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ENVELOPMENT ANALYSIS AND MALMQUIST TOTAL FACTOR PRODUCTIVITY INDEX: AN APPLICATION TO INDIAN AUTOMOBILE FIRMS

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Abstract

India's Economic Reforms(1991) allowed more competition and increased provisions for the entry of new domestic firms and Multi-National Companies(MNCs) in the manufacturing sector. Therefore, it is the need of the hour to assess the TFP and identification of the factors that account for productivity changes. In this study, an attempt has been made to assess the effects of economic reforms on productivity growth in Indian automobile companies using Malmquist Productivity Index by decomposing the TFP change into technical and efficiency changes. The results of the study showed that most of the Indian automobile companies must increase their TFP and efforts must be made to provide a stable pattern to the productivity growth. The benefits of technological progress were not converted into productivity gains as there was no improvement in efficiency in the reform period. The results of the study suggest that there is need for the implementation of specific policies to improve technical progress and efficiency change, in order to bring about a long-run balance in TFP growth.

Key Words: *Productivity, Scale Efficiency, Malmquist Productivity Index, Indian Automobile Industry, Technology Adoption and Managerial Efficiency Growth.*

1. INTRODUCTION

Industry has a major role to play in the economic development of a country. For any country, which wants to perform in their industrial sector, needs to enhance its cost competitiveness by fostering Total Factor Productivity Growth (TFPG). Naturally, measurement of the total factor productivity changes in manufacturing industries and identifying the factors, which account for productivity changes, are of great interest, both in academic and practical senses. Manufacturing industries in developing countries rely heavily on imported intermediate inputs and sophisticated technology. Availability of both these factors also plays a crucial role in the variation in productivity of industry concerned. In the early phases of industrialization, the productivity in Indian manufacturing sector was limited by the government policies such as the reservation of production, high custom tariff distorting resource allocation and prohibiting Indian Industry's ability to compete in the international market, shutting down industries in response to normal competitive market forces and various types of distortions created by the structure of domestic trade taxes and excise duties. However, the situation is gradually changing since 1991 due to the introduction of economic liberalization process though at a slow and halting pace.

The first comprehensive economic reform policy statement was formulated for India in July 1991 in the form of industrial and trade sector liberalization. Over the years several measures were undertaken by them for boosting the industrial productivity. Tariff rates have considerably been brought down and quantitative restrictions on imported goods have been removed to a great extent. These were adopted along with changes in technology-import policy, foreign direct investment policy, to make Indian industrial sector more efficient and productive, technology sounder and an able competitor in the world market. Therefore, analysing productivity and efficiency changes during the post reform period becomes essential for providing strategic inputs to the producers, the government and other stake holders.

2. LITERATURE REVIEW

Several studies have attempted to estimate the relationship between economic reforms and productivity growth in Indian manufacturing sector. Estimation of TFPG of Indian manufacturing industries can be seen from **Goldar (1986), Ahluwalia (1991), Balakrishnan and Pushpangadan (1994), Fujita (1994), Rao (1996), Majumdar (1996), Joshi and Little (1997), Gangopadhyay and Wadhva (1998), Pradhan and Barik (1998), Krishna and Mitra (1998), Mitra (1999), Trivedi et al., (2000), Balakrishnan et al., (2000), Unni and Rani (2001), Forbes (2001), Srivastava (2001), Chand and Sen (2002), Hasan (2002), Goldar and Kumari (2003), Unel (2003), TSL (2003), Driffield and Kambhampatti (2003), Goldar (2004), Das (2004), Mukherjee (2004), Rani and Unni (2004), Pattnayak and Thangavelu (2005), Banga and Goldar (2007), Madheswaran et al., (2007), Milner et al., (2007), Soo (2008), Jabir Ali et al., (2009).** All of them examined the effect of reforms on industrial productivity. Some studies have reported that policies of liberalization improved the productivity of the manfuacturing industry **[For example, See Fujita (1994); Majumdar (1996); Krishna and Mitra (1998); Chand and Sen (2002); Unel (2003); TSL (2003); Pattnayak and Thangavelu (2005); Banga and Goldar (2007)]** whereas some have detected negative effects, or atleast no significant improvement, in productivity growth since the onset of economic reforms in 1991 **[for example, See Trivedi et al., (2000); Balakrishnan et al., (2000); Unni and Rani (2001); Goldar and Kumari (2003); Driffield and Kambhampatti (2003); Goldar (2004); Das (2004)]**. Thus, the topic on the effects of economic reforms on productivity growth remains a critical focus of research.

