CHAPTER - I
INTRODUCTION

1.1 INTRODUCTION

The automobile industry in India is one of the largest markets in the world. The India’s passenger car and commercial vehicle manufacturing industry is the sixth largest in the world, with an annual production of more than 3.9 million units. According to recent reports, India overtook Brazil and became the sixth largest passenger vehicle producer in the world (beating such old and new auto makers as Belgium, United Kingdom, Italy, Canada, Mexico, Russia, Spain, France, Brazil), grew 16 to 18 per cent to sell around three million units in the course of 2011 and 2012. In 2009, India emerged as Asia’s fourth largest exporter of passenger cars, behind Japan, South Korea, and Thailand. In 2010, India beat Thailand to become Asia’s third largest exporter of passenger cars.

As of 2010, India is home to 40 million passenger vehicles. More than 3.7 million automotive vehicles were produced in India in 2010 (an increase of 33.9 per cent), making the country the second (after China) fastest growing automobile market in the world in that year. According to the Society of Indian Automobile Manufacturers, annual vehicle sales are projected to increase to 4 million by 2015, no longer 5 million as previously projected.

The automobile sector in India has come a long way. This sector has reported high growth rate from 26 per cent to a worst negative growth in some segments during past years. Indian auto sector is one of the most vibrant industries. The automobile industry is one of India’s major sectors; accounting for 22 per cent of the country’s manufacturing Gross Domestic Product (GDP). The Indian auto industry, comprising passenger cars, two-wheelers, three-wheelers and commercial vehicles, is the seventh-largest in the world with an annual production of 17.5 million vehicles, of which 2.3 million are exported. Indian Auto market that has the potential to dominate the Global auto industry, provided, a conducive environment for potential innovators to come up with new pilot projects. For the year 2012-2013,
automobile sector has shown a sluggish growth citing high ownership costs like excise duty, cost of registration, fuel costs, road tax and slow rural income growth. Over the next few years, solid but cautious growth is expected due to improved affordability, rising incomes and untapped markets. All these give a promising opportunity for automobile manufactures in India. According to Macquaire equities research, passenger vehicles sale is expected to double in the next four years and growth is anticipated to be higher than 16 per cent from the past 10 years.

**Production**

The cumulative production data for April-March 2013 shows production growth of only 1.20 per cent over the same period last year. The industry produced 16,85,355 vehicles in March 2013 as against 18,45,868 in March 2012, which declined by (-) 8.70 per cent.

**Domestic Sales**

The overall growth in domestic sales during April-March 2013 was 2.61 per cent over the same period last year. While in March 2013 overall sales fell by (-) 7.76 per cent over March 2012. Passenger Vehicles segment grew at 2.15 per cent during April-March 2013 over same period last year. Passenger Cars declined by (-) 6.69 per cent, Utility Vehicles grew by 52.20 per cent and Vans grew only by 1.08 per cent during April-March 2013 as compared to the same period last year. However, in March 2013 passenger car sales further declined by (-) 22.51 per cent over March 2012. Total passenger vehicles sales also declined by (-) 13.01 per cent in March 2013 over same month last year.

The overall Commercial Vehicles segment registered de-growth of (-) 2.02 per cent in April-March 2013 as compared to the same period last year. While Medium and Heavy Commercial Vehicles (M&HCVs) declined by (-) 23.18 per cent, Light Commercial Vehicles grew at 14.04 per cent. In March 2013, M&HCVs sales further declined by (-) 26.16 per cent over March 2012. Three Wheelers sales grew by 4.87 per cent in April-March 2013. Passenger Carriers grew by 8.58 per cent during April-March 2013 and Goods Carriers registered de-growth at (-) 9.20 per cent during this period.

Two Wheelers registered growth of only 2.90 per cent during April-March 2013. Scooters, mopeds and motorcycles grew by 14.24 per cent, 1.53 per cent and
0.12 percent respectively over same period last year. However, in March 2013 all sub-segments of two wheelers, scooters, motorcycles and mopeds registered de-growth at (-) 3.18 percent, (-) 8.32 per cent and (-) 4.54 per cent respectively.

