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Editorial Message

Greetings from team IJBAI!!!

It is a great pleasure for us to publish the Volume 8 Issue 1 in this year 2020.

It's quite a mission to retaining the core value and essence of IJBAI after completion of 7th year in a row.

We are aiming in bringing the essence of Data science practice as it is going through the evolution path. The journal is a platform for exchanging the understanding on data science eco system, insights from various research studies, analytical techniques, and knowledge in various applications and thereby we try to emphasis on constant mission.

We are immensely grateful to Professor Arnab Laha for his column "Analytically Yours" that gets featured in every issue. In the current issue, he enlightens us with his perspectives on spatial data analysis. We are also indebted to Favio Vazquez for his valuable thoughts in every issue. In this issue, he depicts the evolution of Data Science. It has been a talking word for a while now. The article talks about how it evolved from an iteration of statistics, specifically the algorithmic tradition of statistics and data analysis.

We brought an analysis and an application paper focused on manufacturing unit. The paper 'Estimation and Decomposition of Total Factor Productivity Growth of the 2-Digit Manufacturing Industries in India'. The study estimates and decomposes the sources of TFPG of the 2-digit manufacturing industries as well as total manufacturing industry in fifteen major industrialized states in India as well as in All-India during the period from 1981-82 to 2010-11 (total study period), divided in specific periods, using stochastic frontier production function. The methodology necessitates decomposition of the sources of TFPG into technological change, technical efficiency change, allocation efficiency change and scale change. In another paper, author presented the Financial Performance of Nifty 50 Automobile Companies in India. Ii is an Empirical Comparative Analysis, which is descriptive in nature and expands the comparative knowledge in the area of Du Pont Analysis and Altman Z score.

While we present about these papers, how can we miss the virtual world and that to when we are fighting with pandemic and still connected with high hope and spirit. In this virtual era, With the adoption of virtual technology, the maturing of the prop tech market, an exponential growth in demand for warehouses and the looming prospect of 100 per cent FDI in completed projects, Indian realtors geared to upgrade themselves in Covid-19 situation for causing the unexpected game changer for the industry. We are pleased to inform that Associate Professor Matiwos Ensermu from Department of Logistics & Supply Chain Management, College of Business & Economics, School of Commerce, Addis Ababa University presented the study which analyzed factors that contributed for coffee value chain underdevelopment in the upstream supply chain members (farmers) in Ethiopia in terms of factors related to coffee value chain governance, coffee value redistribution among actors and level of government support to develop coffee value chain in the area.

Visiting Faculty, Purba Halady Rao from Indian Institute of Management, Ahmedabad, Gujarat, India brought the understanding on private Sector initiatives for adaption to climate change impacts on water. This paper explores the awareness and possibility of involving the private sector to initiatives amongst practicing managers in India.

Last but not the least, when we talk about various way of data messaging approach, solution for industries, various statistical techniques, we need to talk about measure and monitor the outcome of analytics through various relevant metrices to gauge business movement. We present an article based on Corporate Metrices critically gazes into every aspect of Metrics and how to manage projects using Metrics precisely.

We wish for our good health and we are sure that our readers will appreciate and learn a lot from the present issue. Do let us know your wish, suggestions and views to enrich our journal. Therefore, it would be great to have valuable feedback from our learned readers about the enriched version of IJBAI. We would like to thank all the researchers and renowned data science practitioners who have honored us by selecting our journal to publish some of their research cases. At the end, we extend our heartfelt thanks to all our esteemed readers who continued to support us for the last seven plus years.

Sincerely yours,

Madhumita Ghosh
Joint Editor-in-Chief
&
Tuhin Chattopadhyay
Editor-in-Chief

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Columns

Research Papers

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Analytically Yours:

Spatial Data Analysis

Arnab Kumar Laha*

In this article, we discuss a special kind of data that occurs quite routinely that is referred to as "Spatial Data". In this kind of data, there is a geographical location associated with every data element. For example, one may be interested in studying the variation of temperature across different cities of India. Note that the data here is of the form (Variable, Geographical location) where Variable = Temperature of a city and Geographical location = Name of the city. Another example is the number of confirmed COVID-19 cases in a state on July 22, 2020. Here the Variable is the number of confirmed COVID-19 cases in a state on July 22, 2020, and Geographical location = Name of state. Spatial data analysis refers to a set of techniques that are designed to find pattern and test hypotheses and theories, based on spatial data.

Spatial data abound in our daily lives. Every day when we open our newspapers we find information from around our state, country and the world. If you look at these news items carefully you will notice lots of information that can be properly described as spatial data. Some examples are (a) rainfall in different cities of India on the previous day (b) atmospheric pollution index in different cities of India in the previous day and (c) traffic accidents in different parts of the city that occurred the previous day etc. Other examples of spatial data that are of some interest to business and industry are daily labor rate in different parts of India, sales of anti-malarial medication in the different districts of a state, monthly sale of automobiles in different states of India etc.

Visualization of spatial data is typically done using a "map". By a map, we mean a visual representation on a flat surface of the whole or a part of an area. One of the main aims of map construction is to facilitate the visual examination of the values of the attribute variable at different locations. A popular way to do this is to use a colour-coding scheme; different areas of the map are colored differently based on the value of the attribute variable. Such figures are popularly referred to as "heat map". Fig. 1 below gives a simplified heat-map of the number of COVID-19 cases in different states and union territories of India over five months. In this example, the states are arranged in a column, the dates on which the case numbers are recorded is along the rows, and the observation values are colour-coded. Note that in this simplified heat-map an important information which may be of relevance is missing, that is, the information about the neighboring states/union territories. This could be realized by color coding each state in the actual map of India.

In many applications of spatial data, it is observed that observations from nearby locations are associated. This is a major departure from the predominant assumption in classical statistics that the observations are mutually independent. The observed association can be due to various reasons such as a spatial spillover effect (for example economic conditions in a big city may affect the local economies of the smaller cities near to it), distance decline effect (as with temperature where it is found that with increase in distance the degree of association between temperature of two places declines) etc. The lack of independence in the observations makes spatial data analysis challenging.

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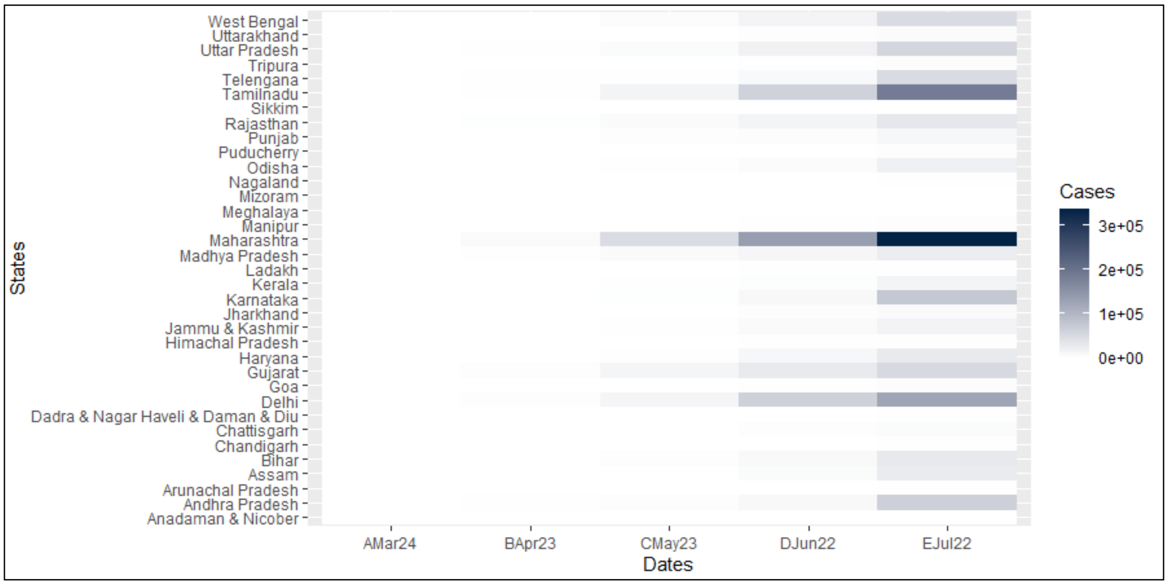

Fig. 1: Heat Map Depicting the Number of COVID-19 Cases in Different States and Union Territories of India during March-July, 2020

Several measures have been proposed to capture spatial association such as Moran's *I* and Geary's *c*. In this article we confine our discussion to the widely used measure Moran's I. It is defined as $I = \frac{n}{W_o} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(z_i-\bar{z})(z_j-\bar{z})}{\sum_{i=1}^{n}(z_i-\bar{z})^2}$

where $W_o = \sum_{i=1}^{n}\sum_{j\neq i}^{n} W_{ij}$ where n is the number of locations, z_i's are value of the variable of interest and W_{ij} are weights that capture the "similarity" of the locations i and j. By convention $W_{ii} = 0$ for all i. Since $E(I) = -\frac{1}{n-1}$ values of I greater than $-\frac{1}{n-1}$ indicate positive spatial autocorrelation while a value of I lesser than $-\frac{1}{n-1}$ indicates negative spatial autocorrelation. Fig. 2 provides a visualization of positive and negative spatial autocorrelation on a grid structure. As in heatmap the darkness of the cell represent the values. We observe that positive spatial autocorrelation leads to clusters of high values whereas negative spatial autocorrelation leads to alternating high and low values preventing any cluster formation. Readers interested to learn more about Spatial data analysis may look at Fischer and Wang (2011).

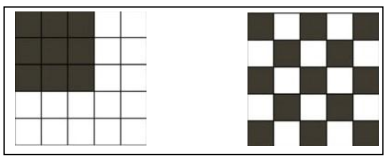

Fig. 2: The Figure on the Left Hand Side Indicates Positive Spatial Autocorrelation While the Figure on the Right Indicates Negative Spatial Autocorrelation

Next, we examine the spread of COVID-19 epidemic in India over the five-month period using Moran's I as the measure of spatial autocorrelation. We consider all the 35 States and Union Territories (UTs) that have reported at least one confirmed COVID-19 case in this five-month period. The data for the number of confirmed COVID-19 cases at different dates for these states/UTs are collected from *covid19india.org*. We define $W_{ij} = 1$ if the State/UT 'i' and State/UT 'j' are neighbouring i.e. share a land border else $W_{ij} = 0$. Since n = 35 we have E(I) = -0.029. Table 1 below gives the obtained value of the Moran's I at thirty day intervals between March 24, 2020, to July 22, 2020.

Table 1: Variation in Moran's I in the Five Month Period March 24, 2020 – July 22, 2020

Date	*24-03-2020*	*23-04-2020*	*23-05-2020*	*22-06-2020*	*22-07-2020*
Moran's I	0.178*	0.195*	0.032	-0.045	0.025

(* indicates positive spatial autocorrelation at 5% level of significance)

We find from Table 1 that during the months of March and April, 2020 positive spatial autocorrelation was present. This means the states/UTs with higher number of COVID-19 cases were clustered together. This effect could be due to the national lockdown which severely restricted movement of people across the country, thereby confining the growth of the epidemic to neighbouring states/UTs. However in the later three months i.e. May - July 2020 we do not find any significant spatial autocorrelation in the number of confirmed COVID-19 cases. A possible reason for this could be the gradual freeing of the movement of people across the country since May, 2020.

Reference

Fischer, M. M., & Wang, J. (2011). *Spatial data analysis: Models, methods and techniques.* Springer.

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The Roots of Data Science

Favio Vazquez*

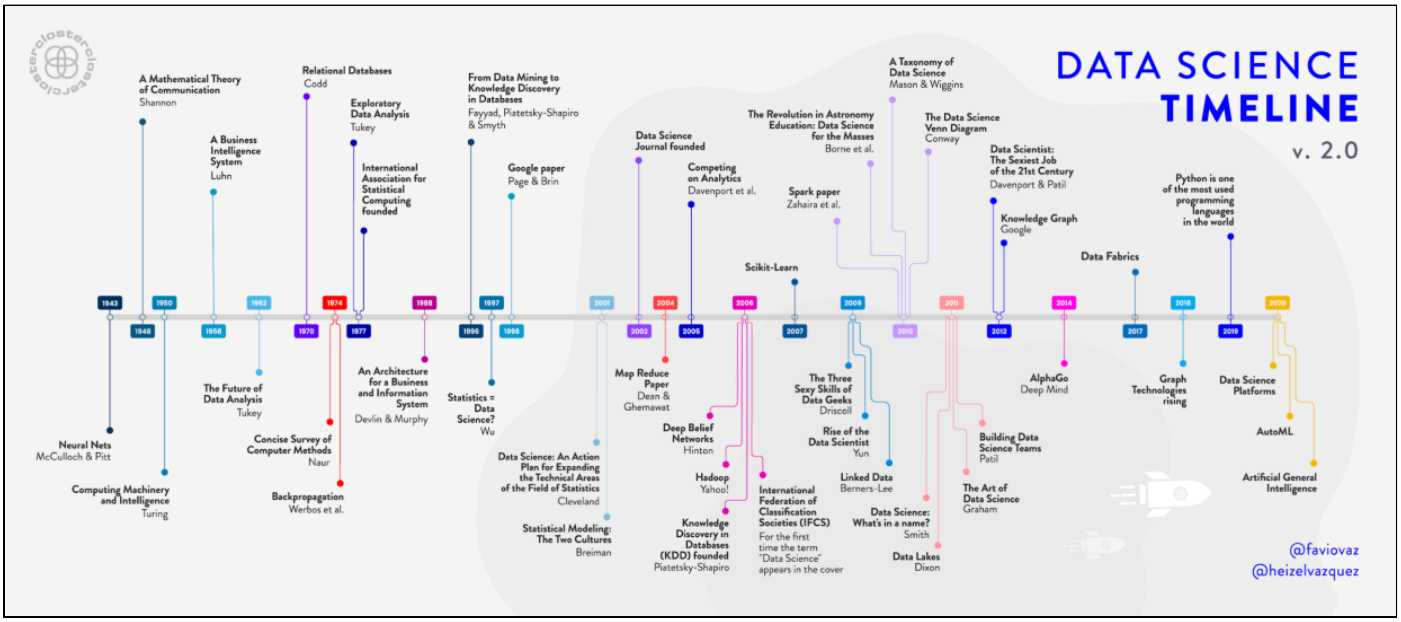
We have a name for the scientific exploration of data to find valuable information and solve business problems: Data Science (DS). This statement is not a definition, just a basic description.

DS has been there for a while now. I have covered my thoughts on the field extensively in the past (check the bottom for resources), but I want to talk about something different in this article.

DS is not coming out of anywhere. It comes from an iteration of statistics, specifically the algorithmic tradition of statistics and data analysis. Three great articles are the founders of our field (as we know it right now):

- The Future of Data Analysis by John Tukey.
- Statistical Modeling: The Two Cultures by Leo Breiman.
- Data Science: An Action Plan for Expanding the Technical Areas of the Field of Statistics by William Cleveland.

But also those papers depend on a bigger picture. I tried to show the full development of the field of DS in the timeline I created with my sister Héizel Vázquez:



Please make sure to check the sources as well.

As we can see, the oldest of the three papers I mention is the one by Tukey. I will tell you why I'm proposing that this is the beginning of our field (even though there are papers before it in the timeline). Still, before that, I want to discuss some notions from the article: A Business Intelligence System by Luhn.

Before the Beginning

In the paper "A Business Intelligence System," Luhn proposed an automatic system to disseminate information to the various sections of any industrial, scientific, or government organization.

But I want to bring two definitions from this article. First, the definition of a business:

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> "Business is a collection of activities carried on for whatever purpose, be it science, technology, commerce, industry, law, government, defence, et cetera."

And the definition of intelligence:

> "The notion of intelligence is […] the ability to apprehend the interrelationships of presented facts in such a way as to guide action towards a desired goal".

I like these definitions. And as we will see, the notion of a "business intelligence system" will guide later authors in their interpretation of data science.

Luhn also said:

> "Efficient communication is key to progress in all fields of human endeavor. […] Information is now being generated and utilized at an ever-increasing rate because of the accelerated pace and scope of human activities and the steady rise in the average level of education. […] There is also a growing need for more prompt decisions at levels of responsibility far below those customary in the past. […] In view of the present growth trends, automation appears to offer the most efficient methods for retrieval and dissemination of this information."

Let's talk about this. The author is talking about communication and information. Also, companies are utilizing this information to make decisions that are much more advanced than what we could do in the past. Please remember that this article is from 1958.

Luhn also talks about the importance of automation for disseminating this information, something that was one of the foundations of data mining (one of the fathers of data science).

So far, we have four significant components that will be important soon:

- Information
- Intelligence
- Business
- Automation

From Statistics to Data Analysis

John Tukey is one of the most important statisticians in history. In the fantastic article "The Future of Data Analysis" he said this:

> For a long time, I have thought I was a statistician, interested in inferences from the particular to the general. But as I have watched mathematical statistics evolve, I have had cause to wonder and to doubt. […] All in all, I have come to feel that my central interest is in data analysis.

A huge statement to make by a statistician. In this time, the words "data science" did not exist as today, but the way Tukey described data analysis is very close to what we call now data science. He even called data analysis a science, because it passes these three tests:

- Intellectual content.
- Organization into an understandable form.
- Reliance upon the test of experience as the ultimate standard of validity.

There's also an important thing he says in the article:

> "If data analysis is to be helpful and useful, it must be practiced."

This seems obvious, but it guided how people then described DS. What do we understand from this article? There's an evolution of statistics that will create what Tukey called a new data analysis, defined as:

> "[The] Procedures for analyzing data, techniques for interpreting the results of such procedures, ways of planning the gathering of data to make its analysis easier, more precise or more accurate, and all the machinery and results of (mathematical) statistics which apply to analyzing data."

Something crucial in this definition is the idea that data analysis also includes the planning for gathering data to analyze, and also the machinery of statistics for analyzing and also interpreting data.

Aside than saying that data analysis should be practised, Tukey says that:

> "We need to face up to more realistic problems."

He was talking about data analysis, of course. Even though the article has the idea of explaining how to teach and use data analysis in a formal and academic realm, Tukey understands that we need to go beyond textbooks and idealistic scenarios. Something important to understand the connection between Luhn's article and this one.

From Data Analysis to Data Science

Thirty-five years later after Tukey's publication, Jeff Wu said this:

Statistics = Data Science?

Where he proposed that statistics should be renamed "data science" and statisticians should be named "data scientists". In today's standards, we know that statistics alone is not of data science, but why? Because we also need programming, business understanding, machine learning, and more (but more on that soon).

In a conversation with Jeff Wu, he mentioned that:

> "My lecture was entitled Statistics = Data Science?. There I characterized statistics as a trilogy of data collection, data analysis and decision making. I was talking about analytic statistics, rather than descriptive statistics. I suggested a change of our name from "statistics" to "data science" and "statistician" to "data scientist." I remember I even jokingly said in the lecture that by merely changing the name to data scientist, the salary will go higher. This is true nowadays. It's interesting."

Something interesting about Wu's definition of statistics is that data analysis is a part of it. I'm not entirely sure if Tukey will agree with Wu, but the idea is clear:

> Data science depends on data collection, data analysis, and decision making.

Finally, we start talking about something else: decision making. This is one of the connections between Tukey's views on data analysis and statistics, and Luhn's views on business intelligence.

Please check the timeline to remember the dates of the articles and presentations that I'm talking about.

Four years after Wu's presentations (2001), two papers put everything together. In April of 2001, Cleveland proposed an action plan to enlarge the technical areas of the field of statistics, and he called it Data Science. And then, in August of the same year, Breiman proposed that the use of the algorithmic modeling (as a different statistical culture) will be better to solve problems with data, rather than the classical statistical modeling.

The two articles are relevant in different ways, Cleveland's article aimed to create an academic plan to teach data science (similar to what Tukey did for data analysis) and Breiman's article had the idea to talk about the practical implications of data science and its relation to business (close to what Luhn wanted to explain with an application).

Even though Cleveland's article was directed to universities and educational institutes, he mentioned:

> Universities have been chosen as the setting for implementation because they have been our traditional institutions for innovation […]. But a similar plan would apply to government research labs and corporate research organizations.

So he's recognizing the importance of the government and also organizations in the process of institutionalizing data science as a serious field.

In the article, Cleveland states that data science depends on four big things (he talks about six things, but taking out the parts related to teaching DS):

Multidisciplinary Projects: Here he mentions:

> The single biggest stimulus of new tools and theories of data science is the analysis of data to solve problems posed in terms of the subject matter under investigation. Creative researchers, faced with problems posed by data, will respond with a wealth of new ideas that often apply much more widely than the particular data sets that gave rise to the ideas.

