorough a phenomenal growth of technology and knowledge on the technological regime of a country like India. In order carry out such investigation the study tried to underpin (a) the rationality behind assessing the traits of India’s technology regime undergoing change in the context of the liberalisation of the economy with reference to India’s manufacturing sector.

(b) Secondly, the study also intended to examine the impact of globalisation on India’s technology regime in a macroeconomic perspective. In order to do so, the impact of the import of technology by India on national expenditure on R&D and the impact of R&D activity on technology intensive exports were studied empirically.

(c) The third objective of the study was to evaluate how, after liberalisation, technological innovation and adoption measured by R&D intensity (R&D expenditure as proportion of sales) was influenced by size of the manufacturing industry (measured by sales turnover), outward orientation measured by earning in foreign exchange(as proportion of sales) and outward orientation measured by exports f.o.b.(as proportion of sales), import intensity of embodied technology(import of capital goods as proportion of sales) and import intensity of disembodied technology(payment of royalties, technical fees etc., by domestic firms abroad as proportion of sales). This was done in the perspective of India’s manufacturing industries in an aggregative framework.

(d) The fourth objective of the study was to examine the impact of liberalisation on India’s technology regime at the disaggregated level. In order to accomplish this, factors influencing the R&D Intensity of India’s manufacturing firms were explored and the relative importance of the factors were assessed empirically.
The data on national expenditure on R&D in current prices were obtained from the Research and Development Statistics: 2007-08- National Science and Technology Management Information System; Department of Science and Technology; Government of India for the period 1980-81 to 2007-2008.

The data on the import of technology in embodied form (import of capital goods) in current prices for the period 1980-81 to 2007-2008 were obtained from the Handbook of Statistics of the Indian Economy: 2010-11, Reserve Bank of India.

The data on the import of technology in disembodied form (payments of royalties, technical fees, etc. by the Indian firms to the foreign firms) in current prices for 1980-81 to 2007-2008 were obtained from the India’s Balance of Payments: Concepts, Compilation and Recent Scenario: 1950-51 to 2003-04 (EPW Research Foundation: February-05), Reserve Bank of India (RBI) Bulletin, April 7, 1999 and RBI Bulletin, March 10, 2010.

The Capitaline Corporate Database, Mumbai, 2009 was used to obtain data on R&D expenditure made by manufacturing industries in India, annual sales turnover, exports of products (f.o.b), foreign exchange earnings in the forms of royalties, technical fees, etc., by the Indian manufacturing industries and import of capital goods. Data were obtained for the period 1996-2009 and all items were in Rs. crores. The industries taken into account were Automobile, Cement, Chemicals, Food Processing, Electric Equipment, Electronics, Engineering, Personal Care, Pharmaceuticals, Refineries, Software, Steel, Telecommunications and Textiles. R&D intensity (RDI) was defined as R&D expenditure as proportion of sales turnover, outward orientation-1(OOR-1) was the earnings in foreign exchange as proportion of sales turnover, outward orientation-2(OOR-2) was exports (f.o.b.) as proportion of sales turnover. payments of royalty and technical fees as proportion of sales turnover was the import of disembodied technology intensity (DTI) and import of capital goods as proportion of sales turnover was the import of embodied technology intensity (ETI) and TECHIM is the technology import intensity which was the sum of embodied and disembodied technology import as proportion of sales.
The Capitaline Corporate Database was also used to obtain data for the Indian manufacturing firms relating to annual sales turnover, R&D expenditure, Profit before tax (PBT), exports of firms (f.o.b) representing Outward Orientation-1, earnings of foreign exchange against sharing knowledge and expertise with foreign firms denoting Outward Orientation-2, import of capital goods representing import of embodied technology (ET) and payment of royalty, technical fee, etc. abroad against acquiring knowledge, technical knowhow, etc. representing import of disembodied technology(DT).

R&D, PBT, Outward Orientation-1, Outward Orientation-2, ET and DT were expressed as percentage of annual sales turnover converting the variables to R&D intensity (RDI), PBTS, OOR-1, OOR-2, ETI and DTI. Market share (MSH) was expressed as the proportion of sales of the respective firms to the sales of the industry; the data for the latter were also obtained from the same source. All the items were expressed in Rs. crores.

While selecting the firms the objective was to obtain data covering as long a period as possible. A thorough screening of the database helped in consolidating data for the following number of firms in connection with the different industries:

- Automobiles - 06
- Cement - 05
- Electric Equipment - 11
- Electronics - 06
- Engineering -11
- Food Processing - 02
- Chemicals -14
- Personal Care - 05
- Pharmaceuticals -15
- Refinery - 05
- Software - 04
- Steel - 04
- Telecommunications - 03
- Textiles - 07

Methodology of the study included the calculation of compound annual growth rates of the relevant variables and the techniques of log-linear models of regression and multiple regression were adopted.

Moreover, the chapter enumerated the significance and limitations of the study.

Chapter 4 was concerned with studying the impact of India’s imported embodied technology on R&D and also the impact of public R&D on India’s exports of High Technology products at the macroeconomic perspective. The log-linear model of regression was applied. Before that the Augmented Dickey-Fuller (ADF) unit root
test was performed for each variable to check whether different time series used in the analyses were stationary or non-stationary.

