A Study on Productivity Performance of Indian Automobile Industry: Growth accounting Analysis
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Abstract

Voluminous literature on growth of nations establishes the key role of productivity in enhancing the pace of economic growth. Rising productivity levels are associated to increased production, lower costs and sustained competitiveness. The term Total Factor Productivity (TFP) measures the changes in output that are non-attributable to changes in input. This paper seeks to examine the productivity performance of the Indian automobile industry via growth accounting approach. The period for the study spans from 1990-91 to 2003-04. Divisia-Tornquist approximation has been used to arrive at productivity estimates for a study period of 15 years. The growth accounting approach is based on the development of indices of output and input. A nonparametric measure of TFP is computed from the ratio of these indices. It should be noted here that the year-to-year specific TFP values might fluctuate, hence, TFP Growth (TFPG) is best considered in terms of productivity trends over a period of time. TFPG is obtained as difference between the rates of growth of real product and real factor input. Apart from the combined estimates of the total factor productivity, in order to evaluate the productivity of individual factors of production (capital, labour, raw material and energy), partial factor productivities have also been computed.

Introduction

The decision in the late Eighties to allow foreign collaborations in all automotive segments was a milestone in the destiny of the Indian auto world. In July 1991, industrial licensing was abolished for all types of automobiles except motorcars. Licensing for motorcars was abolished in April 1993. The competitive environment, which emerged after the liberalisation of the economy, witnessed a positive impact on the Indian economy and the automobile industry in particular. The automobile industry in the country is one of the key sectors of the economy in terms of the employment opportunities that it offers directly as well as indirectly. This paper attempts to examine the productivity performance of Indian automobile industry in post liberalization era.
In today’s highly competitive era where trade barriers in the international market are falling, survival of any industry depends on its cost advantage over others. The rising productivity levels, which are associated to lower costs and increased production play a crucial role in the economic growth of a nation and also ensure sustained competitiveness at global front. Scarcity of resources has been recognised as a limiting factor on the process of economic growth. It is relevant to mention here that output expansion based on increased use of resources may be feasible but it cannot be sustainable. Therefore, efficiency or productivity of resources becomes a critical factor in economic growth (Mongia and Sathaye, 1998). One of the path-breaking discoveries in economic history is that a large part of the increase in output cannot be explained by the traditional factors of production (M. Abramovitz 1956, Solow 1957, Bhasin and Seth 1977). The term Total Factor Productivity (TFP) measures the changes in output that are non-attributable to changes in input. These non-input factors viz., technological progress, economies of scale, capacity utilization, market inefficiency and qualitative changes in inputs etc. make the input factors more efficient hence enabling more production with the same quantity of inputs. TFP gain captures this efficiency and can be measured by the ratio of output and input. Over the years, a rise in this ratio with constant inputs is inferred as TFP gain. The year-to-year specific TFP values may fluctuate; hence TFP Growth (TFPG hereafter) is best considered in terms of productivity trends over a period of time (Oum et al., 1999). TFPG is obtained as difference between the rates of growth of real product and real factor input (Jorgenson and Griliches, 1967). This is given by the time derivative of TFP as: 

\[ \text{TFPG} = \dot{Q} - \dot{X} \]

\[ \dot{Q} = \frac{d\ln Q}{dt}, \quad \text{growth rate of output.} \]

\[ \dot{X} = \frac{d\ln x}{dt}, \quad \text{growth rate of input.} \]
Economic literature recognizes three major approaches to measure TFP:

- Growth accounting / Index number approach
- Econometric / Parametric approach
- Efficiency Frontiers

The growth accounting approach is based on the development of indices of output and input. Indices are made under the assumptions of a particular production function, which is assumed implicitly. Under the Econometric approach, the production function (or its dual in the form of cost or profit function) is explicitly estimated. This approach aims at obtaining the different components of TFP. Efficiency frontier model approach is more appropriate if the study unit is firm not the industry. This approach studies how far a decision-making unit is away from the efficiency frontier. The concept of a production frontier is consistent with the underlying economic theory of optimizing behaviour. Any deviation from a frontier has a natural interpretation as a measure of the efficiency with which economic units pursue their technical or behavioral objectives (Bauer, 1990). Efficiency frontiers can be further studied either through econometric or non-parametric approach. The econometric approach uses parametric representation of the technology along with a two-part composed error term. One part of the composed error term represents statistical noise and is generally assumed to follow a normal distribution. The other part represents inefficiency and is assumed to follow a particular one-sided distribution (Farrel, 1957). The non-parametric approach uses mathematical programming known as Data Envelopment Analysis (DEA). DEA uses linear programming methods to estimate the efficiency frontier function to evaluate the efficiency of a firm or organization (Nyshadham and Rao, 2000; Charnes, Cooper, Lewin, & Seiford, 1994; Gillien & Lall, 1997).
2. **Methodology and Database**