**Exports**

During April-March 2013, overall automobile exports registered de-growth of (-) 1.34 per cent compared to the same period last year. Passenger Vehicles grew by 9.02 per cent, while the other segments like Commercial Vehicles, Three Wheelers and Two Wheelers fell by (-) 13.35 per cent, (-) 16.22 per cent and (-) 0.72 per cent respectively. In March 2013, Passenger Vehicles, Two & Three Wheelers grew by 3.07 per cent, 3.51 per cent and 7.50 per cent respectively. While Commercial Vehicles declined by (-) 28.33 percent.

The auto industry produced a total 1.81 million vehicles, including passenger vehicles, commercial vehicles, three wheelers and two wheelers in February 2014 as against 1.73 million in February 2013, registering a growth of 4.41 per cent over the same month last year. The increase continues to be on account of growth in two wheelers production. Moreover, the overall domestic sales during April–February 2014 grew marginally by 2.68 per cent over the same period last year.

The cumulative foreign direct investment (FDI) inflows into the Indian automobile industry during the period April 2000 to January 2014 was recorded at US$ 9,344 million, an increase of 4 per cent to the total FDI inflows in terms of US$, according to data published by Department of Industrial Policy and Promotion (DIPP), Government of India. The overall automobile exports grew by 6.39 per cent during April–February 2014. Passenger vehicles, three wheelers and two wheelers registered growth at 6.44 per cent, 16.40 per cent and 5.41 per cent respectively, as compared to the same period last year.

**Major Developments & Investments**

German auto maker Volkswagen is planning to expand production capacity and introduce a slew of new models. The group is looking at investing Rs. 1,500 crore (US$ 248.55 million) over the next five years to set up a diesel engine manufacturing facility. Amtek Auto signed an agreement to buy Germany's Kuepper Group of companies for about Rs 16.78 billion (US$ 277.97 million) in December 2013, which was its second big European acquisition in 2013.
Jaguar Land Rover (JLR) will scale up its production capacity to hit 700,000 units by FY 2017 riding on its joint ventures (JV) in China and Brazil, as per analysts. JLR’s capacity for 2014 is pegged at 450,000 units. Infosys has signed a multi-year contract with Volvo Cars to provide application development services to the latter’s global operations.

JCB announced plans to relocate production of compaction equipment to factories in the UK and Pune, India, and close the Gatersleben site in Germany. “The demand for larger compaction equipment is growing at a steady rate in India and we will now have flexibility to produce global quality machines in India for our customers in the region as well as for exports,” highlighted Mr Vipin Sondhi, MD and CEO, JCB India.

Piaggio Vehicles Pvt Ltd, scooter and light commercial vehicle manufacturer, is planning to assemble its super bikes locally, which it sells under the brand Aprilia. The used cars market in India is anticipated to grow at a CAGR of 16 per cent during 2013–17, highlighted the RNCOS report titled, ‘Booming Used Car Market in India Outlook 2017’. Furthermore, India is expected to emerge as a centre for producing compact super bikes. Several global and Indian bike makers plan to utilize India’s mass production base of 16 million two wheelers to roll out sports bikes in the 250cc capacity.

**Government Initiatives**

The Interim Budget 2014-15 added some incentives to the auto industry. To give relief to the automobile industry, the excise duty has been reduced till June 30, 2014 as follows: For small cars, motorcycle, scooters – the duty has been reduced from 12 per cent to 8 per cent. For commercial vehicles and SUVs – the duty has been reduced from 30 per cent to 24 per cent. For large and mid-segment cars – the duty has been reduced from 27/24 per cent to 24/20 per cent. The other incentives from Union Budget 2013–14 are as follows: The period of concession available for specified part of electric and hybrid vehicles till April 2013 has been extended up to March 31, 2015. An exemption from BCD will be provided to lithium ion automotive battery for manufacture of lithium ion battery packs for supply to manufacturers of hybrid and electric vehicles. The Government of India allows 100 per cent FDI in the automotive industry through automatic route.
1.2 ECONOMIC REFORMS OF INDIA: AN OVERVIEW