In Chapter 5, attempt was made to study the impact of globalisation on India’s technology regime at the level of Indian manufacturing industries in the aggregative perspective. Before doing any empirical analysis the nature and status of 14 industries, selected in the study, were discussed. The industries were Automobiles, Cement, Chemicals, Electronics, Software, Telecommunication, Personal Care, Pharmaceuticals, Engineering, Textiles, Refineries, Steel, Food Processing and Electric Equipment. The importance of the variables, namely, R&D intensity (RDI) defined by R&D expenditure as percentage of sales, SIZE measured by annual sales turnover, outward orientation-1 (OOR-1) defined by earnings of foreign exchange by making overseas investment and licensing activity of Indian enterprises by providing technological inputs as proportion of sales, outward orientation-2 (OOR-2) measured by exports (f.o.b) as percentage of sales, import intensity of embodied technology (ETI) measured by import of capital goods as proportion of sales and disembodied technology import intensity (DTI) measured by the payment of royalties, technical fees, etc., as percentage of sales was analysed.

Next, in the pursuit of exploring the impact of globalisation on India’s technology regime at the level of India’s manufacturing industries two models were adopted. In the first model, the influence of industry size and import intensities of embodied and disembodied technologies on R&D intensity of the industries was explored in elasticity terms. In the second model, in order to capture the influence of outward orientation along with the influence of size of the industry and the import of technology on R&D intensity of the industries a multiple regression was run taking R&D intensity as the dependent variable and the explanatory variables were embodied and disembodied technology import intensities, annual sales turnover of the industries as size, export (f.o.b) intensities of firms representing Outward Orientation-1, earnings of foreign exchange against sharing knowledge and expertise with foreign firms denoting Outward Orientation-2 expressed as percentage of sales.
Finally, Chapter 6 discussed the impact of globalisation on India’s technology regime in the perspective of Indian manufacturing firms. Since literature in this area took into account various factors influencing R&D of the firms, this chapter unveiled the importance of R&D intensity, earnings of foreign exchange on account of royalties, technical fees, dividends etc. from abroad, profit margins before tax, market share, royalties and technical fee paid abroad, imports of capital, exports of goods (f.o.b), and size of the firm measured by annual sales turnover. Next, while exploring the impact of different variables on R&D intensities of the manufacturing firms the R&D intensity was regressed on earnings of foreign exchange on account of royalties, technical fees, dividends etc. from abroad as a proportion of its sales, profit margins before tax as proportion of sales, market share, royalties and technical fee paid abroad as proportion of sales, imports of capital goods as proportion of sales, exports of goods (f.o.b) as proportion of sales and annual sales turnover transformed into logarithm for all together 98 firms belonging to the industries selected in the sample, namely, Automobile, Cement, Chemicals, Food Processing, Electric Equipment, Electronics, Engineering, Personal Care, Pharmaceuticals, Refineries, Software, Steel, Telecommunications and Textiles. The details about the firms were given in Appendix 6(a).

7.2 Conclusions of the study

It was revealed that during the period 1970-71 the R&D expenditure in current and constant prices were Rs. 168.0crores and Rs. 244.1crores respectively which as percentage of GDP had been 0.39 in current and 0.05 in constant prices. During the period 1990-91 the R&D expenditure as percentage of GDP rose to 0.77 in both current and constant prices and in 2007-08 it became 0.87% in current as well as constant prices. It became significant about the fact that the bulk of the expenditure on R&D is met by the government though the contribution by the private industries and higher education sectors has been improving moderately since 1995-96.

The number of foreign collaborations was observed to have increased in the post-reform period compared to the pre-reform tenure.
In the period 1970-71, the import of capital goods in India was worth of Rs.403.9crores, i.e. 24.72% of the total imports. During the period 1982-83 the share of this import went down to 19%. In the period 1986-87 the figure rose to 32.28% and though it fell to 13.82% during the period 1990-91 the situation improved thereafter. In spite of the occasional fluctuations the import of capital goods sharply increased to 28.17% of the total imports of the country during the period 2007-08.

During the period 1956-57 to 1970-71 the rate of growth of the payments as royalties, technical fees and copyright was 11.04%, during the period 1971-72 to 1980-81 the growth rate fell to 4.67%, however, it again revived during the period 1981-82 to 1990-91 when the growth rate increased to 24.7%. During the period 1991-92 to 2008-09, the blooming period of liberalisation, the growth rate picked up to 41.98%.

During the period 1970-71 to 2007-08, it was revealed that the proportion of the exports of Low Technology(LT) intensive goods in total exports gradually decreased over time and that of Medium Low Technology(MLT), Medium High Technology(MHT) and High Technology(HT) goods increased gradually.

Drawing upon literature the study observed that the academy-industry linkage has not been vibrant in the Indian scenario and this could not be dispensed with in the context of an emerging technology regime.

The survey of the existing literature done in this chapter revealed that most of the studies about the theme on technology in Indian manufacturing focused on the measurement of productivity in Indian manufacturing, spillover effects of technology ushered through increasing inflow of FDI, technical efficiency of Indian firms, effects of liberalisation on Indian manufacturing and some of these studies underpinned the factors influencing the technology adoption, acquisition and innovation separately rather than concentrating upon the changing character of India’s technology regime and its impact on Indian manufacturing. In this chapter an attempt was made to fill this void by invoking, in the context of Indian manufacturing, an analytical framework for the varying nature of India’s
technology regime after globalisation. The focus of the study was on the macro aspect, industry perspective and analysis at the firm level.

Regarding the impact of the embodied technology import on R&D expenditure the findings suggested that the impact of the variable – Embodied Technology Import (EMTMP) on Research and Development (RD) in the pre-reform period was positive and significant whereas the post-reform scenario showed a reversal of the situation.

Regarding the impact of disembodied technology import (DMTMP) on R&D (RD) expenditure the findings suggested that the impact of the variable DMTMP on RD in both the pre- and post-reform periods were positive and significant.

While studying the impact of overall import of technology it was revealed that in the pre-reform period import of technology had a strong impact on carrying out R&D but the post-reform phase showed negative impact. Lastly, in the pre-reform period the impact of R&D on High Technology intensive goods (HT) exports was positive and significant whereas in the post-reform period the impact was negative.