This paper is based on growth accounting analysis of productivity performance of Indian automobile industry in post liberalization era. Therefore, the study period spans from 1989-90 to 2003-04. Growth accounting approach is considered to be the conventional approach for measuring TFP. The observed growth of output is projected to be explained in terms of growth in factor inputs and the unexplained part or the residual. This residual is attributed to growth in productivity of factors. This approach consists in assuming a certain functional form for the producers' production function and then deriving an index number formula that is consistent with the assumed functional form. These indices differ from each other on the basis of the underlying production function or the aggregation scheme assumed (Mongia and Sathaye, 1998). The most commonly used Indices are: (i) Kendrick Index (ii) Solow Index, and (iii) Divisia Index.

Before going into discussion, one important characteristic of Index Number approach deserve a mention that with this approach we can work on detailed data with many input and output categories regardless of the number of observations over time. Therefore there is no problem of degrees of freedom while working with small samples\(^1\).

The Kendrick Index of total factor productivity assumes a linear and homogeneous production function of degree one in labour and capital. This index is known as arithmetic index as it measures the average productivity of an arithmetic combination of inputs weighted with base year period factor prices.

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\(^1\) Such problem may arise in case of Econometric Approach since it involves estimation of a number of parameters.
While the Kendrick Index is simple to understand and easy to calculate, its major drawback is that it is based on a linear production function implying that the marginal products of the inputs are constant (independent of quantities of inputs). Therefore this Index rules out possible diminishing marginal productivity of factors of production. Apart from this the assumption of neutral technical change rules out the possibility of technical change being biased towards capital or labour (Goldar 1985, Baghel and Pendse 1997). Solow Index is based on Cobb-Douglas production function. It assumes Hicks neutral technical change, constant returns to scale\(^2\), competitive equilibrium and factor rewards being determined by the marginal products. It is important to note here that Solow Index is based on Cobb-Douglas production function, which assumes elasticity of substitution as unity. This seems quite restrictive. Kendrick and Solow indices have certain limitations therefore, a less restrictive index, known as Divisia Index, has gained more importance. It has been introduced by Solow (1957). Further its importance has been highlighted by Ritcher (1966), Jorgenson and Griliches (1967), Christensen and Jorgenson (1969, 1970), Hulten (1973) and Diewurt (1976), among many others. Hulten (1973) have shown that no other index can do better than Divisia as it involves all the information contained in the components. Divisia Index satisfies the factor reversal test, time reversal test and reproductive property. Factor reversal test requires that growth rates of Divisia Index of prices and quantities add up to the growth rate of the value. The time reversal test is satisfied if the Divisia Index is symmetrical in different directions of time. The

\(^2\) Production function is homogeneous of degree one.
reproductive property requires that the Divisia Index of Divisia Indices must be the Divisia Index of the components.

It is well known that Divisia Index of Productivity is a line integral; therefore its value normally depends on the path of integration (Jorgenson and Griliches, 1967). The index will be path independent if and only if the aggregate over which it is defined actually exits. Path independence becomes therefore, an essential element of any acceptable Divisia Index. For a homothetic function $Y = Y (y_1, y_2, \ldots, y_m)$, a Divisia Index is a good indicator of $Y$ because it depends only on initial and final quantities $y_0$ and $y_t$ and is independent of the path taken (Ritcher 1966, Samuelson and Swami 1974).

Application of Divisia Index numbers lies in theoretical analysis, which assumes continuous and instantaneous changes. Aggregate output ($Y$) and input ($X$) have growth rates as $\dot{Y}$ and $\dot{X}$ (Hulten 1973, Diwert 1980). Since $\text{TFP} = \frac{Y}{X}$, the growth rate of $\text{TFP}$ is defined by $\dot{\text{TFP}} = \dot{Y} - \dot{X}$, which assumes continuous and instantaneous changes.

Divisia Index can't be applied in economic research, as most of economic data is available in discrete form. Torquist has provided a discrete approximation to the continuous Divisia Index in order to make its application possible on discrete data (Diewert 1976). A discrete index formula is obtained by replacing the continuous growth rates by discrete difference in logarithms. Hence change in TFP is obtained by:
\[ \Delta \ln TFP = \Delta \ln Y - \Delta \ln X \]

\[
TFPG^2 = \ln q_t - \ln q_{t-1} - \frac{1}{2} \sum_i \left( \theta_{it} + \theta_{it-1} \right) \left( \ln X_{it} - \ln X_{it-1} \right)
\]