Important things to highlight here:

- Data analysis and data science have the primary goal of solving problems (that will be important when we talk about Breiman's article).
- The practitioner of data science needs to work on different issues and fields to be able to have a bigger picture, to exploit creativity, and to understand different types of data and problems posed by data.

Models and Methods: Here he mentions:

> The data analyst faces two critical tasks that employ statistical models and methods: (1) specification-

the building of a model for the data; (2) estimation and distribution-formal, mathematical probabilistic inferences, conditional on the model, in which quantities of a model are estimated, and uncertainty is characterized by probability distributions.

Important to notice that he talks about the practitioner of data science as the data analyst, but we will refer to them as data scientists (something to think about).

In here we have to highlight that:

- Modeling is at the core of data science. This is the process of understanding the "reality", the world around us, but creating a higher level prototype that will describe the things we are seeing, hearing, and feeling. Still, it's a representative thing, not the "actual" or "real" thing. Tukey also talks about this in his articles.
- Data science needs a method (and a methodology).
- The data scientist creates models for the data and uses statistical techniques and methods to develop these methods. As we will see in Breiman's article, he emphasizes algorithms instead of formal mathematical methods.

Computing with Data: Here he mentions:

> Data analysis projects today rely on databases, computer and network hardware, and computer and network software. […] Along with computational methods, computing with data includes database management systems for data analysis, software systems for data analysis, and hardware systems for data analysis.

He also talks about the gap between statisticians and computer scientists:

> […] One current of work is data mining. But the benefit to the data analyst has been limited, because the knowledge among computer scientists about how to think of and approach the analysis of data is limited, just as the knowledge of computing environments by statisticians is limited.

And one of his ideas is that a "merger of the knowledge [Statistics and Computer Science] bases would produce a powerful force for innovation".

Some other things to highlight:

- The data scientists need an understanding of databases and computational software. Programming is there as well. He also talks about statistical packages and related software. But now we know that the path for data science nowadays depends on the understanding of some programming languages (mostly Python and R right now).
- Data science also depends on technological advances. This was true in 2001 and is true today as well. The methods that the data scientists use are shaped by the theoretical developments (check the timeline) but also on the fact that today we have powerful computers, cheaper and faster memory, high-speed internet, and also GPUs and TPUs.
- We need statisticians to learn computer science and computer scientists to learn statistics. This gap is filled right now by data scientists, but we can't forget that moving between these fields is becoming more usual, and we need experts in statistics to learn computer science and experts in computer science to learn statistics, not only people that are proficient in both.

Theory: Here, he mentions:

> Theory, both mathematical and non-mathematical theory, is vital to data science. Theoretical work needs to have a clearly delineated outcome for the data analyst, albeit indirect in many cases. Tools of data science-models and methods together with computational methods and computing systems-link data and theory. New data create the need for new tools. New tools need a new theory to guide their development.

Data science is a practical field, but it needs theory to understand and explain their methods and models. Today we know that if you want to understand machine learning, you will need an understanding of linear algebra, differential calculus, statistics, and probability (to mention some of the most important).

Important things to highlight:

- The tools of data science and its models link the data and the theory. We need to understand the theory to create better models, and when we build models, we use all the theoretical tools.
- Different datasets need different theoretical backgrounds. This is clear in Tukey's paper, where he

mentions some of the most important pieces of mathematics and statistics to work with different datasets. We saw this when big data exploded, and we had to analyze disparate sources of data.

- The theoretical advancements guide the creation of new tools and models. This reminds the history of science, where not only data and experiments led to the creation of new theories, but also, the new theories developed guided experiments, models, and tools.

The Algorithmic Modeling Culture in Data Science

As I mention, in August of 2001, Leo Breiman published a paper on the two cultures of statistics: The data modeling and the algorithmic modeling one. One of the remarks he makes in his article is:

> The roots of statistics, as in science, lie in working with data and checking theory against data. I hope in this century our field will return to its roots.

Here he mentions that there are some people in the statistical culture that are driven by data modeling and some by algorithmic modeling. Where the first ones assume that we have a stochastic data model that maps input variables *x* to response variables *y*. And the second one considers that the mapping process is both complex and unknown, and their approach is to find a function *f(x)* that operates on *x* to predict the responses *y*.

He then goes to discuss why the data modeling culture has been bad for statistics for so long, leading to irrelevant theories and questionable scientific conclusions keeping statisticians from using more suitable algorithmic models and working on exciting new problems. Also, he talks about the wonders of the other part of the spectrum, the algorithmic modeling culture giving examples from his works, and others on how it can solve hard and complex problems.

He states that the algorithmic culture:

> […] Shifts focus from data models to the properties of algorithms. It characterizes their "strength" as predictors, convergence if they are iterative, and what gives them good predictive accuracy. The one assumption made in the theory is that the data is drawn i.i.d. from an unknown multivariate distribution.

He's not saying that the "old" statistical culture is useless. Instead, he means that the algorithmic culture is better suited for the current (back in 2001, of course) problems posed by data.

One of the guiding principles in this new culture, more close to what we do in data science, accordingly to Breiman is:

> The goal is not interpretability, but accurate information.

If we see what happened after his paper, that's exactly what happened. The advancements in algorithms, methods, and models were to improve accuracy, sacrificing interpretability. Luckily in the past years, there has been a tremendous advancement in the explainability and interpretability of "black boxes"; we now have tools to explain how a random forest, support vector machine, or a deep neural network works.

I love the way that he explains the usage of the algorithmic culture in several of these consulting works, and we can see how, changing some fundamentals aspects of the usage of data and mathematics, we can improve accuracy and solve much more complex problems.

Conclusions

Combining the work of the authors mentioned in this article, and adding to that the theoretical, computational, and scientific advancements proposed in the timeline, we can understand the historical development of data science.

The roots of data science are statistics, but also the idea of using data to solve business problems. Data science should be practical, but it relies upon the usage of the theory of mathematics and computer science to function. The practice and study of data science should be a part of every university, government, and organization that wants to use data to solve complex problems.

Data science has become the standard solving problem framework for academia and the industry, and it's going to be like that for a while. But we need to understand where we are coming from, who we are and where we are going.

If we channel the resources we have right now to make this area of knowledge work together for a greater good, we can make a tremendous positive impact in the world and our lives. It's our time.

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Estimation and Decomposition of Total Factor Productivity Growth of the 2-Digit Manufacturing Industries in India: An Interstate Analysis

Prasanta Kumar Roy*

Abstract

The study estimates and decomposes the sources of total factor productivity growth (TFPG) of the 2-digit manufacturing industries as well as total manufacturing industry in 15 major industrialized states in India as well as in All-India during the period from 1981-82 to 2010-11 (total study period), pre-reform period (1981-82 to 1990-91), post-reform period (1991-92 to 2010-11) and for two decades of the post-reform period (i.e., 1990-91 to 2000-01 and 2001-02 to 2010-11), using stochastic frontier production function. The methodology necessitates decomposition of the sources of TFPG into technological change, technical efficiency change, allocation efficiency change and scale change. The main findings of our decomposition are that the growth rates of TFP in most of the 2-digit industries in the major industrialized states in India as well as in All-India have declined during the post-reform period. Also, this decline in TFPG is mainly accounted for by the decline in technical efficiency change and allocation efficiency effect that happened during that period. With respect to scale effect, its contribution to TFPG in the 2-digit industries in the major industrialized states has become very negligible although the manufacturing industries of different states under study and India as a whole have benefitted from economies of scale. The behaviour of the allocation efficiency component clearly indicates inefficient resource allocation in almost all the 2-digit industries under study during the post-reform period. This implies that liberalization of the economy during the post-reform period has increased the price distortion measured by the gap between price and marginal cost of the product of 2-digit manufacturing industries in the major industrialized states in India and in All-India as well. However, the rates of technological progress of almost all the 2-digit industries in most of the states under study have increased. Notwithstanding, as the combined effect of technical efficiency change and allocation efficiency change of these industries outweigh the joint effect of scale change and technological change of the same, TFPG of these industries has declined during the post-reform period.

Keywords: 2-Digit Manufacturing Industries, Stochastic Frontier Production Function, Total Factor Productivity Growth, Technological Progress, Technical Efficiency Change, Scale Change and Allocation Efficiency Change

JEL Classification Codes: C23, L6, O33, O47

Introduction

Growth of output which is not accounted for by the growth in factor inputs is generally treated as total factor productivity growth (TFPG). While measuring the sources of output growth, the contribution of TFPG is, therefore, estimated as a residual, after accounting for the growth of primary inputs, such as, labour and capital. If industries operate on their production possibility frontier producing the maximum possible output or realizing the full potential of the technology, then it implies that improvement in TFP arises from technological progress. This is the main idea behind the growth-accounting measure of TFPG. The objective of the growth-accounting measure of TFPG is to determine how much of output growth is due to the use of primary inputs and how much is due to technological progress. In other words, growth-accounting measure of TFPG determines how much of the growth can be explained by movements along a production function and how much would be attributed to a shift in production

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function. However, growth-accounting measure of TFPG is based on the assumption that industries are operating on the production possibility frontier with full potential of technical efficiency. Further, under growth-accounting approach, it is assumed that there exists CRS (constant returns to scale) in the production process. The assumptions of perfect competition also hold true in this approach.

When it is difficult to satisfy these assumptions, a direct econometric estimation of the production function is usually taken up, which, however, has several limitations too. One of the major disadvantages of the production function approach (PFA) is the problem of identification of production function. Further, the problems of autocorrelation and multi-colinearity encountered in the use of PFA are likely to produce misleading estimates. A further drawback of this approach is the difficulty of explaining the econometric technique to a wide range of users, and the difficulty in replicating and producing productivity estimates on an ongoing basis. Once again, if a more flexible form of production function (like translog production function) is used, it would be difficult to equate output elasticities with factor shares. Further, in the production function estimation approach, we relax the assumption of Hicks neutral technological progress. Moreover, both in the growth-accounting approach as well as in the production function estimation approach, technological progress is usually considered to be the unique source of TFPG. Given the limitations of these approaches and that TFPG has several sources other than the technological progress, such as, change in technical efficiency, economic scale change and allocation efficiency change, the research question boils down to decomposition of the sources of TFPG into several components other than technological progress.

A stochastic frontier model [Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977)] is usually undertaken to decompose the sources productivity growth as the model could minimize the intensity of the problems like multi-collinearity and autocorrelation, and it has the ability to provide information on the specified production technology and technical inefficiency component. Further, stochastic frontier approach (SFA) assumes a given functional form for the relationship between inputs and output. Whenever the functional form is specified, the unknown parameters of the function could be estimated using econometric methods. The stochastic frontier model has been used intensively to decompose the sources of TFPG at the firm, industry, state, and also at the national levels by a good number of researchers. Although a vast number of empirical applications have contributed to identify the sources of TFPG by applying stochastic frontier approach, representative studies are Nishimizu and Page (1982), Baur (1990), Kumbhakar and Lovell (2000), Kim and Han (2001) and Sharma, Sylwester and Margono (2007), to mention only a few. The decomposition of TFPG into efficiency changes and technological progress was first proposed by Nishimizu and Page (1982) using stochastic production frontier. Bauer (1990) estimated a translog cost frontier using data on the US airline industry to decompose TFPG into efficiency changes, technological progress, and scale changes. With the help of translog stochastic production frontier, Kumbhakar and Lovell (2000), Kim and Han (2001) and Sharma et al. (2007) decomposed TFPG into four components: technological progress (TP), technical efficiency change (TEC), allocation efficiency change (AEC) and economic scale change (SC).

Objectives of the Study

The objective of the study is to estimate and decompose the sources of TFPG of the 2-digit major manufacturing industries in India and in its major industrialized states (based on total value added) into four components: technological progress (TP), technical efficiency change (TEC), and effect of scale change (SC) and allocation efficiency effect (AEC).

The 2-digit manufacturing industries considered in our study are:

- Manufacture of food, beverages and tobacco products (20-22),
- Manufacture of textile and textile products (23+24+25+26),
- Manufacture of wood and wood products; furniture and fixtures (27),
- Manufacture of paper and paper products (28),
- Manufacture of chemicals and chemical products (30),
- Manufacture of rubber, petroleum and coal products (31),

- Manufacture of non-metallic mineral products (32),
- Manufacture of basic metals and alloys (33),
- Manufacture of metal products and machinery equipment (34-36),
- Manufacture of transport equipment (37), and
- Total manufacturing industry.

The 15 major industrialized states in India (based on total value added) considered for estimating and decomposing the growth rates of TFPG are:

Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal, and All-India.

Period of study: 1981-82 to 2010-11 (Whole Study Period),

Pre-reform period: 1981-82 to 1990-91,

Post-reform period: 1991-92 to 2010-11, and;

Two decades of the post-reform period: 1991-91 to 2000-01, and 2001-02 to 2010-11.

Hypotheses of the Study

We have made two sets of hypothesis. The first set relates to the objective of the study. The set consists of the following four hypotheses:

(1) The growth rates of TFP and those of the components of TFPG of the 2-digit manufacturing industries across states under study during different sub-periods have not been significantly different from one another.

(2) No significant change in the growth rates of TFP of the 2-digit manufacturing industries in the states under study and in All-India as well has been occurred between the pre-reform and the post-reform periods, i.e., between 1981-82 to 1990-91 and 1991-92 to 2010-11, respectively.

(3) The components of TFPG of the 2-digit manufacturing industries in the states under study and in All-India have not improved in the post-reform period over the pre-reform period.

(4) The growth rates of total factor productivity (TFP), and the growth rates of the components of TFP of the same do not show any significant difference during the two decades of post-liberalization period (1991-92 to 2000-01 and 2001-02 to 2010-11).

To test these hypotheses, we need to construct a suitable model that will contain the parameters relating to technological progress, technical efficiency, scale effect and allocation efficiency effect. The hypotheses made for this purpose are stated below:

(M1) The Cobb-Douglas production is an appropriate functional form in the sense it gives good fit to the data sets.

(M2) There has been no technological change in these industries over the periods under study.

(M3) The technological progress in these industries during the study periods has remained neutral.

(M4) The next null-hypothesis is that the technical inefficiency effects are absent.

(M5) The variables used in the inefficiency effects model have no effect on the level of technical efficiency.

(M6) Each production unit is operating on the production possibility frontier and that the asymmetric and random technical efficiencies in the inefficiency effects model are zero.

We have tested all the above-mentioned hypotheses using appropriate testing methods that are discussed.

The hypotheses M1 through M6 are all about the specification of the model and the contributions of different components of TFPG.

Methodologies

The study uses stochastic production frontier approach for the estimation and decomposition of productivity growth of the 2-digit manufacturing industries (according to the data availability) in India and in its 15 major industrialized states (based on total value added). The translog production function is used in this study as it is assumed to be more appropriate to describe production technology at the disaggregated industry level as well as at the aggregate state/country level.

A stochastic frontier production function as proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) is given by

$$y_{it} = f(x_{it}, \beta, t) \exp(v_{it} - u_{it}) \quad (1)$$

where y_{it} is output of the i^{th} industry (i = 1… N) in the t^{th} time period (t = 1… T); f (.) denotes the production frontier of the i^{th} industry at time't'; x_{it} is the vector of input of industry 'i' at time't'; β is the vector of unknown parameters to be estimated; 't' is the time trend served as a proxy for technological change; v_{it} is a symmetric random error term, independently and identically distributed as $N(0, \sigma^2_v)$, intended to capture random variation in output due to external shocks; u_{it} is a non-negative random variable intended to capture technical inefficiency of industry 'i' at time 't' such that u_{it} is obtained by truncation at zero of the normal distribution with mean $z_{it}\delta$ and variance σ^2_u. Therefore, technical inefficiency effects u_{it} in the stochastic frontier model (1) can be written as

$$u_{it} = z_{it}\delta + w_{it} \quad (2)$$

where z_{it} represents the vector of explanatory variable which may affect technical inefficiency effects of the i^{th} industry in the year 't' and δ is the corresponding parameters vector to be estimated and w_{it} is defined by truncation of the normal distribution with zero mean and variance σ^2. Given that specification, the technical efficiency (TE) level of industry 'i' at time 't' is then defined as

$$TE_{it} = \exp(-z_{it} - w_{it}) \quad (3)$$

where technical efficiency index in equation (3) varies between zero and unity. A measure equal to one indicates that the industry is operating with full technical efficiency. 'TE' is below unity means production process is not optimal.

Taking logs and total differentials of equation (1) with respect to time gives the growth rates of output at time 't' for the i^{th} industry as given by

$$\dot{y}_{it} = \partial \ln f(x_{it}, \beta, t)/\partial t + \sum_j \partial \ln f(x_{it}, \beta, t)/\partial x_{jt} . dx_{jt}/dt - du_{it}/dt \quad (4)$$

The first two terms on the right-hand side of equation (4) measure the change in frontier output caused by technological progress (TP) and by change in input use, respectively. From the formula of output elasticity of input 'j', $\varepsilon_j = \partial \ln f(x_{it}, \beta, t)/\partial \ln x_{jt}$, the second term can be expressed as $\sum \varepsilon_j \dot{x}_{jt}$, where a dot over a variable indicates its rate of change. So that equation (4) can be written as

$$\dot{y}_{it} = TP_{it} + \sum_j \varepsilon_j \dot{x}_{jt} - du_{it}/dt \quad (5)$$

Therefore, the overall growth of output is not only affected by TP and changes in input use, but also by changes in technical efficiency (TE).

To examine the effect of TP and the change in TE on TFPG, let us now express TFPG as output growth unexplained by input growth:

$$T\dot{F}P_{it} = \dot{y}_{it} - \sum_j S_j \dot{x}_{jt} \quad (6)$$

where S_j denotes the observed expenditure share of input 'j'.

Substituting equation (5) into (6), and after some algebraic manipulation, we get

$$T\dot{F}P_{it} = TP_{it} - du_{it}/dt + (\epsilon - 1)\sum_j \lambda_j \dot{x}_{jt} + \sum_j (\lambda_j - S_j)\dot{x}_{jt} \quad (7)$$

where $\epsilon = \sum_j \varepsilon_j$ denotes measurement of returns to scale (RTS) and $\lambda_j = \varepsilon_j/\epsilon$. The first component on the right-hand side of equation (7) represents technological progress (TP). It measures the shift in production frontier over time. The second component, $-du_{it}/dt$, is the change in technical efficiency. It measures the movement of production towards the known frontier. The third component measures the effect of scale change (SC). It shows an industry can be benefitted from economies of scale through access to a larger market. The more it can produce, the lower will be its average fixed cost. The last component, allocation efficiency effect (AEC), measures inefficiency in resource allocation resulting from the deviation of input prices from the value of their marginal products. The last component captures the impact of deviations of inputs' normalized output elasticities from their expenditure shares [Kumbhakar and Lovell (2000)].

Model Specification

To estimate the sources of TFPG identified in equation (7), the stochastic frontier production function and the technical inefficiency function are specified below. The stochastic frontier production function to be estimated here takes the translog form with two inputs labour (L) and capital (K) as:

$$Lny_{it} = \beta_0 + \beta_L lnL_{it} + \beta_K lnK_{it} + \beta_t t + 1/2\beta_{LL}L_{it}^2 + 1/2\beta_{KK}K_{it}^2 + 1/2\beta_{tt}t^2 + \beta_{LK}lnL_{it}lnK_{it} + \beta_{Lt}L_{it}t + \beta_{Kt}K_{it}t + v_{it} - u_{it} \quad (8)$$

where the technical inefficiency function is assumed to be defined by

$$u_{it} = \delta_0 + \delta_1 SK_{it} + \delta_2 KI_{it} + \delta_3 D_{it} + w_{it} \quad (9)$$

where ln denotes the natural logarithm, i = 1,2,....,11 indexes the 11 manufacturing industries, t = 1,2,........,30 indexes the annual observations over the study period 1981-82 to 2010-11, and the variables Y_{it}, L_{it} and K_{it} are, respectively, the output (real value added), labour input, and capital input for the aggregate manufacturing industry in industry 'i' at time 't'; SK_{it} is the index of employers' skill in the organized manufacturing industries of the i^{th} industry in the year 't' measured by the ratio of the number of employees other than workers to total number of employees; KI_{it} denotes the factor intensity of the organized manufacturing industries of the i^{th} industry in the year 't' measured by the ratio of the stock of fixed capital to total number of employees and D_{it} is the reforms dummy which shows the impact of economic reforms on productivity growth (D_{it} takes the value 'o' during the pre-reform period and it takes the value '1' during the post-reform period); w_{it} is the random error term, distributed as $N(0, \sigma^2)$ truncated at $-z_{it}\delta$, which ensures that $u_{it} \geq 0$. Equation (9) shows that the TE component is linearly related to the skill of employees, factor intensity and the effects of economic reforms that is measured by industrial dummies.