In the context of studying the impact of globalisation on India’s technological regime in an aggregative framework of India’s organised manufacturing industries the trend of the variables was discussed. Compound annual growth rates were calculated for the variables during the period 1996-2009. It was observed that SIZE registered highest growth in the Software industry and next to it, were the industries, namely, Telecommunications, Refineries, Food Processing, Engineering, Electric Equipment, Pharmaceuticals, Steel, Electronics, Cement, Automobiles, Personal Care, Chemicals and Textiles.

Regarding the trend of the RDI (R&D expenditure a proportion of sales) it was revealed that the highest RDI in the case of the Automobile industry was achieved in the year 1998, though in the years 2005, 2008 and in 2009 it was better, however, that could not reach near the figure 38.47 achieved in 1998. The figures higher than average were found during the period 1996-2001. In the case of the Cement industry higher than average were the figures in 1996, 2006, 2007
In the Chemicals industries four years exhibited higher than average values, in the case of the Food Processing industry, five years exhibited higher than average values, in the case of Electric Equipment industry seven years, in the case of Electronics industry five years, in the case of Engineering industry only one year, in the personal care products producing industry five years, in the case of Pharmaceuticals industry six years, in the case of Refinery industry five years, in the case of Software industry nine years, in the case of Steel industry six years, in the case of Telecommunications industry nine years and in the case of Textiles industry only four years exhibited RDI higher than averages.

Regarding the growth of the RDI the Steel industry achieved the highest rank followed by Software, Pharmaceuticals, Automobiles, Personal Care, Electric Equipment, Food Processing and Chemicals industries. Negative growth rates were observed in the cases of the Telecommunications, Electronics, Engineering, Textiles, Refineries and Cement industries.

Positive growth rates were achieved by the industries, namely, Telecommunications, Electric Equipment, Automobiles and Pharmaceuticals in respect of the embodied technology import intensity. Negative growth of the disembodied technology import was observed in the Engineering, Textiles, Steel, Food Processing, Chemicals and in Refinery industries and the industries like Software, Personal Care, Automobiles, Electronics and Pharmaceuticals achieved two digit figures with Software experiencing the highest rate of 19.56% in respect of the disembodied technology import intensity. In the cases of the industries other than Food Processing, Cement and Telecommunications industries, positive growth rates of OOR-1 were observed and the industries, namely, Personal Care, Software and Cement industries experienced negative rates of the variable OOR-2.

Two models were adopted to analyse the impact of globalisation on India's technology regime in the aggregative framework.

In Model 1 the influence of SIZE and ETI and DTI on RDI of the industries was explored in elasticity terms with the help of log linear model.
The estimated coefficient of LGSIZE appeared significant in the cases of Cement, Electronics, Pharmaceuticals, Software and Steel industries. Embodied Technology Import Intensity became important for the Chemicals, Electric Equipment, Automobiles and Steel industries and Disembodied Technology Import Intensity appeared significant in the cases of Chemicals, Electronics, Automobiles, Food Processing, Refineries, Software and Steel industries.

From the estimated coefficients it was reasonable to compute different elasticities-

\[ e_1: \text{elasticity of RDI with respect to SIZE} \ (\frac{\delta \log \text{RDI}}{\delta \log \text{SIZE}}) \]

\[ e_2: \text{elasticity of RDI with respect to ETI} \ (\frac{\delta \log \text{RDI}}{\delta \log \text{ETI}}) \]

\[ e_3: \text{elasticity of RDI with respect to DTI} \ (\frac{\delta \log \text{RDI}}{\delta \log \text{DTI}}) \]

In the case of Cement industry, \( e_1, e_2 \) and \( e_3 \) were inelastic and \( e_1 \) and \( e_2 \) were negative while \( e_3 \) was positive. Chemical industry showed positive elasticities for \( e_1 \) and \( e_2 \) and negative for \( e_3 \) and all these values were less than one. Electric Equipment industry witnessed positive \( e_2 \) and \( e_3 \) but showed negative \( e_1 \) and all these values were inelastic. Electronics industry disclosed negative values in cases of \( e_1 \) and \( e_2 \) but positive in case of \( e_3 \). However, all these values were inelastic. Engineering industry yielded negative \( e_1 \), negative \( e_2 \) and positive \( e_3 \) and all these values were inelastic. Automobiles industry revealed positive values in cases of \( e_1 \) and \( e_3 \) and negative value in case of \( e_2 \) and all these values were inelastic. Pharmaceuticals industry showed positive values in cases of \( e_1 \) and \( e_2 \) but negative value in case of \( e_3 \) and all these values were inelastic. Similar were the findings in the cases of the Food Processing and Personal Care industries. Refineries industry disclosed positive value in the case of only \( e_3 \). Software industry showed positive value in the case of only \( e_1 \) and \( e_1 \) was highly elastic and so also was the value of \( e_3 \), though, it was negative. Steel industry disclosed positive values in cases of \( e_1, e_3 \) and \( e_1 \) was elastic. Telecommunications and Textiles industries yielded negative values in the cases of \( e_1 \) and \( e_3 \) and positive values in the case of \( e_2 \). Thus SIZE had positive effects upon RDI in the cases of
the industries engaged in producing chemicals, automobiles, pharmaceuticals, food processing, personal care, software and steel.

In order to capture the influence of outward orientation along with the influence of size of the industry and the import of technology import on RDI, in Model 2, a multiple regression analysis was done taking RDI as the dependent variable and ETI, DTI, SIZE, OOR1 and OOR2 as the explanatory variables.