3. STATEMENT OF THE PROBLEM

To meet the emerging challenges, there is an urgent need to bring efficiency into the production process, either through maximizing the output or minimizing the cost. While there have been numerous studies conducted on productivity growth, only a relatively few studies have concerned themselves with the sources of productivity growth in the Indian Economy. The traditional Tornquist Index which is applied to calculate total factor productivity growth, is incapable of decomposing the productivity change into movements along the frontier because the Tornquist Index assumes that the observed output is the consequence of the best practice frontier. Conversely, the nonparametric Data Envelopment Analysis (DEA) approach is used to compute the Malmquist Total Factor Productivity (TFP) change which has been further decomposed into efficiency and technical change.

Total Factor Productivity can be increased by using its existing technology and factor inputs more efficiently and this is referred to as “efficiency change”. The total factor productivity of an industry can also increase when the industry adopts innovations or technological improvements and this process is referred to as “technological change”. Therefore, changes in TFP from one period to the next are the products of both efficiency change and technological progress. Most previous studies conducted in India have failed to consider the sources of such changes in productivity growth **(Sindhu and Balasubramanyam (2006)).** This study has attempted to assess the effects of economic reforms on productivity growth in Indian automobile companies using the Malmquist Productivity Index and decomposing the TFP change into technical and efficiency changes. In particular, this study intends to find the answers to the following question.

Has the performance of the automobile companies in India improved since the market liberalization of the 1990s in terms of productivity and efficiency changes?

4. METHODOLOGY OF THE STUDY

It is widely believed that Total Factor Productivity (TFP) is either measured by an index of outputs divided by an index of inputs or as the shift in the production function. Technological Change is also defined and measured as the shift in the production function and is thus often synonymous with TFP. However, when production is allowed to be inefficient, TFP change also includes Technical Efficiency Change. In the empirical exercise attempted in this study, the study employed Malmquist Total Factor Productivity Growth which is estimated by using a non-parametric method namely, Data Envelopment Analysis (DEA).

a. Data Envelopment Analysis Approach

The DEA approach was first proposed by **Charnes et al (1978)** to construct a production frontier and since then there have been a vast range of applications in the literature using DEA (**Fare and Lovell 1978; Banker et al., 1984; Zhang et al., 1998; Ray and Ping 2001; Mahadevan 2004**). DEA envelops observes input and output data without requiring *a priori* specification of functional form which turns out to be its major advantage. Production Frontier is empirically constructed using linear programming methods from observed input-output data of sample firms. Efficiency of firms is then measured in terms of how far they are from the frontier. In contrast, different specifications of the production function under the parametric approach provide different results and this remains a methodological problem. Secondly, DEA is more appealing than the econometric model as inefficiency is likely to be correlated with the inputs (**Gong and Sickless 1992**). However, DEA is not free from drawbacks. First, measurement error and statistical noise are assumed to be nonexistent. Second, it does not allow for statistical tests typical of the parametric approach.

b. The Malmquist Productivity Index

The study uses the Malmquist Productivity Index approach to analyze changes in the total factor productivity of selected firms in Indian Automobile Industry over a period of time. The total factor productivity change of a firm has two primary components; the shift in the production frontier over time, representing technical change and the shift in the firm's efficiency relative to the production frontier over time, representing efficiency change. There are several other ways to measure the productivity change of a firm (**such as the Fisher Index or the Tornquist Index**) but the Malmquist Index was employed because it permits the separation of technical change from efficiency change (**Fare, Grosskopf, Norris and Zhang, 1994**) and is consistent with the DEA efficiency estimation methodology.

The Malmquist Index was introduced by **Caves et al (1982 a, b)** who dubbed it the (output based) Malmquist Index after Sten Malmquist who earlier proposed constructing quantity indexes as ratios of distance functions (**See Malmquist, 1953**). The Malmquist Index is calculated as follows ((**as outlined in Fare et al., (1997)**)).

The measurement of the Malmquist Productivity Index is predicated 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 $t = 1,......T$, the output distance function is defined as follows:

$$D^t(z) = \inf\{\theta : y^t / \theta \in P^t(x)\}$$

$$= \left[\sup\{\theta : y^t / \theta \in P^t(x)\}\right]^{-1} \quad (1)$$

where superscript t and D^t denote that technology in period t is used as the reference technology. θ 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^t in relation to the technology at t.