Indian economy has been witnessing major changes in her policy framework since 1991. The old industrial and trade policy regime characterized by extensive public sector participation, control of private sector, restrictions on foreign investment and high tariff and non-tariff barriers were replaced by more liberal economic policies in 1991. An importance objective of these policy reforms was to make the domestic firms more productive and competitive in the international market. In order to achieve these goals, India, in its reforms process, liberalized the policies in the both internal and external sector. The policy measures included the abolition of licensing, allowing more private participation, removing cap on the foreign investment, reduction of tariff and non-tariff restrictions and others. The net impact of economic reforms is visible now in terms of heavy inflow of foreign capital, foreign exchange reserves and a steady and higher rate of economic growth. Besides these, the economic reforms process resulted in significant changes in the productivity growth of the manufacturing sector of the economy also.

The performance of industrial sector has been a subject of debate in India particularly after the initiation of liberalization process. The conventional wisdom in favour of economic reforms is that it will lead to a significant improvement in the productivity growth. Productivity growth is often considered to be key factor in determining the growth of the industry and to enhance the growth of the economy as a whole. The new economic policies in India have liberalized many government controls on production, import of capital goods, raw materials and technology. The reforms made the import of quality raw materials cheaper and more accessible to the domestic firms. In the same way the reforms process have exposed the firms to both the domestic and international competition.

**Indian Automobile Industry**

India’s automotive industry is one of the successful cases of India’s economic liberalization strategy set into motion since 1991. The industry which had been dominated by a few domestic manufacturers was hardly known for any innovations before 1991. But it is now one of the fastest growing manufacturing industries not just in India but globally as well. In 2010, India has emerged as the
second fastest growing car market in the world next only to China. Sales of two wheelers crossed 10 million units during the year, a first, with all major two-wheeler manufacturers registering high double digit growth. India in 2010 was the largest tractor manufacturer, second largest two-wheeler manufacturer, fifth largest commercial vehicle manufacturer and the eleventh largest car manufacturer in the world.

1.3 NEED FOR THE STUDY

India represents one of the world’s largest automobile industries. Easy availability of finance and rising income levels are encouraging the middle class population to upgrade their two wheelers to a car. Besides, the growing organised used car market has also been a positive growth factor in the country. The passenger vehicles production in India has touched 3.23 million units in 2012–13 and is expected to reach 10 million units by 2020–21. The industry is estimated to grow at a compound annual growth rate of 13 per cent during 2012–2021. The industry has recorded exports worth US $ 9.3 billion in 2012–13 and is projected to touch US $ 30 billion by 2020–21. The cumulative Foreign Direct Investment (FDI) inflows into the Indian automobile industry during 2000 to 2013 has recorded US $ 9,079 million, amounting to 4 per cent of the total FDI inflows (in terms of US $). Further, the automobile industry contributes 4 per cent of the national Gross Domestic Product (GDP) and accounts for 5 per cent of the industrial output in India. It is moreover, a major employment generator in the country and it provides employment to around 13 million people directly or indirectly at present, a number that is likely to double by 2016.

1.4 GAPS FOUND

The following gaps are found in the existing literature

1. Growth of Indian Automobile Industry is very few and scanty.
2. A study on partial factor productivity of Indian Automobile Industry is very few.
3. Studies on Decomposition of Technical Efficiency of Indian Automobile Industry are very few and
4. A study on Sources of Productivity Growth of Indian Automobile Industry is also scanty.

1.5 STATEMENT OF THE PROBLEM

The import substitution, industrialization strategy was adopted in India during 1950s, the automobile industry was chosen as one of the prime candidates for launching the process. This is because it had great potential as a lead sector in stimulating the growth of other industries such as iron, steel, glass, plastics and rubber. With the recognition of the need to bring in a competitive atmosphere involving technological modernization and high rates of output growth, the automobile industry in India has been subjected to substantial policy changes over the last two decades. The few liberalization measures had already been introduced in 1980s, the policy reforms initiated in 1991 were much more comprehensive. All the vehicles segment (except passenger cars) and the auto-component segment were delicensed in 1993. Along with the abolition of the need for Monopoly Restrictive and Trade Practices (MRTP) clearances, this meant that the automobile firms were free to enter, expand, diversify, merge or acquire based on their commercial judgments. The liberalization concerning foreign investment encouraged several global players to enter into the Indian market establishing joint ventures (JVs), with domestic players. While Foreign Direct Investment (FDI) upto 51 per cent was allowed on an automatic basis, the same for more than 51 per cent required Government clearances which were approved on a case-to-case basis depending upon the projected exports, sophistication of technology brought in, etc.