Where, TFPG is Total Factor Productivity Growth. \( q_t \) is the output \(^3 \) in the \( t^{th} \) year at constant prices (1990-91). \( \theta_{it} \) is the share of \( i^{th} \) input in in total cost in \( t^{th} \) year at current prices. \( X_{it} \) is the value of \( i^{th} \) input in the total cost in \( t^{th} \) year at current prices. Once the trend values i.e. TFPG is computed, following procedure has been employed to obtain the series on TFP:

- \( TFP_{1990-91} = 100 \) (TFP for 1990-91 is taken to be 100)
- \( TFP_{1991-92} = TFP_{1990-91} (1 + TFPG_{1990-91}) \)
- \( TFP_{1992-93} = TFP_{1991-92} (1 + TFPG_{1991-92}) \)
- ...
- \( TFP_{2003-04} = TFP_{2002-03} (1 + TFPG_{2002-03}) \).

**Trend Growth Rate in TFP**

TFPG mentioned in the proceeding section gives annual growth rates, which exhibit the year to year fluctuations. In order to arrive at a trend growth rate over the study period, the following relationship is estimated.

\[
\ln TFP = \alpha + \beta \ t + \varepsilon
\]

Where, \( \beta \) is the coefficient of the trend growth.

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\(^2\) This expresses the TFPG as the difference between growth rate of output and weighted average of growth rates of inputs. The index derived above is also known as Divisia-Tornquist approximation. As the relationship between the output, input and time is described through Translog production function hence is also termed as Translog index.

\(^3\) Gross output has been taken as the measure of output. To neutralise the effect of inflation, output data has been deflated by WPI for automobile industry at 1990-91 prices.
Partial Productivity Indices

These indices are calculated by dividing the output by value of the input in the total cost. It is obtained as follows:

\[ PPI_{it} = \frac{q_t}{x_{it}} \]

Where \( PPI_{it} \) is the Partial Productivity Index for the \( i^{th} \) input in \( t^{th} \) year.

\( q_t \) is the output in the \( t^{th} \) year at constant prices.

\( x_{it} \) is the value of the \( i^{th} \) input in total cost in \( t^{th} \) year at constant prices.

Study is based on the data taken from the Prowess database developed by Centre for Monitoring Indian Economy (CMIE), Mumbai, India

3. Findings

Results on Divisia Tornquist approximation on Indian automobile industry are shown in table 1 in the form of index on total factor productivity and its growth rates. As it is clear from the figures in the table, Indian automobile industry could not experience productivity gain over the study period. The industry witnessed a downfall in the years 1993-94 to 1994-95. This implies that resources have not been utilised efficiently in this industry. This downswing in productivity levels was followed by recovery in 1995-96, which gathered momentum till 1997-98 with maxima in 1997-98 and again turned worse in 1998-99. This phenomenon continued till the end of the study period with negative TFP growth rates. Figure 1 and 2 display the graphical presentation of the TFP and TFPG estimates. Hence the overall generalization can be made that during the study period the industry
could not perform well on TFP account. This infers that the input growth has
been higher that output growth.

Table 1
TFP index and annual growth rates in Indian Automobile Industry: 1989-90
to 2003-2004

<table>
<thead>
<tr>
<th>Year</th>
<th>TFP</th>
<th>TFPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1990-91</td>
<td>100.9652318</td>
<td>0.009652318</td>
</tr>
<tr>
<td>1991-92</td>
<td>102.1852699</td>
<td>0.012083745</td>
</tr>
<tr>
<td>1992-93</td>
<td>102.2556362</td>
<td>0.000688616</td>
</tr>
<tr>
<td>1993-94</td>
<td>97.07579063</td>
<td>-0.050655845</td>
</tr>
<tr>
<td>1994-95</td>
<td>98.61104388</td>
<td>0.015814996</td>
</tr>
<tr>
<td>1995-96</td>
<td>102.8653123</td>
<td>0.043141906</td>
</tr>
<tr>
<td>1996-97</td>
<td>105.8826759</td>
<td>0.029333149</td>
</tr>
<tr>
<td>1997-98</td>
<td>107.3159888</td>
<td>0.013536803</td>
</tr>
<tr>
<td>1998-99</td>
<td>102.4609625</td>
<td>-0.045240475</td>
</tr>
<tr>
<td>1999-00</td>
<td>92.6890389</td>
<td>-0.095372163</td>
</tr>
<tr>
<td>2000-01</td>
<td>85.48379603</td>
<td>-0.077735652</td>
</tr>
<tr>
<td>2001-02</td>
<td>83.75112324</td>
<td>-0.02026902</td>
</tr>
<tr>
<td>2002-03</td>
<td>85.32053424</td>
<td>0.018738985</td>
</tr>
<tr>
<td>2003-04</td>
<td>87.65604586</td>
<td>0.027373382</td>
</tr>
</tbody>
</table>
Total Factor Productivity (TFP) in Indian Automobile Industry: 1989-2003

TFPG in Indian Automobile Industry: 1989-90 to 2003-04

Fig. 1

Fig. 2
Table 2 presents results on semi-log trend equation. Trend Growth Rate in TFP of Indian automobile industry came out to be -0.015 with t-statistic as -3.63. This makes the coefficient significant at 5 percent level of significance.