The impact of DTI on RDI was significant in the Cement industry. The impacts of ETI, OOR-2 and SIZE were negative upon RDI while the impact of OOR-1 was positive. In the Chemicals industries the influences of ETI, OOR-1 and SIZE were positive but that of DTI and OOR-2 were negative. In the Electric Equipment industry, ETI cast significant positive effect upon RDI. In this industry the impact of DTI and OOR-2 were positive but these were not significant. Only SIZE cast significant impact in the Electronics industry, however, the impact was negative. In this industry, DTI and OOR-1 showed positive impact on RDI though these failed to gain statistical significance. Engineering industry showed positive impacts of DTI and OOR-2 only on RDI but the impacts were not significant. In the Pharmaceuticals industry, the impact of ETI, OOR1 and SIZE were significant. However, in this industry, other than SIZE and ETI, the coefficient of OOR-1 was negative implying that change in OOR-1 caused for reduction in RDI. The Food Processing industry exhibited positive impact of ETI and OOR-2 on RDI though the impact was not significant. ETI, DTI and OOR-1 had positive influence on RDI in the Personal Care products producing industry but these impacts were not significant. In the Refinery industry, the impact of DTI was significant and the coefficient of DTI was positive implying that the change in DTI resulted in the increase in RDI. In the Software industry, except OOR-1 the other variables had negative impact on RDI, however, the impact failed to gain significance. In the case of Telecommunications industry, the impact of OOR-1 was significant; however, coefficient was negative implying that change in OOR-1 caused for reduction in RDI. Lastly, ETI came up with significant impact in the Textiles industry. Moreover, in this industry, also, DTI, OOR-1 and OOR-2 cast significant impact. In this industry, while estimated coefficients of DTI and OOR2 were negative in sign that of ETI and OOR 1 were positive.
It was revealed that SIZE had significant impact on RDI in the Electronics and Pharmaceuticals industries. OOR-2 showed significant impact on RDI in the Textiles industry only. OOR-1 impacted significantly in the Pharmaceuticals, Telecommunications and Textiles industries. DTI exhibited significant impact on RDI in the Cement, Refineries and Textiles industries and ETI had significant influence in the Electric Equipment, Pharmaceuticals and Textiles industries.

SIZE was observed to cast considerable impact only in the Electronics and Pharmaceuticals industries. The Compound Annual Growth Rate (CAGR) of SIZE for these industries were 13.71% and 14.28% respectively which were no less important albeit trailing behind many others. In the cases of the other industries though the CAGR of SIZE was much higher this could not create impact on technological innovation and adoption. This implies that industries growing bigger did not render undertaking R&D seriously.

The import of technology-embodied and disembodied-played appreciable role in influencing R&D in the Cement, Electric Equipment, Pharmaceuticals, Refineries and Textiles industries and these industries constituted less than 50% of the sample size in this study. From the values of elasticities of RDI with respect to ETI and DTI the same observations were made. Therefore 'import and adapt' principle was not effective in the case of Indian manufacturing industries.

Outward Orientation in the form of exports (f. o. b) had a positive impact on RDI in the case of the Textiles industry and negative influence in the Pharmaceuticals and Telecommunications industries. In the case of the Pharmaceuticals industry, import of embodied technology influenced R&D implying that the industry’s import of technology was adopted through incurring R&D and this was supplemented by the growing size of the industry. The industry, like the Refineries, imported technological knowledge and for effective use of that knowledge the industry had to rely on R&D. Contrarily in the cases of the Textiles industry, import of this knowledge provided a relief and the industry’s R&D experienced negative impact after this import of knowledge. However, import of technology in embodied form was supplemented by incurring R&D expenditure, i.e. the imported technology was adopted by the industry through R&D.
The implication for the Outward Orientation appearing not so strong a variable to influence the technological innovation of the Indian manufacturing industries accords with the observation made in the Science and Technology Policy 2003 of the Government of India “Indian exports today derive their comparative advantage through resource and labour rather than through the power of technological innovation”.

Technological innovation in manufacturing occurs in two forms: new inventions provide a leap forward in technology and the other form of innovation comes from the steady improvement in products and manufacturing processes within major technology life cycles (National Manufacturing Competitiveness Council, 2006). Though this improvement involves ‘many less dramatic innovation’ collectively these innovations have a significant effect (ibid). The empirical observations from the Model 2 do not conform to this. Out of the 14 industries considered in the study very few were observed to undertake R&D seriously and though liberalisation has widened the scope of importing technology and exports of goods, industries, in India, have taken little advantage of this. One reason would be that technological innovation and acquisition of new knowledge and its adoption require calibration of policies and reconfiguration of competencies (ibid). However, these appear to be difficult in view of capacity constraints and economic, social and political complexities.

While making any discussion on competitiveness of the industries emphasis is placed on to identify to what extent these industries are able to take advantage of low labour costs, technology intensive exports, increasing productivity but seldom is it questioned how far the changing character of technology regime affects the performance of the industrial sector. This happens in the case of Indian manufacturing sector also. The technology regime under which the Indian manufacturing industries have been performing has undergone a pragmatic change after unshackling of the various controls and barriers but the industries are still devoid of clinging to the frequency of technological opportunity and cumulativeness of learning-the two building blocks of technology regime. This is an important reason for the industries not becoming competitive and unless these
issues are taken care of it is hard to make any dent in the global competition of which technological superiority is an important factor.

While studying the impact of globalisation on India’s technology regime at the level of Indian manufacturing firms, first, the trends of the variables influencing the R&D intensity of the firms were analysed and then multiple regression was done for drawing inference regarding the impact of different variables on the R&D intensity in so far as the latter is the best criterion for assessing technological innovation and adoption.