The Malmquist Productivity Index is defined as follows:

$$TFP = M^t = \frac{D^t(z^{t+1})}{D^t(z^t)} \quad (2)$$

This formulation is called the output-oriented Malmquist Productivity Index in period t, M^t (z^{t+1}, z), 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:

$$M(z^{t+1}, z^t) = [M^t . M^{t+1}]^{1/2} = \left[\left(\frac{D^t(z^{t+1})}{D^t(z^t)}\right)\left(\frac{D^{t+1}(z^{t+1})}{D^{t+1}(z^t)}\right)\right]^{1/2} \quad (3)$$

Equation (3) can be rewritten as:

$$M(z^{t+1}, z^t) = \left(\frac{D^{t+1}(z^{t+1})}{D^t(z^t)}\right) \times \left(\frac{D^t(z^{t+1})}{D^{t+1}(z^{t+1})}\right)\left(\frac{D^t(z^t)}{D^{t+1}(z^t)}\right)^{1/2} \quad (3a)$$

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.

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

$$D^t(z^t),\ D^t(z^{t+1}),\ D^{t+1}(z^t),\ and\ D^{t+1}(z^{t+1}).$$

Calculating the Malmquist Index relative to the variable returns to scale technology, $D_j^t(z^t)$ for each industry, $j \in k = 1,....,K$, one of the four different linear programming problems, can be stated as:

$$\left[D_j^t(z_j^t)^{-1} = \max_{\theta, w} \theta_j\right] \quad (4)$$

subject to $\theta_j y_{m,j}^t \leq \sum_{k=1}^{K} w_k^t y_{m,k}^t \quad m = 1,....,M \quad (4a)$

$$\sum_{k=1}^{K} w_k^t x_{n,j}^t \leq x_{n,j}^t \quad n = 1,......,N \quad (4b)$$

$$w_k^t \geq 0 \quad k = 1,......,K \quad (4c)$$

where $n = 1, ..., N$ are inputs, $m = 1, ..., M$ are outputs, and w_k^t 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 θ, which gives the maximal proportional expansion of output given constraints (4a) – (4).

For the other distance functions, the computation of $D^{t+1}\left(z^{t+1}\right)$ is exactly the same as (4), where $t + 1$ is substituted for t. Two other distance functions require information from two periods, $D^{t}\left(z^{t+1}\right)$ can be computed by replacing $y^{t}_{m,j}$ and $x^{t}_{n,j}$ in (4a) and (4b) with $y^{t+1}_{m,j}$ and $x^{t+1}_{n,j}$, respectively and $D^{t+1}\left(z^{t}\right)$ is the same as $D^{t}\left(z^{t+1}\right)$, where the t and $t + 1$ superscripts are exchanged.

c. Research Design

Keeping in view the scope of the study, it was decided to include all the companies under automobile industry working before or from the year 1996-97 to 2008-09. There were 26 companies operating in the Indian Automobile Industry. But owing to several constraints such as non-availability of financial statements or non-working of a company in a particular year etc., it was compelled to restrict the number of sample companies to 20. The companies under Automobile Industry were classified into three sectors, namely, Commercial Vehicles, Passenger Cars and Multiutility Vehicles and Two and Three Wheelers. For the purpose of the study, all the three sectors were selected. It accounted for 73.23 per cent of the total companies available in the Indian Automobile Industry. The selected 20 companies included five under Commercial Vehicles, six under Passenger Cars and Multiutility Vehicles and nine under Two and Three Wheeler Sectors. It is inferred that sample company represented 98.74 percentage of market share in Commercial Vehicles, 89.76 percentage of market share in Passenger Cars and Multiutility Vehicles and 99.81 percentage of market share in Two and Three Wheelers. Thus the findings based on the occurrence of such representative sample may be presumed to be truly representative of Automobile Industry in the country.