The stochastic frontier production function and the technical inefficiency function specified by equation (8) and (9), respectively, can be jointly estimated by the maximum likelihood estimation (MLE) method using the software FRONTIER 4.1 (Coelli, 1996). Kumbhakar et al. (2015) used STATA to estimate stochastic frontier model. After estimating the stochastic frontier model the rate of technological progress can be computed by differentiating equation (8) with respect to time (t) as

$$TP_{it} = \partial lnf_{it}/\partial t = \beta t + \beta_{tt} t + \beta_{Lt} lnL_{it} + \beta_{kt} lnK_{it} \quad (10)$$

where βt and β_{tt} denote 'Hicksian' parameters and β_{Lt} and β_{kt} denote 'factor augmented' parameters. In case of non-neutral technological change, TP is determined by 'factor augmented' parameters β_{Lt} and β_{kt}, i.e., TP is augmented by factor inputs labour and capital, respectively. In case of non-neutral TP, the change in TP will be different for different input vectors. To avoid this problem, Coeli et al. (1998, p. 234) suggest that the geometric mean between the adjacent periods be used to estimate the TP component. The geometric mean between time 't' and t+1 is written as

$$TPit = [(1 + \partial lnf_{it}/\partial t)(1 + \partial lnf_{i,t+1}/\partial t+1)]^{1/2} - 1 \quad (11)$$

The associated input elasticities of output can be estimated empirically from the following two equations:

$$\text{Labour elasticity of output } (\varepsilon_L) = \partial lnf_{it}/\partial lnL_{it} = \beta_L + \beta_{LL} lnL_{it} + \beta_{LK} lnK_{it} + \beta_{Lt} t \quad (12)$$

$$\text{Capital elasticity of output } (\varepsilon_K) = \partial lnf_{it}/\partial lnK_{it} = \beta_K + \beta_{KL} lnL_{it} + \beta_{KK} lnK_{it} + \beta_{Kt} t \quad (13)$$

The above two equations show the percentage change in output due to 1% change in factor inputs. They are added to estimate the returns to scale component (∈). The scale elasticity output is, therefore, given by the formula

$$\in = \varepsilon_L + \varepsilon_K \quad (14)$$

If scale elasticity exceeds unity, then the technology exhibits increasing returns to scale (IRS); if it is equal to one, the technology obeys constant returns to scale (CRS), and if it is less than unity, the technology shows decreasing returns to scale (DRS).

Data and Variables

The study is based on panel data collected from various issues of Annual Survey of Industries (ASI), Central Statistical Organization (CSO), Ministry of Statistics and Program Implementation, Government of India, New Delhi. To arrive at the measures of output and inputs in real terms, suitable deflators for the variables were constructed. In cases where the exact deflators were not available, the best suitable proxies for the industry concerned were picked up from the WPI series. Series on real gross value added (GVA) for each industry was obtained by deflating the nominal figures by GDP deflator that is obtained by dividing nominal and real GDP, the data of which are obtained from different volumes of National Accounts Statistics (NAS). Implicit price deflator, used to deflate the series on capital stock at current prices, is also constructed by taking data on gross fixed capital formation at current and constant prices from different volumes of National Accounts Statistics (NAS).

The variables used in this study are output and labour and capital inputs. GVA has been taken as the measure of output. Gross output is not taken directly as the measure of output, in order to avoid the possibility of double counting. However, it may appear that net value added might have been a better measure of output index, but since the depreciation figures are not always reliable as the entrepreneurs often provide us with inflated figures to avoid tax-laws, we have preferred GVA as a measure of output to net value added. Data regarding GVA are collected from various issues of ASI and the data regarding the price level are collected from different volumes of NAS published by the CSO.

When value-added is used as a measure of output, nominal value-added needs to be converted into real value-added. This conversion can be done by using either single deflation (SD) or double deflation (DD) method. In case of SD, nominal value-added is deflated by the output price index, i.e., both nominal output and nominal material inputs are deflated by the output price index. Whereas in case of DD, GVA is deflated by the manufacturing price index and the material inputs by the weighted index of the material input prices. In this study, we could not use the DD method as i) ASI data consists of large number of multi-product firms; ii) value added as a proportion of output is low in the formal sector which leads to GVA becoming negative for several industries with DD method for cases where the input price deflator is higher than the output price deflator; and iii) the non-availability of industry specific input deflators. Accordingly we used SD method.

The total number of persons employed is taken as the measure of labour input. As workers, working proprietors and supervisory/managerial staff/technicians, etc., can affect productivity; total number of persons engaged is preferred to number of workers. For recent issues, it is reported in the ASI under the head ‘persons engaged’, for earlier issues, it is reported as ‘number of employees’. This relates to all persons engaged by the factory for wages or not in work directly connected or indirectly with the manufacturing process and includes administrative, technical and clerical staff as also labour used in the production of capital assets for the factory’s own use. Implicit in such a measure is the assumption that workers and other than workers are perfect substitutes. This may not be a proper assumption to work with when the objective of the study is to compare productivity growth across industries, and management is one of the vitally important factors in explaining inter-industry differentials. Total emoluments divided by the total number of persons engaged in production are considered as price of labour input.

The measurement of capital input is the most complex of all input measurements. There exists no universally accepted method for its measurement and, as a result, several methods have been applied to estimate capital input. In many studies, the capital unit is treated as a stock concept measured by the book value of fixed assets. Some studies have applied the perpetual inventory accumulation method (PIAM) to construct capital stock series from annual investment data. In this case, it is assumed that the flow of capital is proportional to the stock of capital.

However, it is essential to point out that each of these measures has drawbacks. The book value method has three limitations. First, the use of ‘lumpy’ capital data underestimates or overestimates the amount of capital expenditure. Second, the book value may not truly represent the physical stock of machinery and equipment used in the production. Third, it does not address the question of capacity utilization. PIAM also does not address the question of capacity utilization. The flow measure is criticized on the ground that the depreciation charges in the financial accounts may be unrelated to the actual wear and tear of hardware.

In this study, however, we compute a new series of capital stock data following the PIAM introduced by Goldsmith (1951). In short, the PIAM consists of adding the net investment data of the current year to an assumed base year of capital stock. Thus, the capital stock series for

Indian manufacturing industries are computed following equation,

$$K_t = Kt + (1 - \delta) Kt_{-1} + I_t$$

where K is capital stock, I is net investment, δ is the depreciation rate (here δ = 0.05) and t denotes time. Rental price of capital which equals the ratio of interest paid and capital invested (Jorgenson & Griliches (1967)) is treated as price of capital in this study.

Empirical Results

Estimation of Stochastic Frontier Production Function

The maximum likelihood estimates of the translog stochastic frontier production (SFP) function and the technical inefficiency effects model are presented in Table 1. The study employed one-step regression method to simultaneously estimate the translog SFP model and the inefficiency effect model. Frontier 4.1-xp software is used for this purpose. Table 1 presents the estimation results for ten 2-digit manufacturing industries as well as total manufacturing industry, with parameter estimates for the stochastic frontier model reported on the left side of Table 1. Meanwhile, those for inefficiency function are reported on the right side of the table. Judging by the likelihood value and t-ratios reported in Table 1, the empirical models might be adjudged as performing very well. Given that γ is highly statistically significant in almost all the 2-digit industries at the 1% probability level, it can be said that technical inefficiencies do exist in most of the 2-digit manufacturing industries. This implies that the translog stochastic production frontier with some effects variables is appropriate for modelling the 2-digit manufacturing industries in the major industrialized states in India and in All-India as well.

Almost all the coefficients of the translog stochastic production function in most of the 2-digit industries (on the left side of Table 1) are found to be statistically significant. However, as in the translog specification there may exist multicollinearity due to the existence of interaction and squared terms, certain estimated coefficients are found to be statistically insignificant (Gounder & Xayayong 2004).

So far as the inefficiency effects are concerned, it is found that almost all the coefficients of the technical inefficiency effects model in all the 2-digit industries are found to be statistically significant. This means that a significant amount of output variation is due to the presence of technical efficiency effect. The estimated coefficients of employers' skill variable (δ_1) are found to be negative in all but three 2-digit industries. This implies that an increase in employees' skill will reduce technical inefficiency effects in all the 2-digit industries except the three. They are found to be positive in case of textile and textile products (23-26), wood and wood products (27) and paper and paper products (28) implying that there exists a positive relationship between employers' skill and technical inefficiency in these three industries although the findings are not statistically significant in case of wood and wood products (27). The estimated coefficients of the capital intensity variable (δ_2) are, however, found to be negative in case of food, beverages and tobacco products (20-22), textile and textile products (23-26), wood and wood products (27), and paper and paper products (28). This means that there exists an inverse relationship between capital intensity and technical inefficiency in these industries although they are not statistically significant in three industries (20-22, 27 and 28). However, for the manufacture of textile and textile products (23-26) these coefficients are statistically significant at 1% probability level. The estimated coefficients of the capital intensity variable (δ_2) in all other industries are found to be positive and statistically significant except in petroleum and coal products (31). This means that an increase in capital intensity in these industries leads to increase in their technical inefficiency. The estimated coefficients of dummy variables (δ_3) are found to be positive in all but three 2-digit industries. This means that economic reforms have boosted technical inefficiency in all these industries except three. In the manufacture of paper and paper products (28), non-metallic mineral products (32) and manufacture of transport equipment (37) the values of δ_3 are found to be negative. This implies that economic reforms have reduced technical inefficiency effects in these three 2-digit manufacturing industries.

Table 1

Maximum Likelihood Estimates for Parameters of the Stochastic Production Frontier and Technical Inefficiency Effects Model of the 2-Digit Manufacturing Industries in Major Industrialized States in India as well as in All-India

Variables	Parameters	Coefficients										
Panel-1: Stochastic frontier model		**20-22**	**23+24+25+26**	**27**	**28**	**30**	**31**	**32**	**33**	**34+35+36**	**37**	**Total**
Constant	β_0	-5.21*** (0.91)	-5.02*** (0.89)	-2.76*** (0.89)	0.48 (0.78)	-2.78*** (0.78)	-0.32 (1.02)	-4.96*** (1.03)	-0.68 (1.10)	-6.55*** (0.90)	-4.64*** (0.66)	-2.07*** (1.10)
lnL	B_L	2.09*** (0.37)	1.38*** (0.37)	1.41*** (0.42)	0.55*** (0.22)	1.01*** (0.30)	-0.52 (0.50)	1.45*** (0.36)	0.036 (0.53)	3.25*** (0.39)	1.99*** (0.24)	2.77*** (0.47)
lnK	β_K	-0.70** (0.32)	0.27 (0.28)	-0.29 (0.32)	-0.03 (0.14)	0.42** (0.21)	1.51*** (0.36)	0.25 (0.23)	0.99*** (0.37)	-1.51** (0.31)	-0.43*** (0.17)	-1.82*** (0.42)
t	β_t	0.19*** (0.03)	-0.0065 (0.02)	0.06** (0.03)	0.13*** (0.02)	0.0073 (0.025)	-0.07** (0.04)	-0.003 (0.024)	-0.036 (0.032)	0.10*** (0.027)	0.08*** (0.02)	0.20*** (0.024)
lnL^2	β_{LL}	-0.15*** (0.035)	-0.058* (0.04)	-0.14*** (0.05)	-0.05*** (0.02)	-0.026 (0.035)	0.11** (0.06)	-0.006 (0.03)	-0.0082 (0.067)	-0.28*** (0.047)	-0.088*** (0.028)	-0.14*** (0.09)
lnK^2	β_{KK}	-0.097*** (0.037)	-0.017 (0.03)	-0.14*** (0.03)	-0.07*** (0.02)	0.015 (0.022)	-0.0049 (0.026)	0.058*** (0.03)	-0.06* (0.039)	-0.12*** (0.034)	0.009 (0.016)	0.0099 (0.08)
t^2	β_{tt}	-0.0029*** (0.0004)	0.0009*** (0.0003)	-0.0013*** (0.0004)	-0.0005** (0.0003)	0.001** (0.0005)	-0.0029*** (0.0005)	0.0008*** (0.0003)	-0.0003 (0.0003)	0.00048*** (0.0003)	-0.00005 (0.0003)	-0.0009*** (0.0002)
lnL*lnK	β_{LK}	0.239*** (0.064)	0.051 (0.07)	0.27*** (0.08)	0.15*** (0.03)	-0.0054 (0.049)	-0.11* (0.07)	-0.08** (0.046)	0.062 (0.098)	0.38*** (0.078)	0.06** (0.04)	0.14 (0.17)
lnL*t	β_{Lt}	-0.029*** (0.005)	0.0025 (0.005)	-0.019*** (0.007)	-0.017*** (0.003)	0.0062 (0.0058)	0.0005 (0.0058)	-0.0004 (0.003)	-0.0052 (0.007)	-0.019*** (0.0075)	-0.016*** (0.004)	-0.03*** (0.0046)
lnK*t	β_{Kt}	0.026*** (0.006)	-0.0034 (0.004)	0.022*** (0.005)	0.0089** (0.003)	-0.0084** (0.0057)	0.016*** (0.0055)	0.0003 (0.0026)	0.012*** (0.0052)	0.012*** (0.0064)	0.011*** (0.003)	0.02*** (0.0044)
Panel-2: Inefficiency effects model												
Intercept	δ_0	-0.31*** (0.05)	-2.20*** (0.79)	-0.74 (1.08)	-9.71** (4.44)	-3.78* (2.98)	-8.34 (8.95)	0.80*** (0.22)	-5.76* (3.58)	0.77*** (0.20)	-4.52*** (1.79)	0.69*** (0.11)
Employers' Skill(OE/TE)	δ_1	-1.09*** (0.27)	3.04*** (0.79)	0.33 (0.47)	11.35** (4.92)	-25.82*** (7.47)	-1.27 (1.19)	-4.00*** (0.96)	-6.36** (3.21)	-2.21*** (0.46)	11.97*** (3.41)	-2.62*** (0.60)
Capital Intensity(K/L)	δ_2	-0.07 (0.18)	-2.53*** (0.21)	-0.25 (0.28)	-0.000006 (0.000007)	0.84*** (0.30)	0.22 (0.25)	0.11*** (0.039)	0.22*** (0.088)	-0.32** (0.18)	1.41*** (0.40)	0.13* (0.11)
Reform Dummy(D)	δ_3	0.80*** (0.14)	0.77*** (0.16)	1.40* (0.96)	-4.05** (1.94)	0.035 (0.28)	1.08 (1.84)	-0.04 (0.08)	2.54** (1.30)	0.18** (0.09)	-4.16*** (1.42)	0.12*** (0.04)
Panel-3: Variance parameters												
Sigma squared	σ^2	0.09*** (0.01)	0.47*** (0.11)	0.20*** (0.02)	2.41** (1.06)	4.36*** (1.69)	2.41 (2.59)	0.10*** (0.008)	2.01*** (1.02)	0.076*** (0.011)	2.58*** (0.76)	0.04*** (0.03)
Gamma	Υ	0.07** (0.03)	0.93*** (0.015)	0.51*** (0.14)	0.98*** (0.0095)	0.97*** (0.01)	0.91*** (0.11)	0.05 (0.25)	0.97*** (0.016)	0.57*** (0.095)	0.96*** (0.14)	0.37* (0.27)
Log-Likelihood		-117.39	1.03	-241.08	-141.58	-375.76	-404.70	-142.22	-257.60	40.09	-287.64	126.08
Standard errors are mentioned in the parenthesis												
*****,** & * denote statistical significance at the 1%, 5% and 10% levels, respectively**												
Source: Authors' own calculation												

Notes:

1. σ^2 refers to variance of the total random term, i.e., $\sigma^2 = \sigma_u^2 + \sigma_v^2$
2. γ refers to proportion of inefficiency error in the total random error, i.e., $\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$. It indicates the level of operation of the industries of their potential output as determined by the frontier technology.

So, it is clear that the estimated coefficients of employers' skill variable in the inefficiency functions are negative in most of the industries, indicating the improvement in technical efficiency in those industries during the last 30 years. Surprisingly, the estimated coefficient of capital intensity variable does not provide a plausible economic interpretation. It is positive in more than 60% of industries. It is to be noted that a positive estimated coefficient means negative gains in technical efficiency and negative effects on productivity growth.

Likewise, the estimated coefficients of dummy variable are positive in almost all the 2-digit industries, indicating that liberalization of the Indian manufacturing industries created a significant negative impact on technical efficiency improvement in these industries.

Lastly, panel 3 of Table 1 reports the estimates of the variance parameters σ^2 and γ that test for the validity of technical inefficiency effect. Both the estimated coefficients (except the value of gamma parameter in the non-metallic minerals product) are found to be statistically significant at the conventional levels which confirm the presence of technical inefficiency effect in the output residual as shown in panel 3. The estimated values of gamma (γ) are found to be more than 50% in as many as eight 2-digit industries. These estimated values are 0.93, 0.51, 0.98, 0.97, 0.91, 0.97, 0.57 and 0.96, respectively, in the manufacture of textile and textile products (23+24+25+26), wood and wood products; furniture and fixtures (27), paper and paper products (28), chemicals and chemical products (30), rubber, petroleum and coal products (31), basic metals and alloys (33), metal products and machinery equipment (34-36) and the manufacture of transport equipment (37). They are found to be statistically significant at less than 1% probability level, implying that output variation in these 2-digit manufacturing industries is significantly dominated by inefficiency error components. Although the estimated values of gamma (γ) are found to be very low in case of the manufacture of food, beverages and tobacco products (20-22), manufacture of non-metallic mineral products (32) and in total manufacturing. This implies that output variations in these 2-digit manufacturing industries are remarkably influenced by random factors.

Tests of Hypotheses

The hypotheses M1 to M6 are tested using likelihood ratio (LR) tests. The likelihood ratio test statistic is $\lambda = -2\,[L\,(H_0)\text{-}L\,(H_1)]$, where $L\,(H_0)$ and $L\,(H_1)$ are the values of log-likelihood function under null and general hypotheses respectively. If null is true, then test statistic (λ) has approximately a Chi-Square (or mixed chi-square) distribution with degrees of freedom equal to the number of restrictions. If null hypothesis includes $\gamma = 0$, then test statistic λ is approximately distributed according to a mixed chi-square distribution. Table 2 presents the test results of various null hypotheses as mentioned below:

At first, we carried out a generalized likelihood ratio test to choose between the null hypotheses of traditional Cobb-Douglas functional form and the alternative of the translog production function specification. All the values of the tests statistics are found to be significantly greater than the critical chi-square table value of 16.81 and 12.59 with six degrees of freedom at, respectively, 1% and 5% levels of significance in almost all the 2-digit industries. We, therefore, reject the null hypotheses of the traditional Cobb-Douglas functional form for most of the 2-digit industries except three, namely, the manufacture of textile and textile products (23-26), chemical and chemical products (30), and petroleum and coal products (31). These results clearly indicate presence of translog production function specification to the Cobb-Douglas representation for as many as eight 2-digit industries. Only these three industries are exceptions.

The second test we have conducted to test the null hypothesis that there is no technological change over time. This implies that all the parameters in equation (9) do not belong to the stochastic production frontier. The values of the generalized likelihood ratio tests as shown in Table 2 are significantly greater than the critical values at 1% probability level. Therefore, the null hypothesis of 'no technological change over time' is strongly rejected.

The third null-hypothesis is that the technological progress is neutral. But the translog specification of stochastic production frontier allows for non-neutral technological progress. Technological progress is neutral if β_{Lt} and β_{Kt} are equal to zero. Here, for the manufacture of textile and textile products (23-26), chemical and chemical products (30), petroleum and coal products (31), and non-metallic mineral products (32), the null hypothesis is accepted. Statistical tests, therefore, suggest the existence of neutral technological progress in the data set of these three industries. However, in case of all other industries, the null hypothesis is rejected, thereby implying, the existence of non-neutral technological change in the data set of these industries.

The fourth null hypothesis states that there is no technical inefficiency effect. The alternative hypothesis in this case is that technical inefficiency is experienced by the industries. Note that the null hypotheses assert that all the coefficients of the technical inefficiency effects model are zero. By applying the restrictions on the original model, the value of likelihood ratio tests is found to be greater than the tabled chi-square values for almost all the 2-digit industries. The results thus provide evidences that technical inefficiencies are present in almost all the 2-digit industries except in petroleum and coal products (31). This implies that the traditional production function is not an adequate representation for the 2-digit manufacturing industries except for the petroleum and coal products (31). So, it can be inferred that inefficiencies are present in the 2-digit manufacturing industries in India (except petroleum and coal products) and they are stochastic.