The Compound Annual Growth Rate (CAGR) of the variables of the firms under various industries was calculated and analysed. The variables considered were annual sales turnover, R&D expenditure, profit before tax (PBT), exports of firms (f.o.b) representing Outward Orientation-1, earnings of foreign exchange against sharing knowledge and expertise with foreign firms denoting Outward Orientation-2, import of capital goods representing import of embodied technology (ET), payment of royalty, technical fee, etc. abroad against acquiring knowledge, technical knowhow, etc. representing import of disembodied technology (DT) and import of finished goods and raw materials (IT).

R&D, PBT, Outward Orientation-1, Outward Orientation-2, ET, DT and IT were expressed as percentage of annual sales turnover converting the variables to R&D intensity (RDI), PBTS, OOR-1, OOR-2, ETI, DTI and ITI. Market share (MSH) was expressed as the proportion of sales of the respective firms to the sales of the industry.

The RDI showed negative CAGR only in the cases of 2 firms in the Automobiles industry and it is interesting to note that the CAGR of the ETI and DTI in the cases of these 2 firms were positive and no less important. It implies that these 2 firms, i.e. Hero Honda Motor and Maruti Suzuki depended on the imported knowledge and technology for technological innovation. The CAGR of the market shares in the cases of the 3 firms under this industry were positive while it was negative in respect of the other 3 firms. The CAGR of OOR-1 and that of OOR-2 were negative in the cases of the 2 firms and 3 firms in this industry respectively.
In the case of the Cement industry, the CAGR of RDI in respect of all the 5 firms was negative. In this industry, except 2 firms, the CAGR of the ETI in the cases of the other firms was negative and except in the case of one firm, CAGR of DTI was also negative. Except the firm, KCP, the growth rate of SIZE was considerable in the cases of other firms within this industry. Except one firm in this industry, MSH showed negative growth rates in the cases of all other firms. The growth rates of OOR-1 and OOR-2 were positive in the cases of 3 firms and that of PBTS was positive in the cases of 2 firms under this industry.

In the Electric Equipment industry, out of the 11 firms selected in the sample set 4 firms had positive CAGR in respect of RDI and DTI and 5 firms had positive EDT growth. The growth rate of SIZE was positive for all firms and for most of the firms OOR-1 and OOR-2 revealed positive growth rates, however, MSH and PBTS were characterised by negative growth rates in most of the firms.

The outcome derived from the analysis of the Electronics industry exhibited positive growth rate of RDI for 4 firms and positive growth rates of ETI and DTI for 1 and 3 firms respectively. For the other variables, the growth rates were same unlike the Electric Equipment industry.

The positive growth rates of RDI, ETI and DTI were observed in 45%, 72% and 18% of the firms belonging to the Engineering industry under study. The OOR- and OOR-2 experienced positive growth in most of the firms and the same was true for the Profit before Tax but MSH growth was negative in most of the sample belonging to the industry.

Only 2 firms were selected in the Food Processing industry and in all these firms RDI had shown positive growth rates. The ETI and DTI growth rates were zero for these firms. The growth rate of Outward Orientation was positive in 1 out of these 2 firms; negative growth rate was observed for MSH in the 2 firms, PBTS was positive for all the firms in the sample.

For the Chemical industry 14 firms were considered and out of these 5 firms showed positive RDI growth, 7 firms exhibited positive ETI and 6 firms revealed
positive DTI growth. In majority of the firms growth rates of OOR-1 and OOR-2, MSH had been positive, and that of PBTs was negative.

In personal care products producing industry, only 1 firm showed positive CAGR of RDI whereas CAGR of ETI had been positive in 2 firms and that of DTI were positive in 4 firms. The growth rate of PBTS had been positive in all the firms. The MSH grew positive in 3 out of 5 firms but in most of the firms belonging to this industry under the study, growth rates of OOR-1 and OOR-2 were negative.

In the Pharmaceuticals industry out of 15 firms in the sample 10 showed positive CAGR of RDI, 6 showed positive CAGR of ETI and 8 revealed positive CAGR of DTI. The growth rate of MSH had been marginally impressive; however, in 10 out of 15 firms positive rates of growth of OOR-1 and OOR-2 were observed and in most of the firms the growth rate of PBTS was positive.

In the Refinery industry, the CAGR of RDI was positive in 3 out of 5 firms and in 1 firm the CAGRs of ETI and DTI were positive. The growth rates of Outward Orientation and Market Share had been quite moderate but that of the Profit before Tax failed to reach expectation.

In the Software industry, in 2 out of 4 firms in the sample, the CAGR of RDI, ETI and DTI were positive. The growth rates of OOR-1 and OOR-2 had been impressive but that of the PBTS and MSH were far from satisfactory.

In the Steel industry, out of 4 firms in the sample, 2 firms exhibited positive CAGR of RDI, 2 revealed positive CAGR of ETI and 1 showed positive CAGR of DTI. The growth rates of OOR-1, OOR-2 and MSH had been negative in most of the firms, however, PBTS revealed positive growth rate in almost all the firms in the industry.

It was observed in the Telecommunications industry that, the CAGR of RDI was positive in 2 out of 3 firms and in 1 firm the CAGR of ETI had been positive while DTI growth had been positive in 2 firms. The growth rate of MSH was negative in all the firms, the growth rate of PBTS was positive in all the firms and in 2 firms, growth rate of OOR-1 had been positive whereas that of OOR-2 had been positive in 1 firm in the industry.
In the Textiles industry, in 28% of the firms in the sample the positive CAGR of RDI and DTI were observed and in 42% of the firms in the sample the CAGR of ETI was positive. In 5 out of 7 firms the positive growth rates of OOR-1 and OOR-2 were observed, the growth of MSH was positive in 5 firms and that of PBTS was positive in only 2 firms.