Also the Ministry of Industry introduced, for the first time, a separate auto policy in 2002. The auto policy 2002 comprises several policy decisions that aim at making the Indian automobile industry globally competitive and for raising its contribution to the economy. Discontinuation of foreign exchange neutrality requirement and approval of 100 per cent FDI via automotive route are the policy decisions which aimed at creating a more conducive employment for the foreign investors.

Further, the entry of firms, mostly with foreign capital and technology, threatened the market share and the rate of progress of most of the venterans in the
Indian automobile industry. Foreign direct investment, resulting in transfer of latest technological configuration to produce vehicles involving technological up-gradation, raised serious questions about sustainability of Indian automobile industry. However, these policy changes positively (negatively) influenced in the Indian automobile industry in terms of growth and productivity during 1991 to 2012.

1.6 HYPOTHESIS

H1: There is no significant difference in the overall growth rates between Indian automobile and automobile ancillaries industry during post-reform period.

H2: There is no significant difference in the overall growth rates of partial factor productivity between Indian automobile and automobile ancillaries industry during post-reform period.

H3: Technical efficiency is expected to be better during post-reform period.

H4: Sources of productivity growth in Indian Automobile Industry is expected to be better during post-reform period.

1.7 OBJECTIVES

This study has been undertaken with reference to the following objectives:

1. To study the growth of Indian Automobile Industry in the post-reform period.

2. To analysis the partial factor productivity growth of Indian Automobile Industry in the post-reform period from 1991 to 2012.

3. To estimate the technical efficiency of Indian Automobile Industry during the study period from 1991 to 2012.

4. To identify the sources of productivity growth in the Indian Automobile Industry during the study period.
1.8 DATA AND METHODOLOGY

Data:

The study is based on the secondary data collected from the electronic data base “PROWESS” compiled by the Centre for Monitoring Indian Economy (CMIE). The data base consists of data on various aspects of Indian manufacturing and is compiled from the annual reports submitted by the firms. The automobile industry has been divided into four major sub-sectors and the ancillary of automobile industry has been classified into three sub-sectors.

Period of the Study

The required data was collected for the period 1991 to 2012; the latest year for which the complete set of data available and thus the study covers a period of 22 years.

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1.9 METHODOLOGY

1.9.1 GROWTH MODEL

Growth is studied with reference to annual growth rates computed based on the compound interest rate formula adopted by the World Bank using the least square methods.
The least squares growth rate ‘r’ is estimated by fitting a least squares linear regression trend line to the logarithmic annual values of the variable in the relevant period. More specifically, the regression equation takes the form

$$\log X_t = a + bt + e_t$$

where this is equivalent to the logarithmic transformation of the compound growth rate equation

$$X_t = X_0 (1+r)^t$$

In these equations, ‘X’ is the variable, ‘t’ is time period and a=log X_0 and b= log (1+r) are the parameters to be estimated, ‘e’ is the error term. If b^* is the least squares estimates of ‘b’ then the average annual percentage growth rate ‘r’ is obtained as \((\text{antilog } b^*) - 1\) and multiplied by 100, to express it as percentage.

1.10 PARTIAL FACTOR PRODUCTIVITY

1.10.1 LABOUR PRODUCTIVITY

Labour productivity may be defined of the ratio between employment in a given economy or industry for a given time period and the output of that economy or industry for a similar time period. Labour productivity is indicated as

$$\text{Labour Productivity} = \frac{\text{Output}}{\text{Labour}} \quad (O/L)$$

Where

- O = Output for a given period
- L = Labour for a given period.