The fifth null hypothesis asserts that inefficiency effect is not a linear function of each of the explanatory variables, i.e., $H_0:\delta_1 = \delta_2 = \delta_3 = 0$. The test results reject the null hypothesis in case of all but four industries. This indicates that the joint effect of these explanatory variables on the level of technical inefficiencies of those industries (except the four) is statistically significant (Table 2). It is only in case of four industries, namely, textile and textile products (23-26), chemical and chemical products (30), petroleum and coal products (31), and manufacture of transport equipment (37), the null-hypothesis is accepted implying that the explanatory variables have no effect on technical inefficiency for these four industries.

The final null-hypothesis specifies that each industry is operating on the technically efficient frontier (H_0: $\mu = 0$). This hypothesis is also rejected in favour of the presence of inefficiency effects at the conventional levels of significance in all the 2-digit industries except the four. In case of food, beverages and tobacco products (20-22); wood and wood products (27); chemical and chemical products (30), and petroleum and coal products (31) the null-hypotheses are accepted in favour of the absence of inefficiency effect.

Table 2: Hypothesis Tests for Model Specification and Statistical Assumptions

Null Hypothesis	*Log-likelihood Value*		*Test statistics*	*Critical Value*		*Decision*
Cobb-Douglas Production Specification H_0: $\beta_{LL} = \beta_{KK} = \beta_{LK} = \beta_{tt} = \beta_{Lt} = \beta_{Kt} = 0$	$L(H_1)$	$L(H_0)$	$\lambda = -2[L(H_0)-L(H_1)]$	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-136.24	37.70	16.81	12.59	Reject H_0
Textile & Textile Products(23+24+25+26)	1.03	11.78	-21.50	16.81	12.59	Accept H_0
Wood & Wood Products (27)	-241.08	-277.38	72.60	16.81	12.59	Reject H_0
Paper & Paper Products (28)	-141.58	-160.43	37.70	16.81	12.59	Reject H_0
Chemical & Chemical Products (30)	-375.76	-352.28	-46.96	16.81	12.59	Accept H_0
Petroleum & Coal Products (31)	-404.70	-403.76	-1.88	16.81	12.59	Accept H_0
Non-Metallic Mineral Products (32)	-142.22	-165.74	47.04	16.81	12.59	Reject H_0
Basic Metal & Alloys Industries (33)	-257.60	-265.42	15.62	16.81	12.59	Reject H_0
Metal Products & Machinery (34+35+36)	40.09	31.31	17.56	16.81	12.59	Reject H_0
Transport Equipment (37)	-287.64	-299.18	23.08	16.81	12.59	Reject H_0
Total Manufacturing	126.08	61.85	128.46	16.81	12.59	Reject H_0
No Technological Change H_0: $\beta_t = \beta_{tt} = \beta_{Lt} = \beta_{Kt} = 0$	$L(H_1)$	$L(H_0)$	$\lambda = -2[L(H_0)-L(H_1)]$	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-158.26	81.74	13.28	9.49	Reject H_0
Textile & Textile Products(23+24+25+26)	1.03	-57.66	117.38	13.28	9.49	Reject H_0
Wood & Wood Products (27)	-241.08	-259.31	35.46	13.28	9.49	Reject H_0
Paper & Paper Products (28)	-141.58	-213.37	143.58	13.28	9.49	Reject H_0
Chemical & Chemical Products (30)	-375.76	-392.43	33.34	13.28	9.49	Reject H_0
Petroleum & Coal Products (31)	-404.70	-428.69	47.98	13.28	9.49	Reject H_0
Non-Metallic Mineral Products (32)	-142.22	-170.85	57.26	13.28	9.49	Reject H_0
Basic Metal & Alloys Industries (33)	-257.60	-292.30	69.40	13.28	9.49	Reject H_0
Metal Products & Machinery (34+35+36)	40.09	-81.61	83.04	13.28	9.49	Reject H_0
Transport Equipment (37)	-287.64	-326.12	76.96	13.28	9.49	Reject H_0
Total Manufacturing	126.08	-206.68	161.20	13.28	9.49	Reject H_0
Technological Change is Neutral H_0: $\beta_{Lt} = \beta_{Kt} = 0$	$L(H_1)$	$L(H_0)$	$\lambda = -2[L(H_0)-L(H_1)]$	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-144.96	55.14	9.21	5.99	Reject H_0
Textile & Textile Products(23+24+25+26)	1.03	0.87	0.32	9.21	5.99	Accept H_0
Wood & Wood Products (27)	-241.08	-270.02	57.88	9.21	5.99	Reject H_0
Paper & Paper Products (28)	-141.58	-154.43	25.70	9.21	5.99	Reject H_0
Chemical & Chemical Products (30)	-375.76	-370.19	-11.14	9.21	5.99	Accept H_0
Petroleum & Coal Products (31)	-404.70	-407.26	5.12	9.21	5.99	Accept H_0
Non-Metallic Mineral Products (32)	-142.22	-142.48	0.52	9.21	5.99	Accept H_0

Technological Change is Neutral *H_0: $\beta_{Lt} = \beta_{Kt} = 0$*	*$L(H_1)$*	*$L(H_0)$*	*$\lambda = -2[L(H_0)-L(H_1)]$*	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Basic Metal & Alloys Industries (33)	-257.60	-272.84	30.48	9.21	5.99	Reject H_0
Metal Products & Machinery (34+35+36)	40.09	44.16	8.14	9.21	5.99	Reject H_0 at 5% level
Transport Equipment (37)	-287.64	-295.45	15.62	9.21	5.99	Reject H_0
Total Manufacturing	126.08	62.60	126.96	9.21	5.99	Reject H_0

Null Hypothesis	*Log-likelihood Value*		*Test statistics*	*Critical value*		*Decision*
No Technical Inefficiency Effects *H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = 0$*	*$L(H_1)$*	*$L(H_0)$*	*$\lambda = -2[L(H_0)-L(H_1)]$*	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-125.71	16.64	16.81	12.59	Reject H_0
Textile & Textile Products(23+24+25+26)	1.03	-14.04	30.14	16.81	12.59	Reject H_0
Wood & Wood Products (27)	-241.08	-266.23	50.30	16.81	12.59	Reject H_0
Paper & Paper Products (28)	-141.58	-169.09	50.02	16.81	12.59	Reject H_0
Chemical & Chemical Products (30)	-375.76	-395.34	39.16	16.81	12.59	Reject H_0
Petroleum & Coal Products (31)	-404.70	-406.81	4.22	16.81	12.59	Accept H_0
Non-Metallic Mineral Products (32)	-142.22	-159.42	34.40	16.81	12.59	Reject H_0
Basic Metal & Alloys Industries (33)	-257.60	-270.91	26.62	16.81	12.59	Reject H_0
Metal Products & Machinery (34+35+36)	40.09	26.36	27.46	16.81	12.59	Reject H_0
Transport Equipment (37)	-287.64	-310.83	46.38	16.81	12.59	Reject H_0
Total Manufacturing	126.08	83.81	84.54	16.81	12.59	Reject H_0
Inefficiency Effects are not a Linear Function of each of the Inefficiency Factors H_0: $\delta_1 = \delta_2 = \delta_3 = 0$	*$L(H_1)$*	*$L(H_0)$*	*$\lambda = -2[L(H_0)-L(H_1)]$*	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-124.01	13.24	11.34	7.81	Reject H_0
Textile & Textile Products(23+24+25+26)	1.03	-1.78	5.62	11.34	7.81	Accept H_0
Wood & Wood Products (27)	-241.08	-266.23	50.30	11.34	7.81	Reject H_0
Paper & Paper Products (28)	-141.58	-149.46	15.76	11.34	7.81	Reject H_0
Chemical & Chemical Products (30)	-375.76	-379.44	7.36	11.34	7.81	Accept H_0
Petroleum & Coal Products (31)	-404.70	-406.94	4.48	11.34	7.81	Accept H_0
Non-Metallic Mineral Products (32)	-142.22	-160.34	36.24	11.34	7.81	Reject H_0
Basic Metal & Alloys Industries (33)	-257.60	-261.77	8.34	11.34	7.81	Reject H_0 at 5% level
Metal Products & Machinery (34+35+36)	40.09	31.50	17.18	11.34	7.81	Reject H_0
Transport Equipment (37)	-287.64	-291.36	7.44	11.34	7.81	Accept H_0
Total Manufacturing	126.08	83.98	84.20	11.34	7.81	Reject H_0
Each Industry is Operating on Technical Efficiency Frontier *H_0: $\mu=0$*	*$L(H_1)$*	*$L(H_0)$*	*$\lambda = -2[L(H_0)-L(H_1)]$*	*At 1% Level*	*At 5% Level*	*Reject H_0/ Accept H_0*
Food, Beverages & Tobacco (20-22)	-117.39	-117.86	0.94	6.63	3.84	Accept H_0
Textile & Textile Products(23+24+25+26)	1.03	-5.70	13.46	6.63	3.84	Reject H_0
Wood & Wood Products (27)	-241.08	-242.22	2.28	6.63	3.84	Accept H_0
Paper & Paper Products (28)	-141.58	-156.76	30.36	6.63	3.84	Reject H_0
Chemical & Chemical Products (30)	-375.76	-376.90	2.28	6.63	3.84	Accept H_0
Petroleum & Coal Products (31)	-404.70	-405.70	2.20	6.63	3.84	Accept H_0
Non-Metallic Mineral Products (32)	-142.22	-149.47	14.50	6.63	3.84	Reject H_0
Basic Metal & Alloys Industries (33)	-257.60	-261.19	7.18	6.63	3.84	Reject H_0
Metal Products & Machinery (34+35+36)	40.09	35.77	8.64	6.63	3.84	Reject H_0
Transport Equipment (37)	-287.64	-290.17	5.06	6.63	3.84	Reject H_0 at 5% level
Total Manufacturing	126.08	106.89	38.38	6.63	3.84	Reject H_0

Source: Authors' own calculation

Thus, on the basis of the test results, we can make the following inferences: 1) the translog production function specification is an appropriate one for as many as eight industries; while for only three industries, namely, manufacture of textile and textile products (23-26), chemical and chemical products (30), and petroleum and coal products (31), Cobb-Douglas production happens to be the best functional specification. 2) The technological progress is found to be non-neutral for as many as seven industries. For only four industries, it happens to be neutral. 3) Furthermore, for the seven industries there exists a linear relationship between inefficiency effect term, on the one hand, and the effects variables, on the other. This relationship is non-linear for the remaining four industries. Thus, the test results relating to model specification guide us to finally select the more appropriate models for two sets of industries-one set consists of seven and the other set consists of the remaining four industries and we carry out the estimation of the parameters of these models. The estimation results are presented in Tables 3 through 7 in Appendix.

Decomposition Results

Based on the translog production function estimates presented in Table 1, we have obtained the four measures of the 2-digit industries across states: technological progress (TP) [Table 3 in the Appendix], the growth of technical efficiency (TEC) [Table 4 in the Appendix], economic scale effect (*SC*) [Table 5 in the Appendix] and allocative efficiency effect (AEC) [Table 6 in the Appendix]. Adding four measures, we obtain total factor productivity growth (TFPG) [Table 7 in the Appendix] of them. As translog specification is used, the performance of these measures varies depending on industries and years. The estimated results are interpreted below:

We know that economic reform of the early 1990s is a significant milestone in the economic growth of India (Goldar & Sengupta, 2016). However, Table 7 (in the Appendix) shows that in almost all the 2-digit industries in most of the states under study as well as in All-India the rates of TFPG have declined during the post-reform period. The decline in the rates of TFPG of these industries can be accounted for by the decline in TEC and AEC in these industries during the reference periods. This is because although in six out of eleven industries, TP has increased significantly and SC has also increased marginally in most of the industries in almost all the states under study and in All-India as well during the post-reform period, the increasing effect of these two could not offset the declining effects of TEC and AEC of the same during the aforesaid period.

Thus, the above results clearly show that although the innovating manufacturing industries in many states under study and in All-India are adopting new technologies, contributing to technological progress, and at the same time reaping the fruits of increasing returns to scale, it appears that these industries failed to follow the best practice technologies of the adopted technology because of their incomplete knowledge of best practice and deviation of factor prices from the factors' marginal productivities. As a result, the major manufacturing industries under study in most of the industrialized states in India as well as in All-India failed to achieve maximum efficiency and the level of efficiency seems to be insufficient to increase TFPG over the years.

As regards the contribution of technical efficiency change to TFPG, only a few industries in a few states under study including All-India enjoyed positive growth rates of technical efficiency over the period. The positive growth rate of technical efficiency change indicates a movement towards the production frontier, which also means an increase in output growth over time. The remaining industries in all other states under study suffered from a declining change in technical efficiency over the period. It reveals that inputs have not been used efficiently in these industries of the states under study over the period.

However, in most of the 2-digit industries increase in TP and SC have often been outweighed by the declining technical as well as allocation efficiency change. Thus, the decline in technical and allocation efficiency changes are the main causes of the low and declining rates of TFPG of the manufacturing industries in India and in its major industrialized states during the post-reform period. It may be mention here that the manufacture of metal products and machinery equipment (34-36) and the manufacture of transport equipment (37) have experienced maximum growth rates of TFP in almost all the states under study during the whole study period and in the post-reform period. On the other hand, it is the manufacture of food, beverages and tobacco products (20-22) that has experienced the highest growth rate of TFP during the pre-reform period. This may be due to better performances of TP in these industries under study during the study periods. However, manufacture of wood and wood products (27) and petroleum and coal products (31) show worse performance during the aforesaid study periods so far as the rates of TFPG are concerned.

But statistical tests suggest that the translog production function specification in case of a few important industries like manufacture of textile and textile products (23-26), chemical and chemical products (30) and petroleum and coal products (31) is not applicable. In case of these three industries, Cobb-Douglas production function represents the better functional specification. Further, for these industries, technological progress is found to have been neutral. Moreover, in case of these industries there is no linear relationship of the inefficiency effect term with the effects variables. So, the estimates of TP itself represent the TFPG estimates in these three important industry groups. Thus, productivity growth decomposition using stochastic frontier model along with translog production specification is not applicable in case of these three industries under the study. However, in case of all other industries the chosen model represents best model specification and decomposition of TFPG using this model remained effective in almost all the 2-digit industries in case of the major industrialized states under study as well as in All-India during the aforementioned study periods.

Summary and Conclusion

The study estimates and decomposes the sources of TFPG of the 2-digit manufacturing industries as well as total manufacturing industry in fifteen major industrialized states in India as well as in All-India during the period from 1981-82 to 2010-11, for the entire period, pre-reform period (1981-82 to 1990-91), post-reform period (1991-92 to 2010-11) and also for the two decades of the post-reform period (1990-91 to 2000-01 and 2001-02 to 2010-11) using stochastic frontier approach. The methodology entails decomposition of the sources of TFPG into technological progress, technical efficiency change, allocation efficiency change and scale change.

The main findings of decomposition is that TFPG in most of the 2-digit industries in major industrialized states in India as well as in All-India have declined during the post-reform period. So far as the sources of TFPG are concerned, it is found that the productivity growth of the Indian manufacturing industries is significantly driven by technological progress. The contributions of scale effect to TFPG of the same in the major industrialized states under study are also found to be positive although they are found to be very negligible. But the decline in TFPG of most of the 2-digit industries in the major industrialized states under study may be partly ascribed to the declines in the TEC and AEC of these industries which have swamped the positive growth in TP and SC of them.

However, it is found that the scale effects in almost all the 2-digit industries including that of total manufacturing industry have increased in most of the states under study during the 2nd half of the post-reform period. So, it can be inferred that the manufacturing industries of different states under study including those in All-India have benefitted from economies of scale during the recent years. But the estimates of scale effects are still far below the estimates of all other components of TFPG. Thus, although factor accumulation may have led to TFP growth through increasing returns to scale, TFPG in most of the 2-digit industries in almost all the states under study have declined during the post-reform period and the decline in TFPG of the same is mainly responsible for the decline in AEC and TEC of them during that period. This means that deregulation of the economy during the post-reform period has increased the price buckle measured by the gap between price and marginal cost of production of the organized manufacturing industries in the major industrialized states in India as well as those in All-India. Therefore, resource allocations in almost all the 2-digit industries under study has been made more inefficiently during the post-reform period. Moreover, factor inputs have been used more inefficiently, i.e., they are producing below their optimal capacity.

Most of the studies on productivity analysis of the organized manufacturing industries in India have also shown that TFPG of the manufacturing industries in India have declined during the post-reform period although the reasons are different. Goldar and Kumari (2003) in their study have shown that the decline in agricultural productivity and the deterioration of capacity utilization are mainly responsible for the decline in TFPG of the Indian manufacturing industries. Kathuria et al. (2014) and Goldar and Sengupta (2016) have shown that the decline in TFPG of the major manufacturing industries in India during the post-reform period is mainly responsible for the decline in technological progress of the same during that period.

Whatever the reasons for the decline in TFPG of the organized manufacturing industries in India are, policies should be geared to allocate resources optimally and to use factor inputs more efficiently. Policies should further be taken to increase scale of production so that per unit cost of production decline and price will tend towards marginal costs. Policy measures intended to improve TFP growth rate might be misdirected if they focus on accelerating the rate of innovation in circumstances where the low rate of TFP growth is brought about by suboptimal size of the firms and low rate of technology diffusion (technical inefficiency), which really happened in the case of the organized manufacturing sector in general. A thorough examination of industrial policy resolutions reveals that the importance and contribution of efficiency in industrial growth has been neglected or given less priority in the framework of industrial strategy (Madheswaran et al., 2007). In this context, the governments should take some policy initiatives to improve productive efficiency of the organized manufacturing industries. Once efficiency increases, it enhances competitiveness by realizing the potential TFP growth of the organized manufacturing industries in India.