It was found that the Pharmaceuticals industry occupied the prime position in terms of the number of firms achieving positive growth of RDI followed by the Chemicals, Engineering, Automobiles, Electronics, Electric Equipment and Refinery industries. The Engineering industry occupied the pivotal position in terms of the number of firms achieving positive growth of ETI followed by Chemicals, Pharmaceuticals, Electric Equipment, Automobiles, Textiles and the rest of the industries. In terms of the number of firms achieving positive growth of DTI, highest position was occupied by the Pharmaceuticals industry followed by the industries such as the Chemicals, Personal Care, Automobiles, Electric Equipment and the rest.

In course of delineating the importance of the variables influencing the R&D intensity of the firms, namely, firm size, technology import, outward orientation, market share and profit margin by the help of multiple regression analysis the study observed that for more than 50% of the observations explanatory power of the equation was found to be statistically significant in terms of the F-test.

In Automobiles sector, in 4 out of the 6 firms under study SIZE casted positive impact on RDI though except in 1 firm, the impact of SIZE in the cases of the other firms was not significant.

In Cement industry, SIZE appeared to have negative impact on R&D intensity and in the Electric Equipment industry mixed results were obtained. While some firms showed positive impact of SIZE on RDI the others showed exactly opposite results. In the case of Electronics industry, 50% of the sample showed positive impact of SIZE.

In most of the firms under study belonging to the Engineering sector the SIZE had a negative impact. In 2 firms only, selected for the sample in the Food
Processing industry the SIZE had a positive influence. The Chemical industry also showed mixed results. The Personal Care product producing industry followed the same trend as followed by the Chemical industry. On the contrary, in the Pharmaceuticals sector, in 10 out of 15 firms the SIZE appeared with positive sign. The similar findings were obtained in case of most of the firms in the Refinery industry. Software showed mixed results. In most of the firms in the Steel and Telecommunications industries the SIZE appeared with negative sign. In 4 out of the 7 firms in the Textiles, SIZE appeared with positive sign.

To sum up, Automobiles, Electronic, Pharmaceuticals and Textiles are the industries of which considerable number of firms demonstrated that the SIZE had a positive impact on the decisions regarding technological innovation and adoption. This outcome was in commensurate with the observations made by Schumpeter.

It was observed from Tables 6.16 to 6.29 that the Market Share appeared with a positive sign in 2 Automobiles firms, 4 Cement firms, 5 Electric Equipment firms, 4 Electronics companies, 5 Engineering firms, 1 Food Processing firm, 8 Chemicals companies, 2 Personal Care product producing firms, 7 Pharmaceuticals firms, in 2 firms each in Refinery and Software sectors, 3 Steel firms, 1 telecommunications company and 3 Textiles firms. Thus 49 firms out of 98 selected ones in the sample exhibit positive impact of Market Share on creating and availing technological opportunity supporting the Nelson –Winter thesis (1982).

Outward orientation, in the forms of exports as well as foreign exchange earned due to royalties etc. appeared to have positive signs in 45 firms and 51 firms under the study respectively. The implication for a large number of firms revealing positive signs of OOR-1 compared to OOR-2 is that overseas investment and technological licensing significantly increased the need for an in-house R&D effort.

Of the two forms of technology imports, embodied technology appeared to have strong impact on R&D intensity compared to disembodied technology import. 3 firms in Automobiles industry, 2 in Cement industry, 6 in Electric Equipment
sector, 3 in Electronics industry, 3 in Engineering industry, 1 in Food Processing sector, 12 in Chemicals industry, 3 in Personal Care products producing sector, 11 in Pharmaceuticals sector, 3 in Refinery sector, 4 in Software industry, 3 in Steel industry, 1 in Telecommunications sector and 2 firms in Textiles sector, i.e. in 57 firms out of 98 in the sample of ETI appeared with positive sign. Though in some cases the statistical significance of the variable was absent failing the ‘t’ test, the findings, nonetheless, supported the fact that the import of technology in the form of capital goods might provide opportunities for technological effort by Indian manufacturing sector.

In 47 firms under the study the import of disembodied technology appeared with positive sign.

In most of the observations PBTS came up with coefficients that were not significantly different from zero in statistical terms. Therefore, profitability did not seem to have strong effect on R&D intensity.

An exhaustive search of the Capitaline corporate Database revealed that, in the Automobiles industry under the study, Ashok Leyland, Hero Honda Motor and Maruti Suzuki displayed more than 25% share belonging to foreign promoters, hence these might be treated as Multi National Enterprise (MNE) affiliates. In these firms ETI appeared with negative influence on RDI and same was true for the DTI except Asok Leyland, which showed positive impact of DTI on R&D intensity.

In the Cement industry there was no MNE affiliate and out of the 5 firms under the study the DTI had positive and ETI had the negative influences on RDI in 2 and 3 firms respectively.

In the Electric Equipment industry, ABB, Amara Raja Batt., Areva T&D and Honda Siel Power were MNE affiliates. In Amra Raja Batt both DTI and ETI appeared with positive sign and in Areva T&D, ETI showed positive impact on RDI.

In Electronics industry, Philips El India and Sharp India were MNE affiliates. Out of these in Sharp India, only, ETI displayed positive impact on RDI.
In the Food Processing industry, both the firms under the study were MNE affiliates and in only Glaxo Smith C H L positive impact of DTI and ETI on RDI were observed but the impacts were marginal as revealed from the values of the respective coefficients.

In the Chemicals industry, Elantas Beck, Clariant Chemica, and Foseco India were MNE affiliates. In Elantas Beck, DTI came up with positive sign, ETI appeared with positive impact on RDI in Clariant Chemica and in Foseco India, DTI showed positive impact on R&D intensity.