1.10.2 CAPITAL PRODUCTIVITY

Capital productivity may be defined as the relationship between investment (or capital) in a given economy or industry for a given time period and the output of that economy or industry for a similar time period. The average productivity ratios give us an idea about on an average, the units of capital required to produce a unit of output and the study of average productivity indices would help to trace the movement and measurement of capital productivity in each firm and its time pattern of change.

$$\text{Capital Productivity} = \frac{\text{Output}}{\text{Capital}} \quad (O/K)$$

Where

- O = Output for a given period
- K = Capital for a given period.
1.10.3 CAPITAL INTENSITY (K/L Ratio)

The capital intensity may be defined as the availability of capital per unit of labour in a given economy or industry for a given time period.

Capital Intensity = Ratio of Capital and Labour (K/L)

Where

K = Capital for a given period.
L = Labour for a given period.

1.11 TOTAL FACTOR PRODUCTIVITY ESTIMATION

The productivity growth is an important way to increase the output of a firm or industry. Inefficiency in the usage of resources and the low productivity is well recognised as contributing factors to substantial welfare losses for a state like India. With the multiplicity of socio-economic demands on its capital, how such limited resources utilised assume fundamental importance. While substantial investment can be a precondition for economic growth, it is only the productivity of such investments, which yield further re-investible resources. These generate a surplus, which then motivate the entrepreneurs towards undertaking further industrial activity.

Productivity growth also comes in handy in the attempt to enhance the competitiveness of the export of a country. Productivity growth lowers labour cost and then, other things remaining constant, reduces the international price of the good concerned. Hence, the efficiency of utilisation of resource has to be given an utmost importance in policy matters, since dynamic efficiencies are critical in ensuring the industrial performance of a nation. For all these reasons productivity growth has been the target of much of the government policies around the world. At the same time economic policies of India tended to neglect productivity growth. Economists pointed out that there are four different ways through which liberalization process can contribute to productivity improvements; i) reduction in inefficiencies, ii) better exploitation of scale of economies, iii) export led imports and iv) faster rates of technological advancements (Srivastava, 1996).

In the Indian literature, there is now belated recognition that the productivity has a major role to play in ensuring industrial success. Productivity is the marginal contribution of a factor or factors to the output growth of a product, given the state
of technology. Productivity is a major source of high levels of production. It is a measure of the efficiency of factors or inputs in production. An increase in the levels of productivity in an economy implies that its factors of production and commodity inputs are manifesting increase in their output efficiency. The productivity improvements along with the increase in the quantities of factors will also be contributing an additional source of output increase (Brahmananda, 1982).

The prosperity of new developed nations has been attributed mainly to the sustained growth of its total factor productivity (Prescott, 1997). The performance of an industry can be understood with the estimation of Total Factor Productivity Growth (TFPG) and its behaviour over a period of time. In the early 1980s the government of India started to adopt and implement certain economic liberalisation measures, which were further intensified in 1990s to make the domestic industries productive and more competitive. These measures have telling impacts on the productivity of Indian industries.

1.1.1 MALMQUIST PRODUCTIVITY INDEX

The Data Envelopment Analysis (DEA) is a special mathematical linear programming model and test to assess efficiency and productivity. It allows use of panel data to estimate changes in total factor productivity and breaking it down into two components namely, technological change (TC) and technical efficiency change (TEC). TFP growth measures how much productivity grows or declines over time. When there are more outputs relative to the quantity of given inputs, then TFP has grown or increased. TFP can grow when adopting innovations such as electronics, improved design, or which we call “technological change” (TC). TFP can also grow when the industry uses their existing technology and economic inputs more efficiently; they can produce more while using the same capital, labour and technology, or more generally by increases in “Technical Efficiency Change” (TEC). TFP change from one year to the next is therefore comprised of technological change and changes in technical efficiency. The TEC is further decomposed into pure technical efficiency change (PTEC) and scale efficiency change (SEC).