Appendix

Table 3(a): Average Annual Rates of Technological Progress (TP) during 1981-82 to 2010-11 (Entire Study Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.74	1.88	2.69	3.16	2.90	3.67	-1.75	2.84	3.10	2.50	2.81	3.95	2.15	2.71	2.03	1.11
23-26	1.63	2.12	2.33	1.42	1.68	1.82	1.79	1.61	1.44	2.05	1.51	1.50	1.51	1.57	1.88	1.34
27	2.22	1.59	-0.24	1.84	2.78	2.19	1.32	2.14	2.74	2.26	1.46	1.83	1.23	3.36	1.37	3.17
28	2.64	4.59	3.38	2.36	3.49	2.99	3.14	3.12	1.80	3.57	3.71	3.27	1.95	2.19	2.18	0.50
30	1.51	2.53	2.26	1.06	2.39	2.01	1.90	1.97	1.27	1.85	2.23	1.47	1.97	1.33	1.70	0.95
31	0.82	-0.15	-0.11	2.32	-1.91	0.24	0.28	-1.04	2.48	-3.52	-3.18	-1.21	1.26	1.12	0.41	5.78
32	2.44	2.39	2.39	2.43	2.42	2.45	2.41	2.46	2.44	2.43	2.42	2.45	2.43	2.41	2.41	2.41
33	3.12	-0.52	3.84	2.80	1.79	2.69	0.65	3.53	3.21	3.67	0.95	1.72	2.42	2.33	3.02	4.79
34-36	2.89	3.90	3.82	2.80	3.20	3.15	3.76	3.44	2.43	4.57	3.09	4.03	2.55	3.00	2.42	1.19
37	2.50	2.23	3.29	2.76	3.24	2.94	3.95	3.24	2.87	4.12	1.88	3.05	2.40	2.72	1.28	1.62
Total	2.61	4.41	5.28	4.14	4.07	3.69	3.04	4.94	3.16	6.47	3.49	4.89	2.29	3.65	2.92	0.96

Table3(b): Average Annual Rates of Technological Progress (TP) during 1981-82 to 1990-91 (Pre-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	2.92	6.06	6.06	6.96	6.41	7.23	2.16	5.28	7.26	6.60	6.94	8.18	5.92	5.68	6.13	4.87
23-26	0.19	0.45	0.63	-0.06	0.20	0.23	0.24	0.22	-0.02	0.31	0.05	-0.04	0.01	0.05	0.31	-0.15
27	4.20	3.11	1.61	2.56	2.75	3.07	2.51	3.35	2.95	3.79	2.21	2.13	1.57	3.58	1.65	3.88
28	3.16	6.45	3.42	3.04	3.88	3.84	4.18	3.69	2.26	3.40	4.45	3.86	2.69	2.86	2.48	0.99
30	-0.14	0.63	0.51	-0.08	0.86	0.45	-0.14	0.75	-0.18	0.92	1.31	0.04	0.09	-0.22	0.24	-0.50
31	5.54	3.51	4.93	5.04	2.43	3.42	4.79	1.51	6.54	-0.72	1.10	3.19	5.55	5.48	4.59	10.4
32	0.77	0.73	0.71	0.74	0.73	0.77	0.73	0.79	0.75	0.76	0.77	0.79	0.76	0.73	0.72	0.73
33	2.28	-0.55	4.05	1.36	1.23	1.46	0.79	3.81	2.43	3.40	0.85	1.84	1.98	1.77	2.82	4.53
34-36	1.65	2.71	1.83	1.04	1.60	1.61	2.72	1.93	0.85	3.18	1.89	2.42	1.07	1.59	0.60	-0.42
37	2.26	1.10	3.02	2.04	2.79	2.33	4.60	2.60	2.23	2.50	1.38	1.74	1.48	1.47	0.49	0.92
Total	3.59	5.17	6.09	4.42	5.47	4.40	4.77	6.05	3.81	7.05	5.20	6.21	3.45	4.36	3.29	1.83

Table 3(c): Average Annual Rates of Technological Progress (TP) during 1991-92 to 2010-11 (Post-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-2.58	-0.22	1.00	1.26	1.15	1.89	-3.71	1.61	1.03	0.45	0.74	1.83	0.26	1.22	-0.01	-0.76
23-26	2.34	2.95	3.18	2.16	2.43	2.62	2.57	2.30	2.17	2.92	2.24	2.26	2.26	2.33	2.67	2.08
27	1.23	0.83	-1.17	1.48	2.80	1.75	0.72	1.54	2.63	1.50	1.09	1.67	1.06	3.25	1.23	2.81
28	2.38	3.67	3.36	2.02	3.29	2.57	2.62	2.84	1.56	3.66	3.34	2.98	1.59	1.85	2.03	0.25
30	2.34	3.48	3.14	1.63	3.16	2.78	2.92	2.58	2.00	2.31	2.69	2.18	2.91	2.10	2.44	1.68
31	-1.54	-1.98	-2.63	0.96	-4.09	-1.35	-1.97	-2.32	0.44	-4.92	-5.33	-3.41	-0.89	-1.06	-1.68	3.48
32	3.27	3.22	3.23	3.27	3.26	3.29	3.25	3.30	3.28	3.27	3.24	3.28	3.27	3.25	3.26	3.25
33	3.55	-0.50	3.73	3.52	2.06	3.30	0.57	3.39	3.60	3.81	1.01	1.66	2.63	2.61	3.11	4.92
34-36	3.51	4.49	4.81	3.68	3.99	3.92	4.28	4.20	3.22	5.26	3.70	4.84	3.29	3.71	3.33	1.99
37	2.62	2.80	3.43	3.11	3.46	3.25	3.62	3.56	3.20	4.92	2.13	3.71	2.85	3.35	1.67	1.97
Total	2.13	4.03	4.88	4.01	3.37	3.33	2.18	4.38	2.84	6.18	2.63	4.23	1.72	3.29	2.74	0.53

Table 3(d): Average Annual Rates of Technological Progress (TP) during 1991-92 to 2000-01 (Post-Reform Period: Decade 1)

S/I	*A.P.*	*ASSAM*	*BIHAR*	*GUJ*	*HAR*	*KAR*	*KERA*	*M.P.*	*MAHA*	*ODISHA*	*PUN*	*RAJ*	*T.N.*	*U.P.*	*W.B.*	*IND*
20-22	-1.01	2.16	2.83	3.23	2.70	3.60	-1.32	3.70	2.98	3.03	3.05	4.48	2.18	2.83	1.87	1.11
23-26	1.61	2.12	2.46	1.42	1.66	1.85	1.80	1.54	1.43	2.17	1.49	1.45	1.52	1.49	1.87	1.32
27	0.99	1.95	-0.07	1.80	3.91	2.03	0.92	2.22	2.72	3.15	1.82	2.11	1.12	3.76	0.87	3.17
28	2.55	4.24	3.16	2.53	3.43	2.89	2.82	3.11	2.06	3.61	3.61	3.19	2.16	2.44	2.41	0.52
30	1.48	2.99	2.37	0.73	2.22	2.15	1.96	1.59	1.14	1.57	1.86	1.22	2.07	1.13	2.17	0.81
31	0.36	-0.42	-0.89	1.87	-1.73	0.18	0.17	0.02	2.64	-2.61	-3.10	-1.13	1.34	1.27	0.30	5.29
32	2.48	2.44	2.44	2.48	2.47	2.50	2.45	2.51	2.48	2.48	2.49	2.50	2.47	2.46	2.46	2.46
33	3.82	-0.63	3.81	3.48	1.90	2.76	0.69	3.31	3.38	3.58	1.00	1.95	2.56	2.77	3.31	4.94
34-36	2.87	2.96	3.76	2.93	3.37	3.17	3.71	3.61	2.69	4.63	3.33	4.21	2.67	3.13	2.55	1.31
37	2.56	2.48	2.81	2.25	3.54	2.93	3.87	3.68	3.13	4.39	2.07	3.01	2.44	3.18	1.14	1.68
Total	2.64	4.25	5.08	4.42	4.10	3.76	2.99	4.80	3.28	6.49	3.6	5.08	2.44	4.19	3.05	1.09

Table 3(e): Average Annual Rates of Technological Progress (TP) during 2001-02 to 2010-11 (Post-Reform Period: Decade 2)

S/I	*A.P.*	*ASSAM*	*BIHAR*	*GUJ*	*HAR*	*KAR*	*KERA*	*M.P.*	*MAHA*	*ODISHA*	*PUN*	*RAJ*	*T.N.*	*U.P.*	*W.B.*	*IND*
20-22	-4.15	-2.60	-0.83	-0.70	-0.40	0.18	-6.11	-0.48	-0.93	-2.13	-1.58	-0.82	-1.66	-0.38	-1.90	-2.63
23-26	3.08	3.79	3.89	2.90	3.20	3.39	3.33	3.07	2.91	3.68	2.99	3.07	3.01	3.16	3.47	2.84
27	1.47	-0.29	-2.27	1.15	1.70	1.48	0.51	0.86	2.54	-0.15	0.36	1.24	0.99	2.73	1.58	2.45
28	2.21	3.10	3.56	1.50	3.16	2.25	2.43	2.56	1.07	3.71	3.07	2.76	1.01	1.26	1.65	-0.01
30	3.20	3.97	3.91	2.53	4.10	3.41	3.87	3.56	2.86	3.05	3.51	3.15	3.76	3.07	2.70	2.54
31	-3.44	-3.54	-4.37	0.05	-6.44	-2.88	-4.10	-4.65	-1.75	-7.22	-7.55	-5.70	-3.11	-3.38	-3.66	1.68
32	4.06	4.00	4.01	4.06	4.05	4.08	4.04	4.09	4.08	4.06	4.00	4.06	4.06	4.05	4.06	4.03
33	3.27	-0.36	3.65	3.56	2.23	3.85	0.45	3.47	3.82	4.04	1.01	1.37	2.71	2.46	2.92	4.91
34-36	4.16	6.03	5.86	4.44	4.62	4.66	4.86	4.78	3.75	5.89	4.07	5.46	3.92	4.28	4.12	2.67
37	2.68	3.12	4.04	3.97	3.37	3.57	3.38	3.44	3.26	5.46	2.20	4.40	3.27	3.51	2.20	2.26
Total	1.61	3.82	4.67	3.59	2.63	2.90	1.36	3.96	2.40	5.88	1.66	3.37	0.99	2.40	2.43	-0.03

Source: Authors' own calculation
S/I- States/Industries

Table 4(a): Average Annual Rates of Technical Efficiency Change (TEC) during 1981-82 to 2010-11 (Entire Study Period)

S/I	*A.P.*	*ASSAM*	*BIHAR*	*GUJ*	*HAR*	*KAR*	*KERA*	*M.P.*	*MAHA*	*ODISHA*	*PUN*	*RAJ*	*T.N.*	*U.P.*	*W.B.*	*IND*
20-22	-0.97	-0.80	-0.32	-0.59	-0.33	-0.34	-1.09	-0.33	-0.34	-0.82	-0.73	-0.64	-0.64	-0.17	-0.53	-0.61
23-26	0.39	-1.37	0.12	0.26	0.26	-0.15	-0.04	0.17	0.21	0.03	0.33	0.12	0.03	0.10	-0.32	0.17
27	-0.64	-2.00	-2.11	-1.47	-1.23	-1.54	-2.02	-0.78	-0.62	-1.01	-1.81	-1.68	-2.33	-0.36	-0.89	-1.52
28	0.24	1.00	0.19	-0.01	-0.35	0.52	0.08	-1.25	0.01	0.26	3.05	0.57	0.15	0.39	-0.21	1.06
30	-0.41	6.24	-0.02	0.05	-0.18	1.92	0.19	0.90	0.41	0.66	0.52	0.13	-2.05	0.11	1.69	0.38
31	-0.17	0.04	3.12	-0.44	-0.57	0.05	-0.48	-2.45	0.24	0.33	0.24	-0.01	-0.57	-0.16	-0.56	-0.45
32	0.81	-1.60	0.52	-1.04	-0.09	-0.17	0.17	-0.86	-0.50	0.10	-1.86	-0.95	-1.51	-0.71	-0.57	0.06
33	-0.70	-0.21	0.51	-1.61	-1.70	-0.89	-1.09	-0.76	-1.77	-2.52	-1.56	-0.12	-0.74	0.26	-4.20	-1.31
34-36	0.14	-0.87	-0.34	0.28	0.13	0.14	-0.67	-0.05	0.20	-1.30	0.33	-0.50	0.09	0.49	0.18	0.26
37	1.10	0.52	-0.18	-0.29	-0.74	-0.34	0.84	0.47	-0.44	0.48	0.26	0.98	-0.10	0.27	0.12	-0.45
Total	-0.81	-0.62	-1.84	-2.19	-1.47	-1.66	-0.92	-1.76	-0.99	-4.03	-0.92	-1.55	-1.12	-0.09	-1.72	-1.36

Table 4(b): Average Annual Rates of Technical Efficiency Change (TEC) during 1981-82 to 1990-91 (Pre-Reform Period)

S/I	*A.P.*	*ASSAM*	*BIHAR*	*GUJ*	*HAR*	*KAR*	*KERA*	*M.P.*	*MAHA*	*ODISHA*	*PUN*	*RAJ*	*T.N.*	*U.P.*	*W.B.*	*IND*
20-22	-0.01	0	-0.01	0	-0.01	0.01	-0.01	0	-0.01	-0.01	0	0	0	0	0.01	-0.01
23-26	0.36	-0.02	0.38	0.63	0.93	0.54	0.45	0.44	0.63	2.17	0.67	0.88	0.52	0.34	-1.02	0.47
27	0.83	0.37	-0.32	0.10	0.26	0.26	-0.38	0.07	-0.04	0.06	0.22	-0.24	-0.04	-0.18	0.05	0.13
28	0.52	3.51	-3.17	0.96	0.20	1.33	-0.25	0.52	0.18	0.10	9.28	1.24	0.61	1.17	0.46	2.29
30	-0.94	16.2	-1.21	-0.40	-0.39	6.93	-0.67	2.43	1.45	-9.64	1.98	6.41	-0.97	0.25	5.43	0.78
31	0.17	0.27	9.07	-0.96	-0.8	0.97	-0.14	-0.42	0.54	0.06	0.07	0.51	0.01	0	-0.42	-0.20
32	4.46	-3.46	2.22	0.24	-1.57	1.28	0.63	0.27	0.44	1.76	-1.59	-0.05	0.25	1.16	0.33	0.69

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
33	-3.87	0.61	2.23	-0.27	-0.66	0.46	-0.72	-0.41	-0.70	0.33	-0.12	-0.80	-0.66	0.63	-4.20	-0.41
34-36	0.55	0.81	-1.35	1.30	0.58	0.56	-0.60	0.44	0.52	-1.14	1.28	-0.18	0.68	1.48	0.35	1.74
37	3.15	0.82	0.93	0.71	0.08	-0.23	1.05	1.46	0.17	2.03	0.74	1.86	0.76	0.57	0.74	-0.59
Total	-0.95	1.69	-0.07	-0.87	-0.74	0.45	-0.66	-0.21	-0.36	-0.51	-1.30	-0.07	-0.11	1.30	-1.35	-0.50

Table 4(c): Average Annual Rates of Technical Efficiency Change (TEC) during 1991-92 to 2010-11 (Post-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-1.46	-1.21	-0.47	-0.89	-0.49	-0.51	-1.64	-0.50	-0.50	-1.23	-1.10	-0.96	-0.96	-0.25	-0.80	-0.92
23-26	0.40	-2.05	-0.01	0.08	-0.07	-0.50	-0.29	0.04	-0.01	-1.05	0.15	-0.25	-0.22	-0.01	0.02	0.02
27	-1.38	-3.19	-3.01	-2.26	-1.98	-2.45	-2.84	-1.20	-0.92	-1.55	-2.83	-2.40	-3.48	-0.45	-1.36	-2.34
28	0.11	-0.26	1.88	-0.49	-0.63	0.12	0.25	-2.14	-0.08	0.33	-0.07	0.24	-0.08	0	-0.55	0.45
30	-0.15	1.24	0.57	0.27	-0.08	-0.58	0.62	0.14	-0.11	5.80	-0.21	-3.01	-2.58	0.04	-0.18	0.17
31	-0.34	-0.08	0.15	-0.18	-0.45	-0.41	-0.65	-3.47	0.09	0.47	0.33	-0.28	-0.86	-0.24	-0.62	-0.58
32	-1.01	-0.67	-0.33	-1.67	0.66	-0.89	-0.05	-1.42	-0.98	-0.73	-1.99	-1.40	-2.39	-1.65	-1.01	-0.25
33	0.89	-0.62	-0.34	-2.28	-2.21	-1.57	-1.28	-0.94	-2.31	-3.94	-2.28	0.22	-0.77	0.07	-4.20	-1.76
34-36	-0.07	-1.70	0.16	-0.23	-0.10	-0.07	-0.70	-0.29	0.03	-1.38	-0.14	-0.66	-0.20	-0.01	0.09	-0.49
37	0.07	0.38	-0.74	-0.79	-1.15	-0.4	0.74	-0.02	-0.75	-0.29	0.02	0.53	-0.53	0.12	-0.19	-0.38
Total	-0.74	-1.78	-2.73	-2.84	-1.83	-2.72	-1.05	-2.53	-1.30	-5.80	-0.72	-2.29	-1.63	-0.79	-1.91	-1.78

Table 4(d): Average Annual Rates of Technical Efficiency Change (TEC) during 1991-92 to 2000-01 (Post-Reform Period: Decade 1)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-3.69	-2.99	-1.63	-1.51	-1.89	-1.80	-3.10	-1.65	-1.35	-2.49	-2.02	-1.25	-2.18	-1.24	-1.79	-1.93
23-26	-0.22	-1.04	-1.49	-0.04	0.12	-0.29	-0.69	0.02	-0.29	-5.97	-0.31	-0.31	-0.48	-0.42	0.14	-0.30
27	-7.44	-10.8	-6.77	-4.73	-4.70	-1.56	-9.10	-10.0	-3.51	-5.11	-6.47	-6.88	-7.21	-4.51	-7.20	-5.81
28	-0.23	0.94	2.82	-1.37	-1.17	-0.13	-0.39	-0.93	-0.77	-0.96	-5.82	-1.79	0.32	-1.09	0.54	0.40
30	-0.81	0.17	-9.52	-0.65	-1.78	-0.83	0.24	0.14	-0.13	-2.10	-0.22	-0.15	-2.83	-1.30	-1.52	-0.56
31	-1.92	-4.04	-2.28	-0.28	-1.15	-8.89	-1.07	-0.29	-0.49	-0.07	-0.31	-0.73	-0.93	-2.48	-8.76	-1.82
32	2.08	-0.13	-0.52	-1.30	1.59	0.59	0.59	-0.01	-0.23	-0.30	-0.46	-0.56	-2.90	0.25	0.04	0.48
33	1.50	1.06	-0.61	-1.42	-0.58	-5.60	0.78	-0.35	-7.17	-1.48	-6.66	0.48	-6.02	-1.30	-2.22	-1.32
34-36	0.35	1.03	0.35	-0.42	0.04	-0.12	-0.59	-0.68	-0.01	-0.21	0.41	0.09	-0.33	-0.66	-0.30	-1.31
37	-0.62	0.94	-0.38	-5.28	-1.46	-0.39	0.82	-0.19	-1.67	-0.79	-1.20	-4.87	-0.77	-4.76	-1.65	-2.06
Total	-0.42	-4.74	-3.42	-3.39	-1.72	-3.60	-1.37	-1.96	-1.52	-3.78	-1.07	-1.96	-2.46	-1.95	-2.42	-2.19

Table 4(e): Average Annual Rates of Technical Efficiency Change (TEC) during 2001-02 to 2010-11 (Post-Reform Period: Decade 2)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	0.77	0.58	0.69	-0.27	0.90	0.78	-0.18	0.65	0.34	0.04	-0.18	-0.66	0.25	0.73	0.20	0.10
23-26	1.02	-3.06	1.47	0.20	-0.26	-0.71	0.11	0.05	0.29	3.88	0.62	-0.20	0.04	0.39	-0.10	0.35
27	4.67	4.40	0.76	0.21	0.73	-3.33	3.43	7.63	1.67	2.01	0.82	2.08	0.25	3.62	4.48	1.13
28	0.44	-1.46	0.93	0.39	-0.09	0.37	0.88	-3.35	0.61	1.63	5.69	2.27	-0.48	1.10	-1.63	0.49
30	0.51	2.31	10.7	1.20	1.62	-0.34	1.00	0.15	-0.09	13.7	-0.19	-5.87	-2.33	1.38	1.16	0.91
31	1.23	3.88	2.57	-0.08	0.24	8.07	-0.23	-6.65	0.67	1.01	0.96	0.18	-0.79	2.00	7.51	0.67
32	-4.10	-1.21	-0.14	-2.05	-0.28	-2.36	-0.69	-2.84	-1.72	-1.16	-3.53	-2.24	-1.87	-3.55	-2.07	-0.99
33	0.28	-2.31	-0.08	-3.13	-3.85	2.46	-3.34	-1.54	2.56	-6.40	2.10	-0.05	4.47	1.45	-6.19	-2.20
34-36	-0.48	-4.44	-0.02	-0.04	-0.23	-0.02	-0.82	0.10	0.08	-2.55	-0.69	-1.41	-0.08	0.64	0.48	0.34
37	0.77	-0.18	-1.10	3.70	-0.84	-0.4	0.65	0.14	0.17	0.21	1.24	5.94	-0.3	5.01	1.27	1.29
Total	-1.06	1.18	-2.04	-2.29	-1.94	-1.85	-0.73	-3.09	-1.08	-7.81	-0.38	-2.62	-0.79	0.38	-1.40	-1.37

Source: Authors' own calculation

S/I- States/Industries

Table 5(a): Average Annual Rates of Scale Effect (SC) during 1981-82 to 2010-11 (Entire Study Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.60	-0.01	-0.02	0.02	0.15	0.08	-0.38	0.03	-0.03	0.09	0.03	0.10	-0.04	-0.03	-0.03	-0.50
23-26	0.27	-0.12	-0.35	0.05	0.59	0.27	0.26	0.22	0.02	-0.66	0.52	0.37	0.01	0.20	0.01	-0.37
27	0.17	-1.16	0.14	0.17	-0.14	0.08	0.10	-0.18	0.14	-0.11	-0.52	0.71	0.15	0.19	0.16	0.01
28	-0.09	4.17	0.12	-0.21	0.03	-0.15	0.14	0.13	0.03	0.29	-0.07	-0.30	-0.07	-0.12	-0.12	0.22
30	1.32	0.84	-0.03	0.46	0.61	0.63	0.44	2.09	0.30	2.92	0.89	0.66	0.48	0.95	0.18	-0.19
31	0.83	-1.29	0.64	-0.24	1.64	0.27	0.58	0.91	0.26	-3.30	1.57	-1.94	0.66	-0.28	0.43	0.37
32	0.28	0.59	-0.08	0.15	0.41	0.65	0.43	0.59	0.27	0.41	2.01	0.76	0.40	0.33	0.45	-0.98
33	-0.89	-0.01	-0.01	-0.37	0.02	-0.28	-0.07	-0.36	-0.24	-0.63	0.27	0.09	-0.19	-0.29	-0.21	-0.23
34-36	0.23	-2.43	0.19	0.37	0.23	0.42	0.07	0.18	0.25	0.01	0.20	0.59	0.16	0.47	-0.17	-0.25
37	-0.03	4.73	0.03	0.71	1.01	0.55	-0.43	0.61	0.26	-0.15	0.10	0.56	0.39	0.57	0.06	-0.43
Total	-0.26	0.05	0.08	0.44	-0.38	-0.14	-0.41	0.23	0.15	0.72	-0.30	0.02	-0.43	0.01	0.22	0.22