Out of 20 selected companies under Indian Automobile Industry, the productivity performance of three Multinational Companies (MNC's), namely, Hyundai Motors India Ltd, Honda Siel Cars India Ltd and Ford India Private Ltd was computed separately because these companies established their operations in India in different accounting years. In order to have uniform period, the productivity performance of the three MNC's were computed from the year 2000-01 to 2008-09 (9 years only).

d. Data Collection

The study was mainly based on secondary data. Majority of data analysed and interpreted in this study were collected from "PROWESS" database which is the most reliable on the empowered corporate database of Centre for Monitoring Indian Economy (CMIE). Besides prowess database, relevant secondary data were also collected from BSE Stock Exchange Official Directory, CIME Publications, Annual Survey of Industry, Business newspapers, Reports on Currency and Finance, Libraries of various Research Institutions, through Internet etc.

5. RESULTS AND DISCUSSION

a. Malmquist Total Factor Productivity

Table-1 shows the mean values of change in Malmquist Total Factor Productivity Index and its components (efficiency change and technology change) for the period 1996-97 to 2008-09. The malmquist index value was greater than one, indicating positive TFPG and the value was less than one, indicating TFPG decline. Note that while the product of the efficiency change and technology change components must be equal to the Malmquist Index, those components may be moving in opposite directions. For all the companies put together, the TFP had decreased by 1.05 per cent during the study period. An important question to investigate is whether the TFPG was achieved by improvement in technical efficiency (catch-up) and / or improvement in technology (shift in production frontier). The decomposition of TFPG into efficiency change and technical change, reported in the **Table-1**, shows that technological efficiency change was the main contributor to TFPG. The average technological efficiency was 2.24 per cent while the average technical efficiency change was negative (-3.20 per cent). This suggests that in the companies studied, technical efficiency was the main barrier to achieving high level of TFP during the period under consideration. Further, the analysis of total factor productivity of three sectors reveals that the overall TFP growth was positive in passenger cars and multiutility sector (2.5 per cent) due to improvement in both technical efficiency of 0.6 per cent and technological efficiency of 1.9 per cent.

Another significant result from the **Table-1** is that the efficiency change tended to be a negative contributor to total factor productivity in the commercial vehicles and two and three wheeler sector (i.e, it was less than unity) and technological change tended to be a positive contributor (i.e., it was greater than unity), suggesting that improvement in these sectors was due to their productivity based on production frontier effect. The overall technical efficiency change in these sectors was less than one, which is the main cause in dampening the total factor productivity for whole industries.

Technical efficiency change is the result of pure technical efficiency change and scale efficiency change. With regard to pure efficiency change, it was more than one in cars and multiutility vehicles sector only. In the case of scale efficiency change, a value close to unity shows that all the sectors were operating at optimum scale. In short, scale efficiency only had contributed to the improvement in technical efficiency in all the three sectors and the whole Indian Automobile Industry during the study period.

Another interesting finding is that only 10 out of 17 companies had registered growth in TFP during the period 1996-97 to 2008-09 (**Table-1**). Further, all the companies, except LML Ltd, under two and three wheeler sector recorded technological efficiency improvement. But only 6 out of 17 companies had recorded technical efficiency improvement. However, not all the companies registered a similar performance during the period. Some companies, for instance, Ashok Leyland Ltd and Tata Motors Ltd (under commercial vehicles sector), Hindustan Motors Ltd (under passenger cars and multiutility vehicles sector) and Bajaj Auto Ltd, Hero Honda Motors Ltd and Majestic Auto Ltd (under two and three wheeler sector) had experienced an increase in overall technical efficiency during the period while remaining companies experienced a negative growth in technical efficiency. But as far as technological efficiency was concerned, all the selected companies, except LML Ltd, had experienced a big increase in overall technological efficiency range from 1.002 to 1.048 during the period. Only in the case of Ashok Leyland Ltd and Tata Motors Ltd (commercial vehicle sector), Hindustan Motors Ltd (passenger cars and multiutility vehicles sector) and Bajaj Auto Ltd, Hero Honda Motors Ltd and Majestic Auto Ltd (two and three wheeler sector), improvement in these industries was due to their productivity based both on catching up effect and production frontier effect.