Out of the 5 firms selected under the study in the Personal Care products producing sector, 3 were MNE affiliates, namely, Colgate-Palm., Hind. Unilever and P & G Hygiene. ETI appeared with negative sign in 3 and DTI revealed the positive influence except for Hind Uniliver. The positive impact of DTI on R&D intensity in Colgate-Palm and in P & G Hygiene implied that imported knowledge in the disembodied form required for its absorption an upliftment of R&D in these firms.

Abbott India, Aventis Pharma, Guj. Themis Bio., Merck, Novartis India and Pfizer were MNE affiliates in the Pharmaceuticals industry under the study. In the first 4 firms DTI appeared with positive signs whereas ETI showed negative influence on RDI. In Novartis India and Pfizer both DTI and ETI showed negative impact on R&D intensity. Compared to this, in several domestic firms belonging to this industry under the study significant positive impacts of DTI and ETI were observed the implication for which would be that MNE affiliates directly absorbed the imported knowledge without undertaking R&D to that effect in comparison to their domestic counterparts.

In Refinery sector, the firms under the study were not MNE affiliates. Among these, in B P C L, C P C L and H P C L positive impacts of DTI on R&D intensity were observed and in HPL and Reliance, ETI demonstrated positive impacts implying that in Refinery, domestic firms had to undertake R&D seriously to adopt and absorb imported knowledge.
In the Software sector, under the study, Hewlett-Packard was only MNE affiliate. In this firm both DTI and ETI showed positive influences on RDI which implied that all firms, under the study in the Software industry, were prone to undertake R&D to absorb and adopt imported technology.

In Steel industry, there was no MNE affiliate among the selected firms under the study and domestic firms were found trying to undertake R&D for assimilation and absorption imported knowledge.

In the domestic firms selected under the study in the Telecommunications sector the R&D was not affected by the imports of disembodied and embodied technologies. However, in FCI OEN Connect., the only MNE affiliate out of the firms selected under the study, positive impacts of imported technologies on R&D intensity was observed.

In the Textiles sector none of the firms selected under the study was MNE affiliate and the domestic firms were not found to have bothered about carrying on R&D in connection with the import of technologies.

Technological opportunities were made available to the Indian firms after globalisation not to a large extent but not even in an insignificant manner. The capability building on the part of the Indian firms to absorb and assimilate acquired technology was of a mixed variety cutting across different industries and MNE affiliates were no exception. Technology acquisition was sluggish for most of the firms and even where this was robust its impact on technological innovation varied from one to another. No matter whether it was MNE affiliate or domestic firm ETI demonstrates steady impact in some cases, whereas, in others, import of knowledge in disembodied form appeared to be crucial. Since the number of firms was not large in the sample no conclusive evidence could be found for making a comparison as to how the import of technology-embodied or disembodied- prompted the domestic firms and MNE affiliates on carrying out further technological activity. However, since the empirical findings in section 6.6 supported the fact that 58% of the firms in the sample showed an advancement of technological activity prompted by the import of capital goods, it may, safely, be inferred that the Indian manufacturing firms were yet to adopt technology
embedded in the form of knowledge. The connotation is truly that the cumulativeness of technological learning and the properties of knowledge base for the Indian manufacturing were still not strong enough to evolve into a confirmed technology regime.

The study, in its entirety, appeared significant in many respects.

First, the main focus of this study was on India’s manufacturing sector. This should be attributed to the longstanding importance of the sector in India’s economy which was discussed in the chapter1 of the study. The relatively declining trend of the agricultural sector in accommodating the pressure of population on it and the heightening importance of the service sector in making contribution to the GDP need a careful scrutiny in a country like India where the surplus population from agriculture could hardly be absorbed into the latter owing to lack of proper training and education and this called forth an assessment of the position that could be occupied by the manufacturing sector in relieving the pressures upon the economy. In this study an attempt was made in that direction.

Secondly, at the advent of the globalisation the production structure and organisational pattern of the manufacturing industries had undergone several changes. Firms started to realize that in order to be competitive its nature of indulging in mass production has to be replaced by the multiproduct trait and more emphasis would have to be placed on ensuring quality and quick response to customer demand. It is the situation under which innovation registered an indelible mark. No matter whether it is product or process innovation- the central theme is continuous improvement and up gradation of technology that implicates acquisition, adoption and consolidation of knowledge. Firms should no longer be viewed as optimizing agent, rather, they should endeavour to modify the demand for their products and get themselves accustomed to the development of new technologies. Technology is a powerful factor for the growth of the manufacturing sector but, in the context of the changes in the production structures and organisational pattern of the sector that was ushered through globalisation, the concept of technology defined in terms of the production function approach of the neo-classical type could no longer be appropriate. The concept of ‘technology regime’, introduced by the Evolutionary Theory in the hands of Nelson and Winter
initially and by the others subsequently appeared to be meaningful and contextual since, according to this concept, technologies should not be defined in terms of a stylized input-output analysis, rather these should best be seen as ‘being linked with other technologies, economic activities and production and user practices and a whole range of institutions forming a technology system’ (Mulder, Reschke and Kemp, 1999). In this study this point was clarified and explained in detail.

Thirdly, where most studied concentrated on the issues pertaining to the productivity of the Indian manufacturing sector, this study, unveiled the emerging nature of India’s technological regime after the liberalisation of the economy in 1991. The main components of the regime defined in terms of acquisition and adoption of new technology and technological innovation were discussed in the context of Indian scenario. Moreover, the association of the technological regime of India with the country’s manufacturing sector was studied in analytical framework. After liberalisation of the economy the scope was widened for the import of technology, exports of goods, earnings of foreign exchange through royalties, etc. and a vast market with pronounced competitive elements. Accordingly, in order to gain competitive edge over others the need for technological innovation was aggravated calling forth enhanced R&D expenditure by the government as well as the private sector. All these necessitated a review of the trend of import of technology, R&D expenditure incurred, exports of goods, earnings of foreign exchange by the government, industries and the firms which was accommodated in the study at the macroeconomic perspective.