Table 5(b): Average Annual Rates of Scale Effect (SC) during 1981-82 to 1990-91 (Pre-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.30	0.02	-0.11	-0.02	0.14	-0.01	0.10	-0.03	0	-0.14	0.08	-0.20	0.04	-0.04	-0.06	-0.26
23-26	0.33	-0.41	-0.77	-0.05	0.30	0.29	-0.25	0.14	0	0.37	0.76	0.60	0.13	0.22	0.02	-0.25
27	-0.05	-0.04	0.16	-0.06	0.07	-0.08	0.01	-0.12	-0.05	-0.27	-0.05	0.04	-0.14	0.06	0.05	0.01
28	0.21	13.1	0.60	0.06	0.06	0.02	0.46	-0.03	0.25	0.07	-0.15	0.08	0.16	0.26	-0.13	0.26
30	3.01	-1.99	0.19	1.07	1.12	0.95	1.46	5.80	0.82	7.98	2.17	0	1.04	2.18	-0.09	-0.11
31	-0.07	-2.58	0.32	0.37	1.15	0.12	-0.36	-0.57	0.01	-9.30	2.75	-7.31	-0.09	-1.09	0.21	-0.25
32	0.55	1.10	-0.07	-0.14	0.43	0.38	0.41	0.80	0.15	0.29	1.17	0.94	0.14	-0.08	-0.10	-1.16
33	-2.12	0.28	-0.11	-0.14	0	-0.05	-0.12	-0.35	-0.16	-0.42	0.06	-0.07	-0.30	-0.04	-0.19	-0.27
34-36	0.49	0.77	0.35	0.19	0.18	0.43	0.18	0.33	0.13	1.29	0.47	0.54	0.21	0.50	0.05	-0.14
37	0.01	-2.41	-0.51	0.17	1.35	0.66	-0.96	0.77	0.03	0.30	0.04	-0.28	0.01	0.02	0.25	-0.43
Total	-0.10	0.15	-0.09	0.06	-0.01	-0.09	-0.07	0.43	0.09	0.29	0.08	0.16	-0.18	0.39	-0.02	0.27

Table 5(c): Average Annual Rates of Scale Effect (SC) during 1991-92 to 2010-11 (Post-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.75	-0.02	0.03	0.04	0.16	0.13	-0.62	0.07	-0.04	0.20	0	0.25	-0.09	-0.03	-0.01	-0.61
23-26	0.24	0.02	-0.14	0.10	0.73	0.26	0.51	0.27	0.03	-1.18	0.40	0.26	-0.06	0.20	0.01	-0.44
27	0.29	-1.72	0.12	0.28	-0.24	0.17	0.14	-0.22	0.24	-0.03	-0.76	1.05	0.29	0.26	0.21	0.01
28	-0.24	-0.30	-0.11	-0.35	0.01	-0.23	-0.02	0.20	-0.08	0.40	-0.03	-0.50	-0.19	-0.31	-0.12	0.20
30	0.48	2.25	-0.14	0.15	0.35	0.47	-0.07	0.24	0.04	0.40	0.24	1.00	0.19	0.33	0.32	-0.24
31	1.28	-0.65	0.80	-0.54	1.88	0.35	1.05	1.65	0.38	-0.30	0.99	0.74	1.04	0.13	0.55	0.68
32	0.14	0.34	-0.08	0.29	0.40	0.79	0.44	0.49	0.32	0.47	2.43	0.67	0.52	0.53	0.72	-0.90
33	-0.28	-0.16	0.04	-0.48	0.03	-0.39	-0.05	-0.37	-0.28	-0.74	0.38	0.17	-0.14	-0.42	-0.22	-0.21
34-36	0.10	-4.03	0.10	0.46	0.26	0.42	0.01	0.11	0.31	-0.63	0.07	0.62	0.14	0.45	-0.28	-0.31
37	-0.05	8.30	0.30	0.97	0.85	0.50	-0.16	0.53	0.37	-0.38	0.13	0.99	0.58	0.84	-0.03	-0.43
Total	-0.34	-0.01	0.16	0.63	-0.57	-0.16	-0.58	0.13	0.17	0.94	-0.49	-0.05	-0.56	-0.18	0.35	0.19

Table 5(d): Average Annual Rates of Scale Effect (SC) during 1991-92 to 2000-01 (Post-reform Period: Decade 1)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.77	0.05	-0.07	0.04	0.12	0.13	-0.72	0.13	-0.02	0.43	0.04	0.35	-0.08	-0.05	0.04	-0.59
23-26	-0.05	1.01	-0.39	0.14	1.02	0.44	0.92	0.59	0.01	-0.67	0.29	0.21	0.04	0.10	0.02	-0.46
27	0.36	-3.63	-0.27	0.09	-1.19	0.14	0.10	-0.26	0.23	-0.13	-1.29	1.06	0.18	-0.01	0.03	-0.07
28	0.02	-0.20	1.14	-0.15	0.16	0.04	-0.39	0.9	0.12	0.23	-0.35	-0.49	0.03	0.11	0.11	0.29
30	0.79	2.93	-0.02	0.35	0.43	0.47	0.03	0.47	0.05	0.71	0.28	1.94	0.38	0.53	0.23	-0.26
31	0.62	-0.40	0.73	0.16	1.45	-0.12	0.62	0.45	-0.01	-1.38	1.03	0.16	-0.16	-1.78	0.44	0.23
32	0.39	-0.05	-0.01	0.33	0.31	0.69	0.22	0.34	0.36	-0.01	4.49	0.95	0.71	0.45	0.35	-0.78
33	-0.49	-0.77	0.10	-0.64	-0.08	-0.38	-0.17	-0.56	-0.26	-0.67	0.09	-0.22	-0.41	-0.94	-0.53	-0.13
34-36	-0.01	0.16	-0.41	0.25	0.37	-0.01	0.21	-0.01	0.41	-1.38	0.17	0.20	0.10	0.39	-0.77	-0.20
37	-0.13	17.0	-0.29	-0.19	1.35	0.33	-0.42	0.53	0.46	-1.91	0.29	-0.83	0.64	1.51	-0.03	-0.40
Total	0.10	0.12	0.04	0.63	-0.23	-0.15	-0.16	0.16	0.27	0.16	0.51	0.45	-0.14	0.10	1.11	0.28

Table 5(e): Average Annual Rates of Scale Effect (SC) during 2001-02 to 2010-11 (Post-Reform Period: Decade 2)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.73	-0.10	0.12	0.03	0.20	0.13	-0.52	0	-0.07	-0.02	-0.03	0.15	-0.10	-0.02	-0.07	-0.63
23-26	0.52	-0.97	0.11	0.06	0.44	0.08	0.10	-0.06	0.06	-1.68	0.50	0.31	-0.15	0.30	-0.01	-0.41
27	0.22	0.18	0.52	0.48	0.71	0.19	0.19	-0.17	0.25	0.06	-0.23	1.04	0.41	0.51	0.39	0.09
28	-0.51	-0.41	-1.36	-0.54	-0.14	-0.51	0.35	-0.49	-0.29	0.57	0.28	-0.51	-0.40	-0.72	-0.34	0.11
30	0.17	1.57	-0.26	-0.04	0.27	0.48	-0.17	0.01	0.03	0.09	0.20	0.06	0	0.13	0.40	-0.21
31	1.94	-0.89	0.87	-1.25	2.31	0.82	1.48	2.86	0.78	0.77	0.95	1.32	2.24	2.04	0.65	1.13
32	-0.11	0.73	-0.15	0.25	0.50	0.89	0.66	0.64	0.29	0.95	0.37	0.40	0.33	0.60	1.10	-1.02
33	-0.07	0.46	-0.02	-0.32	0.13	-0.40	0.08	-0.18	-0.31	-0.80	0.67	0.56	0.14	0.10	0.09	-0.30
34-36	0.21	-8.22	0.62	0.68	0.15	0.85	-0.19	0.22	0.20	0.11	-0.03	1.04	0.19	0.50	0.21	-0.42
37	0.03	-0.36	0.90	2.13	0.35	0.67	0.09	0.53	0.28	1.16	-0.03	2.81	0.52	0.17	-0.03	-0.46
Total	-0.77	-0.13	0.28	0.62	-0.91	-0.18	-1.000	0.09	0.08	1.72	-1.48	-0.54	-0.97	-0.45	-0.42	0.11

Source: Authors' own calculation

S/I- States/Industries

Table 6(a): Average Annual Rate of Allocation Efficiency Change (AEC) during 1981-82 to 2010-11 (Entire Study Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	4.05	0.49	0.93	-0.05	0.10	-0.38	1.85	-0.99	0.23	-1.53	0.05	-0.89	0.46	1.31	0.82	2.86
23-26	-0.14	-1.91	-0.12	0.35	0.31	1.14	-0.31	0.67	0.54	-1.24	0.17	-0.12	0.85	-0.07	1.81	1.55
27	-0.98	-8.02	-0.92	-3.92	-16.4	-0.23	0.13	-6.98	-1.01	-11.4	-11.3	-6.36	0.07	-4.47	0.05	-0.36
28	-1.80	-25.0	0.28	-1.70	-1.24	-1.67	-0.95	-2.58	-0.84	-2.48	-4.42	-1.27	-2.70	-0.35	-2.01	-1.09
30	1.30	-13.2	4.07	0.01	1.12	0.25	-0.10	-0.84	2.28	-7.35	1.39	-1.13	-0.30	-2.31	-1.48	1.72
31	0.52	2.27	2.66	-0.40	2.46	-1.66	0.58	1.00	0.47	0.50	0.32	-0.75	1.02	-1.55	2.66	-1.52
32	0.85	0.50	0.95	0.93	1.50	1.36	2.02	0.86	1.91	0.76	-1.38	0.28	1.11	1.99	1.69	2.32
33	-4.90	0.78	-0.15	-2.38	-0.22	-0.88	-0.02	0.05	-0.67	-0.91	1.49	-0.46	-0.40	-1.03	0.32	-1.07
34-36	0.22	-7.39	-3.45	0.44	0.01	-0.35	-1.36	-0.75	0.81	-1.68	-0.42	-1.96	0.85	-0.42	0.11	2.58
37	-0.32	3.73	1.08	3.07	0.75	2.34	0.22	-0.27	2.37	-1.21	1.84	1.17	2.48	0.31	0.96	5.88
Total	2.57	-0.28	1.35	1.34	1.24	1.98	0.69	0.67	2.44	0.10	0.58	0.16	2.32	0.35	1.99	3.88

Table 6(b): Average Annual Rate of Allocation Efficiency Change (AEC) during 1981-82 to 1990-91 (Pre-reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	1.38	0.94	1.44	-0.21	-0.09	-0.58	-0.71	0.89	-0.28	-0.95	-0.05	-1.17	-0.08	2.16	-0.38	2.26
23-26	2.22	-3.10	-1.20	2.13	0.80	2.28	-0.20	1.99	1.49	0.17	1.37	0.21	1.74	1.54	3.91	2.86
27	0.42	0.16	0.11	-0.85	-1.36	-0.90	-4.46	-2.52	0.13	-34.1	2.17	-9.72	0.75	-1.67	2.39	-0.27
28	0.52	-81.8	-1.29	-0.37	-1.48	-2.43	-3.59	-1.75	-0.14	-2.16	-6.32	0.40	-4.59	-0.38	0.10	-0.72
30	5.25	-18.1	3.74	-0.88	4.28	-0.49	0.07	-1.15	5.34	-15.7	3.45	-0.17	3.80	-5.85	-0.35	3.96
31	-0.57	4.32	0.68	-0.79	3.27	0.44	0.26	6.33	1.23	0.63	1.03	-2.62	2.57	-3.80	0.86	-0.60
32	1.84	1.35	-0.63	2.38	0.81	1.83	2.17	1.55	1.84	0.55	1.23	0.85	1.20	1.56	0.23	3.62
33	-13.5	2.83	-0.08	0.81	1.21	-1.04	2.11	-1.06	1.89	0.58	1.58	-0.73	0.05	1.55	2.72	-0.31
34-36	0.22	-2.17	-0.50	0.98	0.42	0.71	-0.64	0.33	1.69	-1.10	-0.63	-0.55	1.18	-0.08	1.83	2.69
37	-1.03	-0.88	-3.65	1.29	0.39	2.52	1.25	-0.06	3.11	-0.01	1.08	0.13	1.20	2.79	0.83	8.57
Total	1.28	-0.99	-0.16	0.93	-0.08	0.50	-0.08	-0.54	2.61	-1.16	0.06	-0.43	1.71	-1.03	2.48	3.25

Table 6(c): Average Annual Rate of Allocation Efficiency Change (AEC) during 1991-92 to 2010-11 (Post-reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	5.38	0.26	0.68	0.03	0.19	-0.28	3.13	-1.92	0.49	-1.81	0.10	-0.76	0.73	0.88	1.42	3.17
23-26	-1.32	-1.31	0.42	-0.55	0.06	0.57	-0.37	0.02	0.07	-1.94	-0.43	-0.29	0.41	-0.87	0.76	0.89
27	-1.67	-12.1	-1.44	-5.45	-23.9	0.10	2.42	-9.21	-1.57	-0.12	-18.0	-4.68	-0.27	-5.87	-1.12	-0.41
28	-2.96	3.36	1.07	-2.36	-1.12	-1.29	0.38	-3.00	-1.19	-2.64	-3.47	-2.11	-1.75	-0.33	-3.06	-1.27
30	-0.68	-10.7	4.24	0.45	-0.46	0.62	-0.18	-0.69	0.75	-3.17	0.36	-1.61	-2.35	-0.54	-2.04	0.60
31	1.06	1.25	3.65	-0.21	2.05	-2.70	0.74	-1.66	0.09	0.44	-0.03	0.18	0.24	-0.43	3.55	-1.98

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
32	0.35	0.08	1.74	0.21	1.85	1.13	1.94	0.52	1.94	0.87	-2.68	0	1.07	2.20	2.42	1.67
33	-0.59	-0.25	-0.18	-3.97	-0.93	-0.80	-1.08	0.60	-1.95	-1.66	1.44	-0.33	-0.63	-2.33	-0.88	-1.46
34-36	0.23	-10.0	-4.92	0.17	-0.19	-0.88	-1.72	-1.29	0.37	-1.97	-0.31	-2.67	0.69	-0.59	-0.74	2.53
37	0.04	6.04	3.45	3.96	0.94	2.25	-0.30	-0.37	2.00	-1.81	2.22	1.69	3.11	-0.93	1.03	4.54
Total	3.22	0.07	2.11	1.54	1.89	2.72	1.07	1.27	2.36	0.73	0.84	0.45	2.63	1.03	1.74	4.19

Table 6(d): Average Annual Rate of Allocation Efficiency Change (AEC) during 1991-92 to 2000-01 (Post-Reform Period: Decade 1)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	4.63	-0.34	1.17	-0.85	-0.37	-0.54	4.82	-3.71	0.07	-3.04	-0.55	-2.22	0.28	0.94	1.28	2.78
23-26	-1.74	1.16	0.95	-1.41	0.51	0.95	0.54	-0.23	0.85	-2.19	-0.58	-0.23	0.53	-1.60	0.40	1.58
27	-1.49	-13.6	-2.62	-6.98	-46.6	-0.56	3.29	-12.5	-2.42	-0.37	-29.0	-8.97	1.39	-9.44	0.51	-1.00
28	-4.96	6.98	1.85	-4.27	-1.92	-2.65	0.63	-5.17	-2.08	-4.14	-2.32	-3.55	-2.91	-0.33	-2.78	-1.83
30	-0.93	-22.8	-2.59	0.81	-1.00	-0.03	0.56	-0.85	0.95	-3.04	0.74	-4.50	-4.87	-0.94	-1.71	1.06
31	1.87	6.34	3.16	-0.29	1.23	-5.58	-0.18	-0.57	-0.17	-0.66	-0.10	0.13	-0.32	-2.27	4.42	-3.09
32	0.09	-0.21	3.86	0.66	1.16	0.06	0.19	0.55	2.79	0.65	-3.04	-1.14	0.77	2.49	2.73	2.49
33	-1.88	-0.52	-0.10	-8.02	-0.63	-1.14	-0.79	0.23	-2.33	-2.84	2.03	-1.04	-1.18	-3.88	-1.92	-1.60
34-36	-0.27	0.10	-5.22	0.21	0.03	-0.17	-0.88	-2.20	0.19	-2.37	-0.29	-3.26	0.64	-1.00	-1.30	2.97
37	0.06	12.3	2.68	2.84	1.94	3.27	-1.47	-1.22	3.32	-3.69	2.08	0.78	4.96	-0.40	-0.08	7.20
Total	-0.53	1.45	1.07	1.45	1.31	2.27	0.25	0.10	1.83	-0.53	-0.99	-1.01	1.69	0.95	-0.18	3.22

Table 6(e): Average Annual Rate of Allocation Efficiency Change (AEC) during 2001-02 to 2010-11 (Post-Reform Period: Decade 2)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	6.13	0.87	0.18	0.92	0.75	-0.02	1.44	-0.14	0.91	-0.58	0.74	0.71	1.18	0.82	1.56	3.55
23-26	-0.89	-3.79	-0.11	0.32	-0.39	0.20	-1.28	0.26	-0.72	-1.69	-0.27	-0.35	0.28	-0.15	1.13	0.20
27	-1.86	-10.6	-0.25	-3.92	-1.16	0.75	1.56	-5.92	-0.73	0.13	-6.94	-0.39	-1.94	-2.29	-2.76	0.18
28	-0.96	-0.26	0.28	-0.45	-0.31	0.07	0.12	-0.82	-0.30	-1.14	-4.62	-0.66	-0.59	-0.34	-3.34	-0.70
30	-0.43	1.29	11.1	0.10	0.08	1.27	-0.93	-0.53	0.55	-3.29	-0.03	1.27	0.17	-0.13	-2.37	0.15
31	0.24	-3.84	4.14	-0.12	2.87	0.17	1.65	-2.75	0.35	1.54	0.03	0.23	0.80	1.40	2.69	-0.88
32	0.61	0.37	-0.39	-0.24	2.54	2.20	3.70	0.49	1.09	1.10	-2.32	1.15	1.36	1.91	2.11	0.84
33	0.70	0.03	-0.25	0.08	-1.24	-0.46	-1.37	0.96	-1.57	-0.47	0.85	0.37	-0.07	-0.77	0.16	-1.31
34-36	0.72	-20.1	-4.62	0.14	-0.41	-1.59	-2.56	-0.39	0.55	-1.56	-0.33	-2.08	0.73	-0.18	-0.19	2.09
37	0.01	-0.19	4.21	5.08	-0.06	1.22	0.86	0.48	0.67	0.07	2.35	2.60	1.27	-1.46	2.13	1.88
Total	6.97	-1.30	3.15	1.63	2.48	3.16	1.90	2.45	2.90	20	2.67	1.91	3.57	1.12	3.67	5.17

Source: Authors' own calculation
S/I- States/Industries

Table 7(a): Average Annual Rate of Total Factor Productivity Growth (TFPG) during 1981-82 to 2010-11 (Entire Study Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	1.73	1.55	3.28	2.54	2.82	3.04	-1.38	1.55	2.98	0.24	2.15	2.52	1.92	3.82	2.30	2.87
23-26	2.15	-1.29	1.97	2.08	2.84	3.08	1.69	2.68	2.21	0.18	2.53	1.87	2.39	1.81	3.38	2.68
27	0.77	-9.60	-3.10	-3.38	-15.0	0.50	-0.48	-5.79	1.25	-10.3	-12.1	-5.50	-0.89	-1.28	0.68	1.30
28	0.99	-15.3	3.98	0.44	1.93	1.70	2.42	-0.59	0.99	1.64	2.74	2.27	-0.67	2.11	-0.16	0.69
30	3.72	-3.59	6.29	1.58	3.94	4.81	2.43	4.12	4.27	-1.92	5.03	1.13	0.10	0.07	2.10	2.85
31	2.00	0.87	6.31	1.24	1.61	-1.10	0.97	-1.58	3.44	-5.99	-1.05	-3.92	2.37	-0.87	2.94	4.18
32	4.38	1.88	3.78	2.47	4.24	4.30	5.03	3.06	4.10	3.71	1.19	2.55	2.43	4.01	3.99	3.80
33	-3.37	0.04	4.19	-1.55	-0.10	0.64	-0.54	2.45	0.53	-0.39	1.16	1.22	1.09	1.26	-1.08	2.18
34-36	3.49	-6.79	0.21	3.90	3.57	3.36	1.80	2.82	3.68	1.60	3.21	2.16	3.66	3.54	2.55	3.77
37	3.25	11.2	4.22	6.24	4.27	5.49	4.58	4.05	5.06	3.24	4.08	5.76	5.16	3.87	2.41	6.62
Total	4.12	3.56	4.87	3.73	3.46	3.87	2.39	4.08	4.77	3.26	2.85	3.52	3.06	3.92	3.41	3.70