### Table 2

**Estimates of semi-log trend**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>4.696</td>
<td>120</td>
</tr>
<tr>
<td>$\beta$</td>
<td>-0.015</td>
<td>-3.63</td>
</tr>
</tbody>
</table>

**Partial Productivity Indices (PPIs)**

Results on Partial factor productivity indices are reported in table no. 3 with graphical presentation in fig. 3. Among all the four inputs viz., capital, labour, material and energy labour has experienced the maximum productivity gain in Indian automobile industry during the study period. However rise in labour productivity can be caused by a rise in capital labour ratio. Study of capital intensity in automobile industry has revealed that in this industry capital intensity has grown at a trend growth rate of 0.14. This finding suggests rise in labour productivity index is not due to more efficient use of this factor rather than due to the continuous increase in the capital labour ratio. This exploration becomes important when other factor indices could not show any significant gain during the study period. Hence the overall generalisation about the performance of the
individual inputs can be made that they could not be utilised efficiently in the process of conversion to the final product.

### Table 3

Partial Factor Productivity Indices of Individual Inputs: 1989-90 to 2003-04

<table>
<thead>
<tr>
<th>Year</th>
<th>Partial Factor Productivity Index of K</th>
<th>Partial Factor Productivity Index of L</th>
<th>Partial Factor Productivity Index of M</th>
<th>Partial Factor Productivity Index of E</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989-90</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>1990-91</td>
<td>102.9624009</td>
<td>98.00637323</td>
<td>100.4509721</td>
<td>99.4578</td>
</tr>
<tr>
<td>1991-92</td>
<td>104.3668829</td>
<td>101.2305635</td>
<td>101.4513358</td>
<td>93.3168</td>
</tr>
<tr>
<td>1992-93</td>
<td>105.3830499</td>
<td>103.5243438</td>
<td>100.4765878</td>
<td>98.9138</td>
</tr>
<tr>
<td>1993-94</td>
<td>94.21077244</td>
<td>97.69180743</td>
<td>99.25247021</td>
<td>86.765</td>
</tr>
<tr>
<td>1994-95</td>
<td>93.23678334</td>
<td>106.0082389</td>
<td>101.422053</td>
<td>84.4603</td>
</tr>
<tr>
<td>1995-96</td>
<td>104.9759068</td>
<td>124.3817201</td>
<td>99.51717066</td>
<td>90.9464</td>
</tr>
<tr>
<td>1996-97</td>
<td>114.7638193</td>
<td>133.0061557</td>
<td>98.59677044</td>
<td>104.411</td>
</tr>
<tr>
<td>1997-98</td>
<td>115.9813925</td>
<td>138.684906</td>
<td>99.76502474</td>
<td>104.181</td>
</tr>
<tr>
<td>1998-99</td>
<td>99.5364615</td>
<td>127.3314751</td>
<td>101.5686359</td>
<td>96.2978</td>
</tr>
<tr>
<td>1999-00</td>
<td>78.21930735</td>
<td>118.4079774</td>
<td>100.8849593</td>
<td>94.7766</td>
</tr>
<tr>
<td>2000-01</td>
<td>65.83212515</td>
<td>137.1211873</td>
<td>97.05451084</td>
<td>100.126</td>
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<tr>
<td>2001-02</td>
<td>64.1151281</td>
<td>140.0469066</td>
<td>95.02837285</td>
<td>101.552</td>
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<tr>
<td>2002-03</td>
<td>63.8464983</td>
<td>142.9887485</td>
<td>98.53080852</td>
<td>111.174</td>
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<tr>
<td>2003-04</td>
<td>67.3738442</td>
<td>148.531493</td>
<td>98.92019785</td>
<td>113.227</td>
</tr>
</tbody>
</table>
Conclusion
In this paper an attempt has been made to assess the productivity performance of Indian automobile industry via growth accounting approach. With in the framework of this approach, Divisia-Tornquist index has been used to obtain estimates of total factor productivity index in this industry. Results on TFP reveal that Indian automobile industry could not experience positive productivity growth in the post liberalisation era. Trend growth rate in TFP came out to be $-0.015$, which is significant at 5 percent level of significance. The results on partial factor productivity indices also corroborate the TFP deterioration in this industry.
References

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