Fourthly, the study tried to explore the factors influencing the R&D expenditure of the government, industries and the firms since expenditure incurred on R&D was a better proxy for the technology adoption, acquisition and absorption of new technology.

Lastly, the treatment of industry and the firm separately in the study was done in view of the fact that in evolutionary theory decision rules made within the firms are viewed as a legacy from the firms’ past. These rules are appropriate to the circumstances within which the firms find themselves. These are not responsive to the situations which the firms encounter irregularly. Firms expand or contract
facing disequilibria no matter whether industries are near equilibrium. Innovation, in evolutionary theory, is treated as stochastic and as variable across firms (Nelson and Winter, 1982). Moreover, it was pointed out in another study that the industries, in evolutionary theory, could not be treated as aggregation of firms ‘because firms are a combination, even compromise, of internalizing and externalizing tendencies’ (Bloch and Finch, 2007).

This study was based upon data for the pre-and post-reform periods in respect of analysing the impact of technology import on R&D expenditure and the impact of the latter on technology intensive exports in India’s macroeconomic perspective. But while discussing the impact of various factors on the R&D expenditure of India’s manufacturing sector both at the industry and firm levels the study had to remain contented with the data pertaining to the post-reform period only because time series data for the pre-reform period was not systematically available. Therefore, for studying the changing nature of India’s technology regime in the aggregative and disaggregate cases comparison between pre- and post-reform scenario could not be made.

Secondly, while selecting the firms belonging to different industries the main focus of the study was to collect data for as long a period as possible so that while pursuing regressing analysis the degrees of freedom should not be minimum. In doing so the study was left with the selection of 98 firms only.

Lastly, the number of firms selected in the sample was not uniform. The reason for this was that either the information was not provided by firms themselves to Capitaline or because of a lag in the compilation of data.

While carrying out the exercise of deciphering the impact of technology import on national R&D in the Indian macroeconomic perspective it was evident that the import of embodied technology was supplemented by involving more R&D during pre-reform period but the post-reform scenario provided a complete reversal of the phenomenon. Embodied technology import involves import of capital goods and adoption of that imported plant or machinery in the local environment must involve doing R&D which was truly the case in the pre-reform phase implying that R&D done at the government level was appropriated by the firms to
accommodate the imported know-how. In the post-reform situation R&D and embodied technology import acted as substitutes suggesting that the benefits of national R&D hardly spilt over to the level of firms or it might be that the imported plants or machinery were directly absorbed requiring no initiative to carry on R&D. However, the disembodied technology import, i.e. import of knowledge needed R&D to be done both during pre-and post-reform phases implying that inclination toward learning and acquiring knowledge in the manufacturing environment of the country was prevalent all along, strong in some cases, latent in others. In chapter 5 of the study it was evident that out of 14 industries 7 showed the elasticity of R&D intensity with respect to disembodied technology import intensity and also with respect to embodied technology import intensity being positive. The regression analysis showed that disembodied technology import had significant impact upon R&D in some industries and the same was true in the case of embodied technology import intensity. In chapter 6 of the study it was revealed that 45 out of 98, manufacturing firms selected in the sample belonging to different industries showed positive impact of disembodied technology import on R&D but 55 firms out of 98 disclosed positive impact of embodied technology import intensity.

The upshot of the above is that globalisation has widened the scope for Indian firms operating in a vast market but under a threat of intense competition. Firms have been trying to cope up with the changing situation by getting more access to import capital goods, knowledge and by going for more outward orientation. However, to what extent this has been conducive to building up a strong and vibrant technology regime of the economy leaves much room for apprehension. This study made an attempt to explore the impact of globalisation on India’s technological regime. Based upon secondary data relating to the manufacturing industries and the firms and also to the economy as a whole the empirical analysis done in this study unveiled the fact that the manufacturing sector of the Indian economy is yet to mature in terms of a vibrant technology regime in this globalised environment. While some industries in the aggregative sense and firms belonging to different industries set examples of their innovation and technology adoption being affected by the technology import, outward orientation, most of these remained unmoved by in an environment of import of technology,
outward orientation getting boosted up through liberalised policy options made available to them by the government. One corollary of this is that technology diffusion or knowledge spillover within the firms in the manufacturing sector has not been strong enough and technology policy has yet to be directed towards achieving the goal of constituting a sound technology regime in the country.

To what extent a firm will carry on innovation activities depends on how wide would be the scope of other institution supplying the knowledge and skills that corroborate the efforts of individual firms (Metcalfe, 1994). If the technology policy takes the innovation possibilities of firms as given then its aims would either be to reduce the cost of research to the firm, R&D subsidies and tax incentives for R&D or to enhance the pay off from innovation by widening the scope of protection of patents. On the other hand, the technology policy may seek to uplift the possibilities of innovation which entail collaborative R&D programmes and the initiative taken to link the internal efforts of firms with public R&D carried out in the science base (ibid.). In Chapter 4, it was observed that knowledge spillover from public R&D to the private sector was not considerable. Hence the technology policy of the country should move towards coupling the manufacturing firms into the scientific and technological networks which could provide more opportunities and incentives for innovation.

7.3 Avenues for further research

This study focused on changing nature of India’s technological regime in respect of India’s manufacturing sector in the era of globalisation. The study aimed at identifying how the technological opportunity, adoption and absorption in India’s manufacturing sector were undergone changes and what factors were responsible for the changes. There are other aspects of technology regime, namely, cumulativeness of learning and properties of knowledge base studying of which in the context of Indian industries require building up of appropriate database which future studies may take into account and secondly, an in depth analysis might be done to study the spillover of the public R&D to the private industries since the advent of liberalisation of the economy.