Table 7(b): Average Annual Rate of Total Factor Productivity Growth (TFPG) during 1981-82 to 1990-91 (Pre-Reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	4.00	7.02	7.38	6.73	6.44	6.65	1.54	6.14	6.99	5.49	6.97	6.81	5.88	7.81	5.70	6.86
23-26	3.10	-3.08	-1.00	2.66	2.23	3.34	0.24	2.79	2.10	3.02	2.86	1.65	2.39	2.15	3.21	2.93
27	5.39	3.61	1.56	1.76	1.72	2.35	-2.32	0.79	2.99	-30.5	4.55	-7.79	2.13	1.78	4.14	3.76
28	4.41	-58.7	-0.40	3.69	2.67	2.77	0.80	2.43	2.56	1.42	9.68	5.59	-1.14	3.91	2.92	2.81
30	7.18	-3.22	3.23	-0.28	5.86	7.84	0.72	7.83	7.43	-16.5	8.91	6.28	3.95	-3.64	5.23	4.13
31	5.07	5.51	15.0	3.66	6.05	4.94	4.55	6.86	8.32	-9.33	4.95	-6.23	8.05	0.6	5.23	9.32
32	7.62	-0.29	2.23	3.23	0.40	4.26	3.94	3.41	3.18	3.36	1.58	2.52	2.35	3.37	1.18	3.88
33	-17.2	3.17	6.09	1.76	1.77	0.83	2.06	1.99	3.45	3.89	2.37	0.24	1.07	3.91	1.15	3.55
34-36	2.90	2.12	0.33	3.51	2.78	3.31	1.67	3.03	3.19	2.23	3.01	2.23	3.14	3.50	2.84	3.87
37	4.40	-1.37	-0.20	4.21	4.61	5.28	5.95	4.76	5.53	4.82	3.24	3.46	3.45	4.86	2.31	8.47
Total	3.82	6.03	5.77	4.53	4.64	5.27	3.95	5.73	6.15	5.67	4.03	5.87	4.87	5.02	4.40	4.84

Table 7(c): Average Annual Rate of Total Factor Productivity Growth (TFPG) during 1991-92 to 2010-11 (Post-reform Period)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	0.59	-1.19	1.24	0.44	1.01	1.23	-2.84	-0.74	0.97	-2.39	-0.27	0.37	-0.05	1.82	0.60	0.87
23-26	1.67	-0.39	3.45	1.79	3.14	2.96	2.42	2.62	2.27	-1.24	2.36	1.98	2.40	1.64	3.47	2.56
27	-1.54	-16.2	-5.50	-5.96	-23.0	-0.40	0.45	-9.08	0.38	-0.21	-20.5	-4.36	-2.40	-2.81	-1.06	0.07
28	-0.71	6.46	6.19	-1.18	1.56	1.17	3.23	-2.09	0.21	1.75	-0.73	0.61	-0.43	1.21	-1.70	-0.37
30	1.99	-3.77	7.81	2.51	2.97	3.29	3.28	2.27	2.68	5.34	3.08	-1.44	-1.83	1.93	0.53	2.22
31	0.46	-1.46	1.97	0.03	-0.60	-4.10	-0.82	-5.79	1.01	-4.31	-4.05	-2.77	-0.47	-1.60	1.80	1.61
32	2.75	2.96	4.55	2.10	6.16	4.32	5.58	2.89	4.57	3.88	1.00	2.56	2.47	4.33	5.39	3.76
33	3.56	-1.52	3.25	-3.21	-1.10	0.54	-1.84	2.67	-0.94	-2.52	0.55	1.71	1.10	-0.06	-2.19	1.50
34-36	3.78	-11.2	0.15	4.09	3.96	3.38	1.87	2.72	3.93	1.28	3.31	2.13	3.92	3.56	2.41	3.72
37	2.68	17.5	6.44	7.26	4.09	5.60	3.89	3.69	4.82	2.45	4.50	6.91	6.02	3.38	2.47	5.70
Total	4.27	2.32	4.42	3.33	2.86	3.17	1.61	3.26	4.08	2.06	2.26	2.34	2.16	3.36	2.92	3.13

Table 7(d): Average Annual Rate of Total Factor Productivity Growth (TFPG) during 1991-92 to 2000-01 (Post-reform Period: Decade 1)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	-0.84	-1.13	2.30	0.91	0.56	1.39	-0.31	-1.52	1.68	-2.07	0.52	1.36	0.21	2.49	1.40	1.37
23-26	-0.40	3.25	1.53	0.10	3.30	2.96	2.57	1.93	2.00	-6.67	0.88	1.13	1.62	-0.43	2.43	2.14
27	-7.58	-26.1	-9.70	-9.82	-49.0	0.04	-4.79	-20.6	-2.98	-2.46	-34.9	-12.7	-4.52	-10.2	-5.79	-3.71
28	-2.61	12.0	8.97	-3.26	0.49	0.15	2.67	-2.09	-0.67	-1.26	-4.77	-2.64	-0.40	1.13	0.27	-0.63
30	0.53	-16.7	-9.80	1.23	-0.10	1.76	2.80	1.34	2.01	-2.86	2.67	-1.49	-5.26	-0.59	-0.83	1.05
31	0.94	1.48	0.72	1.46	-0.20	-14.0	-0.46	-0.40	1.97	-4.72	-2.48	-1.57	-0.07	-5.25	-3.59	0.61
32	5.05	2.04	5.77	2.17	5.52	3.83	3.45	3.40	5.40	2.82	3.48	1.75	1.05	5.65	5.58	4.65
33	2.95	-0.86	3.20	-6.60	0.62	-4.40	0.51	2.63	-6.38	-1.42	-3.54	1.16	-5.05	-3.36	-1.36	1.89
34-36	2.94	4.25	-1.50	2.97	3.80	2.87	2.45	0.72	3.27	0.68	3.61	1.24	3.09	1.88	0.18	2.76
37	1.88	32.6	4.82	-0.37	5.37	6.14	2.81	2.80	5.24	-2.01	3.24	-1.92	7.28	-0.47	-0.63	6.42
Total	1.79	1.07	2.77	3.12	3.47	2.29	1.71	3.10	3.87	2.33	2.05	2.56	1.53	3.28	1.55	2.40

Table 7(e): Average Annual Rate of Total Factor Productivity Growth (TFPG) during 2001-02 to 2010-11 (Post-reform Period: Decade 2)

S/I	A.P.	ASSAM	BIHAR	GUJ	HAR	KAR	KERA	M.P.	MAHA	ODISHA	PUN	RAJ	T.N.	U.P.	W.B.	IND
20-22	2.02	-1.25	0.17	-0.03	1.45	1.06	-5.37	0.04	0.26	-2.70	-1.05	-0.62	-0.32	1.15	-0.21	0.38
23-26	3.73	-4.03	5.36	3.48	2.98	2.95	2.26	3.32	2.53	4.19	3.84	2.83	3.17	3.71	4.50	2.98
27	4.50	-6.30	-1.20	-2.09	1.98	-0.90	5.69	2.40	3.74	2.05	-5.99	3.96	-0.29	4.57	3.68	3.85
28	1.18	0.97	3.41	0.90	2.62	2.18	3.78	-2.09	1.09	4.76	3.30	3.86	-0.46	1.30	-3.66	-0.12
30	3.45	9.14	25.4	3.79	6.08	4.82	3.77	3.19	3.35	13.5	3.50	-1.39	1.60	4.46	1.89	3.38
31	-0.02	-4.40	3.22	-1.41	-1.00	6.18	-1.19	-11.2	0.05	-3.90	-5.62	-3.97	-0.86	2.05	7.18	2.60
32	0.45	3.89	3.33	2.02	6.81	4.81	7.71	2.39	3.73	4.95	-1.48	3.38	3.89	3.01	5.20	2.87
33	4.17	-2.19	3.30	0.19	-2.70	5.45	-4.19	2.72	4.51	-3.63	4.63	2.26	7.25	3.23	-3.02	1.11
34-36	4.62	-26.7	1.83	5.22	4.13	3.90	1.29	4.71	4.59	1.89	3.02	3.02	4.76	5.24	4.63	4.68
37	3.48	2.38	8.05	14.9	2.82	5.06	4.98	4.58	4.40	6.90	5.75	15.7	4.75	7.23	5.57	4.97
Total	6.75	3.57	6.06	3.55	2.26	4.04	1.52	3.41	4.29	1.79	2.46	2.12	2.80	3.44	4.28	3.87

Source: Authors' own calculation
S/I- States/Industries

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Financial Performance of Nifty 50 Automobile Companies in India - An Empirical Comparative Analysis

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Abstract

The present study is mainly based on the secondary data and the data is collected from the annual report of selected company and websites of moneycontrol.com, BSE.com etc for the period of Ten years, which ended on 31st March. The period of the study is 2009-10 to 2018-19. Edward Altman's Z score, IGR and SGR under Du Pont analysis were used as dependent variables and profitability ratios, liquidity ratios, per share ratios, were applied as independent variables. Earlier studies applied EPS, DPS, ROCE and operating profit etc. (Suwaidan 2004, Shailesh 2013, Butalal Ajmera 2019). All the parameters have been analyzed with descriptive statistics, Karl Pearson's correlation, Friedman test and coefficient of determination applied for its validity. EPS, DPS and Net Profit Margin have a positive impact on IGR at 84.9% (R Square). EPS, DPS, Net profit Margin, Current ratio, Quick ratio, Enterprise value/ Operating revenue and Price/Book value per share have a positive impact on SGR at 82.1%. EPS, ROCE, BVPS, NP Margin, Asset turnover and Current ratio have a significant impact at 0.01 levels and Quick ratio and Price/Book value per share have significant impact on Altman Z score at 0.05 levels of selected Nifty 50 automobile companies in India for the study period.

Keywords: Altman Z Score, DuPont Analysis of IGR and SGR and Automobile Industry

Introduction

Financial Performance

Company analysis is an issue of Economy-Industry-Company analysis sequence. Financial analysis starts with a historical analysis of incomes and dividend and its growth rates. Growth of economy depends on growth and development of industry sector. The literature review of Grifin and Mahon (1997) stated that the most popular financial measures are size, ROA, ROE, asset age and 5 years ROS. Bert Scholtens (2006), Brammer et al. (2006) measured financial performance based on Profit after Tax and Market capitalization as stock market performances. Fiori et al. (2009) financial performance be measured based on profitability, solvency, liquidity and repayment capacity. Theofanis Karagiorgos (2010) measured financial performances based on total sales, total assets, number of employees and risk and also measured stock return based on market capitalization. Zhi Tang et al. (2011) measured financial performances based on ROA. Babalola et al. (2012) in Nigeria, Swati Goyal in India measured financial performances based on Profit After Tax. Evelyn Setiawan et al. (2012) measured financial performances based on ROI and size measured by Total Sales and leverage measured by Total debt to Total Equity. Butala Ajmera (2019) measured based on EPS, DPS, ROCE etc.

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Financial Performance under Du-Pont Analysis

Return on Investment (ROA) is Profit margin * Assets turnover. ie PAT/Sales * Sales/Total Assets. When the investment turnover is multiplied by the Net profit ratio, the product is known as ROI. This pattern is also known as DU PONT Analysis.

Return on Equity is ROA * Equity multiplier. I e PAT/ Sales * Sales/Total Asset* Total Asset/ Shareholder Fund. (PAT/SHF)

Measuring the Growth of the Firm

Internal Growth rate (IGR) is ROA * b/1 – ROA * b, where b is retention rate. Retention rate is 1- Dividend payout ratio, where Sustainable growth rate(SGR) is ROE * b/ 1 – ROE * b

Altman Z Score

Edward Altman published formulae to access the probability that a firm will measure financial health. Z score includes five easily derived business ratios, weighted by coefficients. Edward Altman's Z score was calculated and used as financial performance parameter. (Z score = $1.20 X_1 + 1.40X_2 + 3.30X_3 + 0.60X_4 + 0.99X_5$, where X_1 is working capital/Total Assets, X_2 is Retained earnings/Total Assets, X_3 is EBIT/Total Assets, X_4 is Market Capitalization/Total Value of Liability and X_5 is Sales/Total Assets).

Table 1: Standard Z Score Parameters

Situation	*Z Score*	*Zones*	
I	Below 1.80	Bankruptcy Zone	Failure is certain
II	Between 1.80 -2.99	Healthy Zone	Uncertain to Predict
III	Above 2.99	Too Healthy Zone	Not to Fall

Source: Dr Shiv Prasad and Dr Veena Kumari, Indian Journal of Accounting (June 2013)

Review of Literature

Akinmulegun Sunday Ojo (2012) empirically examined the effect of financial leverage (measured by Debt-Equity ratio) on Earnings per Share (EPS) and Net Assets per Share (NAPS). Author used panel data on effect of leverage on performance indicators of some corporate firms in Nigeria during 1993 and 2005 and employed econometric technique of Vector Auto Regression (VAR) on the variables and found that leverage shock on EPS indirectly affect the NAPS. Leverage therefore significantly affects Corporate Performance.

Singh (2012) examined working Capital Ratio, Sales to Total Asset ratio, Cash conversion cycle and applied Karl Pearson's coefficient correlation and Regression analysis based on pooled observations and concluded that working capital turnover ratio, Sales to Total Assets ratio and ROCE has positive significant relationship with profitability of both IT and Telecom Industry in India and also observed that Telecom industry is operating below average so far as working capital management concerned.

Shailesh et al. (2013) examined capital structure practices with its effect on profitability of top 5 pharmaceutical companies in India, listed on BSE for the period of 5 years and used operating profit margin ratio, ROCE, RONW and Debt Equity ratio and applied Regression analysis and found that profitability of selected firms in India, is insignificant in bringing any changes in their Capital structure.

Aparna et al. (2018) studied availability of number of economies for producing on a large scale and small size firms by availing the internal economies particularly, carried out to identify whether these internal economies derived from different functional areas are truly enjoyed or not and selected 9335 public limited companies under seven categories for ther period of three years from 2014-2016 and applied Analysis of Variance, concluded that greater difference among the different categories of public limited companies with respect to their profitability, expenditure and turnover positions.

Chandrakumar Mangalam (2010) studied the impact of financial leverage, Operating leverage and combined leverage on EPS of the Indian companies. Author concluded that there is a significant relationship between degree of operating leverage, degree of financial leverage and combined leverage and positive significance between degree of financial leverage and EPS.

Shiv Prasad et al. (2013) examined financial health of ITDC, public sector undertaking in India and concluded that the financial health was in the too healthy zone during 2007, 2008 and 2009, which have come to gray area due to recession in tourism sector, global crisis and terrorist attack at Mumbai.

Jothi Jayakrishnan et al. (2015) studied the relationship between fourteen capital structure determinants and its effects on capital structure of fifty chemical companies in India for the period of six years from 2000-2013 and concluded that profitability, uniqueness and manufacturing sources are the positive determinants, but tax and retained earnings are negative determinants of the capital structure of the selected chemical companies in India.

Butalal Ajmera (2019) used secondary data to analyze the relationship between financial leverage and earnings and dividend policy of selected steel companies in India, and applied correlation matrix and found that DPS has significant and positive relationship with ROCE, DPR and Ke and concluded that DPS has insignificant impact on independent variables, but DPS has been negatively affected by degree of financial leverage.

Statement of the Problem

This study was descriptive in nature and expands the comparative knowledge in the area of Du Pont Analysis and Altman Z score of selected nifty 50 automobile companies have significant impact on financial performance is the considerable attention. In this study Profitability ratios, Liquidity ratios and Per share ratios were treated as other financial independent variables and IGR, SGR and Altman Z score were used as dependent financial variables. A comparative empirical study has been applied with these financial variables to what extent these independent variables impact on dependent variables of selected companies in India for the period ended from 31st March 2010 to 31st March 2019.

Objectives of the Study

- To Calculate the Internal Growth Rate (IGR) and Sustainable Growth Rate (SGR) under Du Pont analysis of selected companies.
- To determine the Altman Z score of selected companies.
- To find any relationship between Altman Z score and Du Pont growth rates.
- To determine whether independent variables have any cause and effect impact on IGR, SGR and Altman Z score of selected Nifty 50 Automobile companies in India.

Research Methodology

The study is based on secondary data consists of the annual reports of selected companies collected through moneycontrol.com for the 10 years period from 31st March 2010 to 31st March 2019. Various reports like magazines, published books and web sites were also referred for the present study.

IGR and SGR under Du Pont analysis and profitability ratios, Liquidity ratios and per share ratios were used as modern financial variable instead of other financial variables like operating profit ratio, ROCE etc. (Suwaidan 2004), Adam Lindgreen et al. (2008), Jain Neeta et al., Zhi Tang et al. (2010) Md Abdur Rouf (2011), Yaghoub Alavi Matin et al. 2011 and Altman B model Dr Krishn Awatar (2019). For the analysis Mean, Standard Deviation, one sample t test, Correlation coefficients and regression analysis have been applied for its validity.

Analysis and Interpretations

Table 2: Descriptive Statistics

Nifty 50-Automobiles	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	53	11.5092	6.47598	0.957	0.327
Sustainable Growth Rate	53	21.3051	15.45703	1.823	0.327
Earnings Per Share	60	128.4628	150.90340	2.492	0.309
Dividend Per Share	60	38.9783	35.51824	0.721	0.309
Book Value Per Share	60	468.6048	486.73185	2.392	0.309
Return on Cap Employed	60	24.7505	16.82412	0.207	0.309

Nifty 50-Automobiles	N	Mean	Std. Deviation	Skewness	
NP Margin	60	10.2975	6.80007	-0.760	0.309
Asset Turnover	60	135.8392	50.68032	0.444	0.309
Altman Z Score	60	5.4007	2.59711	1.608	0.309
Current Ratio	60	1.1963	0.61787	0.706	0.309
Quick Ratio	60	.9872	0.60135	0.795	0.309
Inventory Turn-over Ratio	60	21.7375	10.29169	0.191	0.309
Enterprise Value/ Operating Rev-enue	60	3.0683	2.52740	2.133	0.309
Price/Book Value	60	6.5658	5.47473	2.620	0.309
Valid N (listwise)	53				

The above Table 2 shows that the Mean value of IGR is 11.5092 and SGR is 21.30. Hero motors, Eicher motors and Bajaj auto Ltd has higher mean value than the Nifty 50 auto. The Mean value EPS is 128.46, where Eicher motors, Hero Motors and Maruti Suzuki Ltd has higher than the average level. Mean value of DPS is 38.97, where Bajaj auto, Eicher and Hero motors has the higher value. Mean value of BVPS is 468.60, where Eicher and Maruti Ltd has the higher value. Mean value of ROCE is 24.75, where Bajaj auto, Eicher and Hero motors has the higher value. Mean value of NPM is 10.29, where Bajaj auto, Eicher and Hero motors has the higher value. Mean value of ATR is 135.84, where Bajaj auto, Hero motors and Maruti Suzuki Ltd has the higher value. Mean value of Altman Z Score is 5.40, where Bajaj auto, Eicher and Hero motors has the higher value. i.e these companies were financially sound.

Null Hypothesis-1: That there is no any significant relationship between IGR, SGR with Altman Z score of selected companies in India.

Table 3: Correlation Co-efficient of Selected Dependent Variables

		Internal Growth Rate	Sustainable Growth Rate
Sustainable Growth Rate	Pearson Correlation	0.874**	
	Sig. (2-tailed)	0.000	
Altman Z Score	Pearson Correlation	0.777	0.594
	Sig. (2-tailed)	0.000	0.000

Table 3 shows that IGR has positive significant relationship with SGR and Altman Z Score at 0.01 levels and at the same time SGR also has significant positive relationship with Altman Z score at 0.01 levels. Hence, rejected the null hypothesis and stated that there is significant relationship between IGR, SGR with Altman Z score of Nifty 50 automobile companies in India.

Null Hypothesis-2: That there is no any significant relationship between the dependent and independent variables of Nifty 50 companies in India.