The technical efficiency change could be further decomposed into pure technical efficiency change and scale efficiency change displayed in the last two columns in **Table-1**. With regard to pure efficiency change, it was one or more than one for Ashok Leyland Ltd, Tata Motors Ltd and Swaraj Mazda Ltd (Commercial vehicle sector), Hindustan Motors

Ltd, Mahindra and Mahindra Ltd and Maruti Udyog Ltd (Passenger cars and Multiutility vehicles sector) and Bajaj Auto Ltd, Hero Honda Motors Ltd and Majestic Auto Ltd (Two and three wheeler sector) during the study period. Scale efficiency indicates whether the firm could increase its productivity by becoming larger. It is evident from the **Table** that in the case of scale efficiency change, value close to unity shows that most of the companies were operating at optimum scale. The results of the study show that both the pure and scale efficiency had contributed to the growth of overall efficiency. This suggests that while achieving high levels of technical performance over time, technical efficiency was not a long-run constraint. From the **Table-1**, the comparison of total factor productivity change in different companies shows that Hero Honda Motors Ltd on an average recorded the highest growth in TFP (12.1 per cent), followed by Majestic Auto Ltd (5.7 per cent) and Bajaj Auto Ltd (4.1 per cent). The worst performers in terms of total factor productivity growth were Maharashtra Scooters Ltd (-28 per cent), followed by Kinetic Motors Ltd (-9 per cent). Both the best and worst performers in terms of total factor productivity growth were found in two and three wheeler sector of Indian Automobile Industry during the study period.

The mean values of changes in Malmquist Total Factor Productivity Index and its components (efficiency change and technology change) for the three multinational companies in Indian Automobile Industry for the period 1996-97 to 2008-09, are presented in **Table-2**. The analysis of total factor productivity of three MNCs reveals that the overall TFP growth was positive for Ford India Private Ltd and Honda Siel Cars India Ltd but it was negative for Hyundai Motors India Ltd during the study period. The overall TFP growth was the highest for Ford India Private Ltd (27 per cent) due to improvement in technical efficiency of 24 per cent and technological efficiency of 2.3 per cent. Similarly, in Honda Siel Cars India Ltd, the productivity growth was 2.7 per cent, with technical efficiency growth at 1.2 per cent and technological efficiency change at 1.5 per cent. Another significant result inferred from the **Table-2** is that technological change tended to be a negative contributor to total factor productivity in the Hyundai Motors India Ltd (i.e., it was less than unity), which was the main cause in dampening the total factor productivity in Hyundai Motors India Ltd. The analysis of two components of technical efficiency change presented in the **Table** reveals that pure efficiency change was more than one in Ford India Private Ltd only. In the case of scale efficiency change, in all the three MNCs, scale efficiency which was one or more than one, had contributed to the improvement in technical efficiency. The **Table** also reveals that Hyundai Motors India Ltd did not show any change in terms of pure efficiency change and scale efficiency change during 1997-2009.

6. CONCLUSION

The empirical estimates of productivity performance in the Indian Automobile Industry yielded several results that appear striking. The overall automobile industry improved technical (technological) change efficiency by 2.2 per cent while technical efficiency change was negative and dampened the overall total factor productivity during 1997-2009 by 1.4 per cent. Among the three sectors, both technical efficiency change and technical change registered a positive effect on the productivity only in the case of passenger cars and multiutility vehicles sector. However, in the case of commercial vehicles sectors, technical progress led to an increase of productivity by 0.4 per cent during the study period. The results from individual companies show that TFP growth was mainly contributed by technological change while technical efficiency change was positive only for ten out of twenty companies. It suggests that Indian Automobile Industry lacked managerial efficiency growth. Except a few companies like Hero Honda Motors Ltd and Ford India Private Ltd which recordeds **Table** productivity, all other companies recorded a mixed trend over 1997-2009, which affected the productivity and ranking of companies. Ford India Private Ltd was at the top in ranking in terms of TFP, followed by Hero Honda Motors Ltd due to the highest technical change and technical efficiency. Maharashtra Scooters Ltd and Kinetic Motor Company Ltd were among the worst performers in terms of productivity over 1997-2009. The main reason for this worst performance was less improvement in managerial efficiency.

The research result suggests that Indian Automobile Companies must increase total factor productivity in most of the companies under study and efforts must be made to provide as **Table** pattern to the productivity growth. The reform process had increased access to superior technology in the manufacturing sector through higher foreign participation as well as greater access to importation of higher quality of raw materials and capital equipment. However, the benefits of technological progress were not converted into productivity gains, as there was no improvement in efficiency in the reform period. The results of this study suggest the need for the implementation of specific policies to improve technical progress and efficiency change, in order to precipitate a long-run balance in TFP growth. Technological progress should be encouraged in industries with slow technical progress and industries, with slow efficiency change rates and they should be encouraged to use existing technology more effectively via increased training and education.