This study uses the output-oriented model of DEA-Malmquist to put much weight on the expansion of output quantity out of a given amount of inputs.
Therefore, TFP index is a ratio of the weighted aggregate outputs to weighted aggregate inputs, using multiple outputs and inputs. Input and output quantities of industries are sets of data used to construct a piece-wise frontier over the data points. Efficiency measures are then calculated relative to this frontier that represents an efficient technology. The best-practice industry determines the production frontier, that is, those that have the highest level of production given a level of economic inputs. Points that lie below the piece-wise frontier are considered inefficient while points that lie on or above the frontier are efficient. Since many inputs are used, and shared outputs may be produced, the Malmquist approach was developed to combine inputs and outputs and then measure changes.

The Malmquist index measures the total factor productivity change (TFPC), between two data points over time, by calculating the ratio of distances of each data points relative to a common technology.

As per Malmquist Productivity Index (MPI) approach, total factor productivity can increase not only due to technical progress (shifting of frontier) but also due to improvement in technical efficiency (catch-up). This approach has become quite popular because: (i) it does not require price data, therefore suitable when price data are not available or price data are distorted, (ii) it rests on much weaker behavioural assumptions, since it does not assume cost minimizing or revenue maximizing behaviour, (iii) it uses time serious data and provides a decomposition of productivity change into two components – technical change and technical efficiency change. The significance of the decomposition is that it provides information on the source of overall productivity change (Singh and Agarwal, 2006).

The measurement of the Malmquist productivity index is based on distance functions. For simplicity, \( z^t = (x^t, y^t) \) and \( z^{t+1} = (x^{t+1}, y^{t+1}) \), where \( x^t \) is the vector of inputs used in production and \( y^t \) is the vector of outputs. Now, for each time period \( t=1, \ldots, T \), the output distance function is defined as follows:

\[
D^t(z) = \inf \{ \theta : y^t / \theta \in P^t(x) \} = \left[ \sup \{ \theta : y^t \in P^t(x) \} \right]^{-1} \tag{1}
\]
where superscript \( t \) and \( D_t \) denote that technology in period \( t \) is used as the reference technology. \( \theta \) is scalar, and its value is the efficiency score for each production activity. It satisfies \( 0 < \theta \leq 1 \) for a non-negative output level, with a value of 1 indicating a point of the frontier, and thus a technically efficient production activity. This output distance function is defined as the reciprocal of the maximal proportional expansion of output vector \( y^t \) with the given input vector \( x^1 \) in relation to the technology at \( t \).

The Malmquist productivity index is defined as follows:

\[
TFP = M^t = \frac{D^t(z^{t+1})}{D^t(z^t)}
\]  

(2)

This formulation is called the output-oriented Malmquist productivity index in period \( t \), \( M^t \left( z^{t+1}, z^t \right) \), where the technology in period \( t \) is the reference technology for two differing pairs of outputs and inputs. Alternatively, we can define \( M^{t+1} \) where the technology in period \( t+1 \) is employed as the reference technology.

Consistent with the study of Fare et al., (1994), the output-based Malmquist productivity index is defined as the geometric mean of two output-distance functions, in order to avoid selecting an arbitrary benchmark:

\[
M(z^{t+1}, z^t) = \left[ M^t(z^{t+1}, z^t) \right]^{\frac{1}{2}}
\]

(3)

Equation (3) can be rewritten as:

\[
M(z^{t+1}, z^t) = \left( \frac{D^{t+1}(z^{t+1})}{D^t(z^{t+1})} \right)^{\frac{1}{2}} \times \left( \frac{D^t(z^t)}{D^{t+1}(z^{t+1})} \right)^{\frac{1}{2}}
\]

(3')

where the ratio outside the brackets measures the change in relative efficiency between \( t \) and \( t+1 \), and the geometric mean inside the brackets measures the shift in frontier. That is, the Malmquist productivity index can be decomposed into change in efficiency and change in technical progress\(^1\).