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Table-1

Changes in Total Factor Productivity and its Components of Selected Indian Automobile Companies during 1996-97 to 2008-09.
(Malmquist Index Summary of Company Means)

Company	TFP Change	Components of TFPG		Components of Technical Efficiency Change	
		Technological Change	Technical Efficiency Change	Pure Technical Efficiency Change	Scale Efficiency Change
Ashok Leyland Ltd	1.030	1.022	1.008	1.012	0.996
Tata Motors Ltd	1.026	1.020	1.006	1.000	1.006
Bajaj Tempo Ltd	0.975	1.009	0.966	0.965	1.001
Eicher Motors Ltd	0.981	1.007	0.974	0.977	0.997
Swaraj Mazda Ltd	1.007	1.026	0.981	1.000	0.981
Hindustan Motors Ltd	1.026	1.002	1.024	1.025	0.999
Mahindra and Mahindra Ltd	1.034	1.039	0.995	1.022	0.974
Maruti Udyog Ltd	1.015	1.015	1.000	1.000	1.000
Bajaj Auto Ltd	1.041	1.017	1.024	1.000	1.024
LML Ltd	0.937	0.990	0.946	0.964	0.981
Maharashtra Scooters Ltd	0.723	1.044	0.692	0.708	0.978
TVS Motor Company Ltd	1.019	1.040	0.980	0.970	1.010
Kinetic Motor Company Ltd	0.910	1.027	0.885	0.891	0.994
Hero Honda Motors Ltd	1.121	1.048	1.070	1.060	1.009
Kinetic Engineering Ltd	0.953	1.011	0.943	0.961	0.981
Majestic Auto Ltd	1.057	1.030	1.026	1.054	0.974
Scooters India Ltd	0.967	1.033	0.936	0.935	1.001
Commercial Vechicles	**1.004**	**1.017**	**0.987**	**0.991**	**0.996**
Passenger Cars and Multiutility Vechicles	**1.025**	**1.019**	**1.006**	**1.016**	**0.991**
Two and Three Wheelers	**0.963**	**1.027**	**0.938**	**0.943**	**0.995**
Whole Automobile Industry	**0.986**	**1.022**	**0.964**	**0.970**	**0.994**

Source: Computed from the annual accounts of Indian Automobile Companies

Table-2

Changes in Total Factor Productivity and its Components of Three MNC in Indian Automobile Companies during 1996-97 to 2008-09.

(Malmquist Index Summary of Company Means)

Company	TFP Change	Components of TFPG		Components of Technical Efficiency Change	
		Technological Change	Technical Efficiency Change	Pure Technical Efficiency Change	Scale Efficiency Change
Hyundai Motors India Ltd	0.976	0.976	1.000	1.000	1.000
Honda Siel cars India Ltd	1.027	1.015	1.012	1.000	1.012
Ford India Private Ltd	1.270	1.023	1.241	1.224	1.014

Source: Computed from the annual accounts of Indian Automobile Companies

Table-3

Ranking of Companies based on Malmquist TFP and its Components

Company	Ranks				
	TFP Change	Tech. Change	TE Change	PE Change	SE Change
Ashok Leyland Ltd	6	10	7	6	13
Tata Motors Ltd	8	11	8	7	6
Bajaj Tempo Ltd	15	16	15	15	7
Eicher Motors Ltd	13	17	14	13	12
Swaraj Mazda Ltd	12	8	12	8	15
Hindustan Motors Ltd	9	18	4	4	11
Mahindra and Mahindra Ltd	5	4	11	5	19
Maruti Udyog Ltd	11	13	9	9	9
Bajaj Auto Ltd	4	12	5	10	1
LML Ltd	18	19	16	16	16
Maharashtra Scooters Ltd	20	2	20	20	18
TVS Motor Company Ltd	10	3	13	14	4
Kinetic Motor Company Ltd	19	7	19	19	14
Hero Honda Motors Ltd	2	1	2	2	5
Kinetic Engineering Ltd	17	15	17	17	17
Majestic Auto Ltd	3	6	3	3	20
Scooters India Ltd	16	5	18	18	8
Hyundai Motors India Ltd	14	20	10	11	10
Honda Siel Cars India Ltd	7	14	6	12	3
Ford India Private Ltd	1	9	1	1	2

Source: Computed from the annual accounts of Malmquist TFP