In a previous empirical work, Fare et al., (1994) utilized non-parametric linear-programming techniques. As can be seen in (3’), we must solve four different linear

\(^1\) See Fare et al., (1994) for a graphical explanation.
programming problems: $D'(z)$, $D'(z^{t+1})$, $D^{t+1}(z)$, and $D^{t+1}(z^{t+1})$. Calculating the Malmquist index relative to the variable returns to scale technology. $D_j'(z^t)$ for each industry, $j \in k = 1, \ldots, K$, one of the four different linear programming problems, can be stated as:

$$\left[D_j'(z^t)^{-1}\right] = \max_{\theta, w} \theta_j$$ (4)

subject to $\theta_j y'_{m,j} \leq \sum_{k=1}^K w_k y'_{m,k}$ $m = 1, \ldots, M$ (4a)

$\sum_{k=1}^K w_k x'_{n,j} \leq x'_{n,j}$ $n = 1, \ldots, N$ (4b)

$w_k \geq 0$ $k = 1, \ldots, K$ (4c)

where $n = 1, \ldots, N$ are inputs, $m = 1, \ldots, M$ are outputs, and $w_k$ is an intensity variable indicating the production intensity of a particular activity. (Here, each industry is an activity). These intensity variables are used as weights in taking convex combinations of the observed outputs and inputs in both (4a) and (4b). From Equation 4, the reciprocal of the output distance function can be used to find the maximum of $\theta$, which gives the maximal proportional expansion of output given constraints (4a)–(4).

For the other distance functions, the computation of $D^{t+1}(z^{t+1})$ is exactly the same as (4), where $t + 1$ is substituted for $t$. Two other distance functions require information from two periods, $D'(z^{t+1})$ can be computed by replacing $y'_{m,j}$ and $x'_{n,j}$ in (4a) and (4b) with $y^{t+1}_{m,j}$ and $x^{t+1}_{n,j}$, respectively, and $D^{t+1}(z^t)$ is the same as $D'(z^{t+1})$, where the $t$ and $t + 1$ superscripts are exchanged3.

The output-oriented Malmquist indices of productivity change are computed using the data envelope approach discussed below. We used the computer software DEAP (Coelli, 1996) to calculate these indices.

2 Ray and Desli (1997) emphasized the importance of variable-returns-to-scale (VRS) in using a reference technology. In some cases, however, the VRS method has an infeasible solution (Ray and Desli, 1997, p.1037). In response to Ray and Desli (1997), Fare et al., (1997) commented that constant-returns-to-scale captures long-run results, whereas the VRS is appropriate for the short-run. Since our study analyzes the long-run productivity trend for 1991 to 2012, we use the method of Fare et al., (1994).

The following tables presented estimated mean values are geometric mean of Malmquist indices viz; total factor productivity changes (TFPCH), decomposed into technical efficiency change (EFFCH) and technological change (TECHCH). TECHCH is further decomposed into pure technical efficiency change (PECH) and scale efficiency change (SECH). The companies are arranged in descending order of their Malmquist productivity indices (TFPCH). The value of TFPCH higher than unity reveals productivity growth and lower than one indicates decline in productivity. Percentage change in productivity is given by (TFPCH - 1) x 100. The same rule applies to other indices presented in the table.

The total factor productivity change can be decomposed as,

\[ \text{TFP change} = \text{Technical efficiency change} \times \text{Technical change} \]

Further technical efficiency change decomposed as,

\[ \text{Technical efficiency change} = \text{Scale efficiency change} \times \text{Pure efficiency change} \]

1.12 LIMITATIONS OF THE STUDY

All the data relating to various economic indicators were in monetary terms and different indices were used to adjust them for a common base. For want of exact index, in some cases the nearest commodity group price index were used for deflations and in such cases the adjustments may be approximate and not accurate. The study mainly focuses its attention on Indian automobile industry and its sub-sectors and not on individual enterprises. In other words it is a macro analysis at all India level. Hence, the performance of individual firms may be at variance with the broad conclusions drawn at the end. The nature of ownership, private, public or foreign, was not divided separately in the analysis as they significantly influence the productivity growth.
1.13 CHAPTER SCHEME

The whole study has been divided into five chapters.

The first chapter deals with introduction, need for the study, statement of the problem, hypothesis, objectives, brief methodology and limitations.

Chapter two presents a brief review of the earlier studies.

Chapter three examines the Growth of Indian Automobile Industry during the post-reform period.

Chapter four evaluates the Sources of Productivity Growth in Indian Automobile Industry in the post-reform period.

Chapter five briefly presents the summary of findings and conclusion.
REFERENCES