Table 4: Correlation Co-efficient of Selected Independent Variables

Variables		IGR	SGR	Altman Z Score	Results 1	Results 2	Results 3
Earnings Per Share	Correlation	0.873	0.375	0.681	Yes	Yes	Yes
	Significance	**0.000**	**0.006**	**0.000**			
Dividend Per Share	Correlation	0.531	0.280	0.509	Yes	Yes	Yes
	Significance	**0.000**	**0.042**	**0.000**			
Book Value Per Share	Correlation	0.367	0.091	0.298	Yes	No	No
	Significance	**0.000**	**0.516**	**0.021**			
Return on Capital Employed	Correlation	0.749	0.676	0.578	Yes	Yes	Yes
	Significance	**0.000**	**0.000**	**0.000**			
Net Profit Margin	Correlation	0.767	0.609	0.703	Yes	Yes	Yes
	Significance	**0.000**	**0.000**	**0.000**			
Asset Turnover	Correlation	0.310	0.300	0.183	Yes	Yes	No
	Significance	**0.024**	**0.029**	**0.162**			

Variables		IGR	SGR	Altman Z Score	Results		
					1	2	3
Current Ratio	Correlation	0.239	0.021	0.122	No	No	No
	Significance	**0.085**	**0.882**	**0.351**			
Quick Ratio	Correlation	0.279	0.037	0.172	Yes	No	No
	Significance	**0.043**	**0.794**	**0.189**			
Inventory Turnover Ratio	Correlation	0.328	0.227	0.230	Yes	No	No
	Significance	**0.016**	**0.102**	**0.076**			
Enterprise Vale/Operating Revenue	Correlation	0.466	0.362	0.467	Yes	Yes	Yes
	Significance	**0.000**	**0.008**	**0.000**			
Price/Book Value Per Share	Correlation	0.620	0.599	0.576	Yes	Yes	Yes
	Significance	**0.000**	**0.000**	**0.000**			

Table 4 shows that all the selected independent variables have positive and significant relationship with IGR (except Current ratio), SGR (except BVPS, Current ratio, Quick ratio and Inventory turnover ratio) and Altman Z score (except Asset Turnover and Liquidity ratios) at 0.05 levels.

Null Hypothesis-3: That there are no any significant differences between the selected independent variables of Nifty 50 companies in India.

Table 5: Ranks

	Mean Rank
Earnings Per Share	8.43
Dividend Per Share	6.82
Book Value Per Share	10.70
Return On Capital Employed	6.75
NP Margin	5.02
Asset Turnover	9.90
Current Ratio	2.37
Quick Ratio	1.42
Inventory Turnover Ratio	6.77
Enterprise Value/Operating Revenue	3.37
Price/Book Value	4.47

Table 6: Test Statistics[a]

N	60
Chi-Square	492.654
df	10
Asymp. Sig.	0.000

a. Friedman Test

Friedman test statistics proved that the independent variables has significant at 0.01 levels and rejected null hypothesis and concluded that there are significant differences between the selected independent variables.

Null Hypothesis-4: The independent variables have no any impact on IGR, SGR and Altman Z score of selected Nifty 50 automobile companies In India.

Table 7: Co-efficient Results of Nifty 50 (Automobile)

Variables	Model Summary		ANOVA		Standardized Coefficient		
	R	R Square	F	Sig	IGR	SGR	Altman Z Score
(Constant) IGR	0.922	0.849	21.024	**0.000**	**0.049**		
(Constant) SGR	0.906	0.821	17.047	**0.000**		**0.041**	
(Constant) Altman Z score	0.948	0.898	38.505	**0.000**			**0.013**
Earnings Per Share					**0.014**	**0.020**	**0.000**
Dividend Per Share					**0.000**	**0.000**	**0.655**
Book Value Per Share					0.306	0.739	**0.000**
Return on Capital Employed					0.229	0.572	**0.000**

Variables	Model Summary		ANOVA		Standardized Coefficient		
	R	R Square	F	Sig	IGR	SGR	Altman Z Score
Net Profit Margin					**0.012**	**0.024**	**0.000**
Asset Turnover					0.243	0.567	**0.000**
Current Ratio					0.567	**0.014**	**0.009**
Quick Ratio					0.544	**0.019**	**0.010**
Inventory Turnover Ratio					0.998	0.782	0.554
Enterprise Vale/Operating Revenue					0.272	**0.003**	0.981
Price/Book Value Per Share					0.191	**0.002**	**0.019**

Table 7 showed that the f value of IGR is 21.024 and significant at 0.01 levels and proved that EPS, DPS and Net Profit Margin has positive impact on IGR at 84.9% (R Square). F value of SGR is 17.047 and has significant with predictors at 0.01 levels. EPS, DPS, Netprofit Margin, Current ratio, Quick ratio, Enterprise value/Operating revenue and Price/Book value per share have positive impact on SGR at 82.1% of selected companies in India. F value of Altman Z score is 38.505 and is significant at 0.01 levels. EPS, ROCE, BVPS, NP Margin, Asset turnover and Current ratio have significant impact at 0.01 levels and Quick ratio and Price/Book value per share have significant impact at 0.05 levels on Altman Z score and these variables has influences to the extent of 89.8% of selected Nifty 50 automobile companies in India.

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Annexure

Table 8: Descriptive Statistics

Bajaj Auto Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
	Statistic	*Statistic*	*Statistic*	*Statistic*	*Std. Error*
Internal Growth Rate	10	15.5180	6.84816	1.231	0.687
Sustainable Growth Rate	10	31.3590	23.05394	1.343	0.687
Earnings Per Share	10	122.1510	20.00187	0.751	0.687
Dividend Per Share	10	50.0000	7.45356	0.000	0.687
Book Value Per Share	10	401.5440	205.85325	0.594	0.687
Return on Cap Employed	10	35.8690	11.01390	1.722	0.687
NP Margin	10	16.1020	2.00585	0.802	0.687
Asset Turnover	10	138.2240	26.74034	0.227	0.687
Altman Z Score	10	5.7910	0.64714	-0.478	0.687
Current Ratio	10	1.5430	0.74033	0.424	0.687
Quick Ratio	10	1.4010	0.66807	0.718	0.687
Inventory Turnover Ratio	10	30.0530	2.36216	-0.259	0.687
Enterprise Value/Ope.Revenue	10	2.8420	0.38632	1.365	0.687
Price/Book Value	10	6.2920	2.00761	0.636	0.687
Eicher Motors Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	8	17.7838	7.89078	0.181	0.752
Sustainable Growth Rate	8	31.6888	16.36196	0.382	0.752
Earnings Per Share	10	321.8220	271.96974	0.358	0.687
Dividend Per Share	10	56.2000	47.51327	0.322	0.687
Book Value Per Share	10	824.6880	891.18927	1.171	0.687
Return on Cap Employed	10	34.2870	18.73377	-0.499	0.687
NP Margin	10	18.7590	2.52498	-0.651	0.687
Asset Turnover	10	102.4130	45.43454	-1.097	0.687
Altman Z Score	10	9.2700	3.30724	0.704	0.687
Current Ratio	10	1.3390	0.81961	0.152	0.687
Quick Ratio	10	1.1440	0.77357	0.373	0.687
Inventory Turnover Ratio	10	15.3250	6.57720	-1.294	0.687
Enterprise Value/Ope.Revenue	10	7.4580	3.43969	-0.651	0.687
Price/Book Value	10	13.8890	9.31380	0.751	0.687
Hero Motors Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	9	11.6700	4.00620	-0.363	0.717
Sustainable Growth Rate	9	21.7944	13.55605	1.337	0.717
Earnings Per Share	10	134.3120	32.08289	0.528	0.687
Dividend Per Share	10	78.4000	21.37600	0.050	0.687
Book Value Per Share	10	353.2150	174.97970	0.590	0.687
Return on Cap Employed	10	41.7310	7.13517	2.331	0.687
NP Margin	10	10.4300	1.73638	0.915	0.687
Asset Turnover	10	217.3070	31.25872	0.169	0.687
Altman Z Score	10	6.4860	0.86791	-0.676	0.687
Current Ratio	10	1.3800	0.45605	-0.008	0.687
Quick Ratio	10	1.2230	0.40749	0.203	0.687
Inventory Turnover Ratio	10	37.3500	3.68351	0.263	0.687

Hero Motors Ltd	N	Mean	Std. Deviation	Skewness	
Enterprise Value/Ope.Revenue	10	1.8820	0.33092	-0.314	0.687
Price/Book Value	10	7.7580	2.26410	0.075	0.687
Mahindra & Mahindra Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	10	9.0390	1.43319	0.026	0.687
Sustainable Growth Rate	10	17.6380	5.26360	0.062	0.687
Earnings Per Share	10	46.9490	10.65503	-0.003	0.687
Dividend Per Share	10	11.3500	2.13503	-0.812	0.687
Book Value Per Share	10	274.1290	94.48947	0.466	0.687
Return on Cap Employed	10	16.4200	2.22296	-0.518	0.687
NP Margin	10	9.1700	1.20447	1.221	0.687
Asset Turnover	10	119.1400	14.14926	0.761	0.687
Altman Z Score	10	3.6630	0.15952	-0.701	0.687
Current Ratio	10	1.1660	0.11983	-0.938	0.687
Quick Ratio	10	.8900	0.12841	-0.919	0.687
Inventory Turnover Ratio	10	15.3240	1.42218	0.504	0.687
Enterprise Value/Ope.Revenue	10	1.6240	0.20956	-0.604	0.687
Price/Book Value	10	3.3330	0.52673	-0.457	0.687
Maruti Suzuki India Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	10	10.6170	2.57540	0.246	0.687
Sustainable Growth Rate	10	15.5930	3.71460	0.368	0.687
Earnings Per Share	10	144.1230	79.45527	0.546	0.687
Dividend Per Share	10	33.6000	32.21783	0.775	0.687
Book Value Per Share	10	852.5350	393.31291	0.708	0.687
Return on Cap Employed	10	17.6800	5.66068	0.406	0.687
NP Margin	10	7.7110	2.01207	-0.075	0.687
Asset Turnover	10	153.2600	21.76444	1.154	0.687
Altman Z Score	10	4.7520	0.48751	-0.114	0.687
Current Ratio	10	1.2100	0.61516	0.764	0.687
Quick Ratio	10	.9430	0.59311	0.728	0.687
Inventory Turnover Ratio	10	22.8680	3.01006	-0.454	0.687
Enterprise Value/Ope.Revenue	10	1.8270	0.82566	0.570	0.687
Price/Book Value	10	3.7820	1.34400	0.675	0.687
Tata Motors Ltd	*N*	*Mean*	*Std. Deviation*	*Skewness*	
Internal Growth Rate	6	1.8250	1.31995	0.205	0.845
Sustainable Growth Rate	6	5.6017	4.62483	0.712	0.845
Earnings Per Share	10	1.4200	15.67528	1.520	0.687
Dividend Per Share	10	4.3200	7.16795	1.756	0.687
Book Value Per Share	10	105.5180	96.27807	1.840	0.687
Return on Cap Employed	10	2.5160	7.39330	-1.883	0.687
NP Margin	10	-.3870	5.61482	-1.532	0.687
Asset Turnover	10	84.6910	15.21409	0.778	0.687
Altman Z Score	10	2.4420	0.42624	-0.194	0.687
Current Ratio	10	.5400	0.09274	-1.006	0.687
Quick Ratio	10	.3220	0.08917	-1.187	0.687
Inventory Turnover Ratio	10	9.5050	3.75892	-1.093	0.687
Enterprise Value/Ope.Revenue	10	2.7770	1.37989	0.764	0.687
Price/Book Value	10	4.3410	3.39512	1.360	0.687

Table 9: IGR and SGR Calculations (Consolidated)

1. Bajaj Auto Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	17.07	21.46	62.87	12.01	15.59
31-03- 2018	17.07	21.29	60.88	11.59	14.88
31-03- 2017	18.38	22.46	96.23	21.47	27.56
31-03- 2016	23.83	29.62	26.37	06.70	08.47
31-03- 2015	18.08	26.31	48.58	09.62	14.65
31-03- 2014	21.99	33.75	55.40	13.86	22.98
31-03- 2013	24.39	38.51	57.22	16.21	28.25
31-03- 2012	27.10	49.72	56.66	18.13	39.21
31-03- 2011	36.11	68.01	65.35	30.87	79.98
31-03- 2010	19.46	58.05	65.96	14.72	62.02

Internal Growth Rate = Average return on Asset * Average retention rate = 0.15518 * 0.5946 = 0.0922 or **09.22% AND Sustainable Growth Rate = Average Return on Equity * Ave retention rate** = 0.31359 * 0.5946 = 0999 or 18**.64%**

2. Eicher Motors Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	21.67	28.82	85.41	22.70	32.64
31-03- 2018	21.97	31.88	81.49	21.58	35.08
31-03- 2017	28.15	39.77	-	-	-
31-03- 2016	36.12	56.03	64.24	30.20	56.22
31-03- 2015	-	-	-	-	-
31-12- 2014	25.07	45.30	75.76	23.44	52.23
31-12- 2013	18.78	33.92	70.89	15.35	31.64
31-12- 2012	14.13	23.01	62.70	09.70	16.84
31-12- 2011	15.91	23.06	65.33	11.59	17.72
31-12- 2010	11.79	16.51	60.73	07.71	11.14

Internal Growth Rate = Average return on Asset * Average retention rate = 0.1778 * 0.7081 = 0.1259 or **12.59% AND Sustainable Growth Rate = Average Return on Equity * Ave retention rate** = 0.3618 * 0.7081 = 2243 **or 22.43%**

3. Hero Motors Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	19.18	26.32	43.95	09.19	13.07
31-03- 2018	22.08	31.41	54.09	13.56	20.45
31-03- 2017	22.98	33.39	48.56	12.56	19.34
31-03- 2016	25.38	39.42	54.11	15.91	27.11
31-03- 2015	22.67	36.47	49.78	12.71	22.17
31-03- 2014	20.88	37.66	38.41	08.72	16.90
31-03- 2013	21.96	42.31	43.44	10.46	22.50
31-03- 2012	24.04	55.43	62.22	17.58	52.53
31-03- 2011	17.97	65.21	-	-	-
31-03- 2010	26.18	64.41	01.59	04.34	02.08

Internal Growth Rate = Average return on Asset * Average retention rate = 0.1167 * 0.4401 = 0.0513 or **05.13% AND Sustainable Growth Rate = Average Return on Equity * Ave retention rate** = 0.2179 * 0.4401 = 0959 **or 09.59%**

4. Mahindra and Mahindra Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	09.10	14.01	80.57	07.90	12.71
31-03- 2018	09.18	14.37	78.76	07.79	12.76
31-03- 2017	09.11	13.60	76.92	07.52	11.68
31-03- 2016	09.02	14.29	73.58	07.11	11.74
31-03- 2015	10.08	17.25	77.56	08.47	15.45
31-03- 2014	12.01	22.39	77.06	10.19	20.85
31-03- 2013	12.21	22.88	76.2	10.25	21.11
31-03- 2012	12.03	24.08	73.35	09.67	21.44
31-03- 2011	13.62	26.46	73.48	11.11	24.13
31-03- 2010	12.78	26.72	73.68	10.38	24.51

Internal Growth Rate = Average return on Asset * Average retention rate = 0.0937 * 0.6842 = 0.0641 or **06.41% AND Sustainable Growth Rate = Average Return on Equity * Ave retention rate** = 0.1764 * 0.6842 =0.1207 **or 12.07%**

5. Maruti Suzuki India Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	11.91	16.25	67.79	08.84	12.37
31-03- 2018	13.00	18.49	70.66	10.11	15.02
31-03- 2017	14.34	20.17	85.62	14.00	20.87
31-03- 2016	12.79	17.95	85.93	12.34	18.23
31-03- 2015	11.06	15.65	79.66	09.66	14.24
31-03- 2014	09.11	13.26	86.98	08.60	13.03
31-03- 2013	08.94	12.87	89.90	08.74	13.08
31-03- 2012	07.33	10.76	86.75	06.79	10.29
31-03- 2011	12.42	16.50	90.54	12.66	17.55
31-03- 2010	15.18	21.10	83.07	14.43	21.25

Internal Growth Rate = Average return on Asset * Average retention rate = 0.1062* 0.8269 = 0.0878 or **08.78% AND Sustainable Growth Rate = Average Return on Equity * Ave retention rate** = 0.1559 * 0.8269 =1289 **or 12.89%**

6. Tata Motors Ltd

Year Ended on	ROA	ROE	Retention %	IGR	SGR
31-03- 2019	03.31	09.11	-	03.31	09.11
31-03- 2018	-01.74	-05.13	-	-	-
31-03- 2017	-04.12	-11.48	-	-	-
31-03- 2016	-00.10	-00.26	80.00	-	-
31-03- 2015	-09.48	-31.93	-	-	-
31-03- 2014	00.67	01.74	73.04	00.48	01.28
31-03- 2013	00.57	01.57	69.56	00.39	01.10
31-03- 2012	02.27	06.33	55.05	01.39	03.60
31-03- 2011	03.34	09.06	59.84	02.00	05.73
31-03- 2010	04.38	15.15	74.87	03.38	12.79

Table 10: Edward Altman's Z Score of Automobile Industry in India (Nifty-50)

Company Name	Year	X_1	X_2	X_3	X_4	X_5	Z Score
Bajaj Auto Ltd	2009-10	-0.087	0.445	0.894	2.040	1.361	**04.653**
	2010-11	-0.107	0.700	1.551	2.742	1.816	**06.702**
	2011-12	0.060	0.727	1.204	2.628	1.798	**06.417**
	2012-13	0.198	0.854	1.125	2.502	1.649	**06.328**
	2013-14	0.072	0.885	1.036	2.442	1.399	**05.834**
	2014-15	0.388	0.935	0.865	2.238	1.411	**05.937**
	2015-16	0.141	1.102	1.108	2.532	1.131	**06.014**
	2016-17	0.355	1.125	0.845	2.334	1.092	**05.751**
	2017-18	0.258	1.104	0.805	2.004	1.101	**05.272**
	2018-19	0.096	1.097	0.825	1.842	1.153	**05.013**
Eicher Motors Ltd	2009-10	-0.175	0.639	0.525	3.354	0.910	**05.253**
	2010-11	-0.144	0.939	0.726	3.120	1.158	**05.799**
	2011-12	0.602	0.918	0.733	3.054	1.386	**06.693**
	2012-13	0.435	0.823	1.168	4.595	1.723	**08.744**
	2013-14	0.335	0.749	1.778	5.438	2.100	**10.404**
	2014-15	0.158	0.757	1.917	10.761	2.090	**15.683**
	2015-16	-0.05	0.892	1.686	8.594	1.767	**12.934**
	2016-17	-0.262	0.984	1.359	7.527	1.297	**10.902**
	2017-18	0.050	0.959	1.122	5.942	1.179	**09.252**
	2018-19	0.306	1.048	1.089	3.545	1.076	**07.064**
Hero Motors Ltd	2009-10	-0.274	0.561	1.096	2.736	1.871	**05.991**
	2010-11	-0.026	0.381	0.763	1.764	1.812	**04.695**
	2011-12	0.058	0.600	0.964	2.490	2.396	**06.514**
	2012-13	0.113	0.721	0.868	1.926	2.484	**06.113**
	2013-14	0.134	0.770	0.875	2.706	2.524	**07.013**
	2014-15	0.159	0.865	1.046	3.000	2.643	**07.712**
	2015-16	0.184	0.896	1.175	2.862	2.326	**07.441**
	2016-17	0.274	0.960	1.046	2.634	1.950	**06.863**
	2017-18	0.323	0.980	1.033	2.544	1.764	**06.642**
	2018-19	0.270	1.020	0.938	1.740	1.930	**05.892**

Company Name	*Year*	X_1	X_2	X_3	X_4	X_5	*Z Score*
Mahindra and Mahindra Ltd	2009-10	0.062	0.647	0.591	1.134	1.139	**03.573**
	2010-11	-0.031	0.717	0.607	1.261	1.210	**03.764**
	2011-12	0.030	0.696	0.521	1.031	1.338	**03.616**
	2012-13	0.033	0.732	0.558	1.116	1.478	**03.917**
	2013-14	0.096	0.737	0.489	1.109	1.304	**03.735**
	2014-15	0.042	0.805	0.434	1.274	1.196	**03.751**
	2015-16	0.060	0.872	0.416	1.211	1.163	**03.722**
	2016-17	0.088	0.928	0.403	1.141	1.124	**03.684**
	2017-18	0.079	0.876	0.432	1.114	1.038	**03.539**
	2018-19	0.085	0.893	0.403	0.906	1.038	**03.325**
Maruti Suzuki Ltd	2009-10	-0.013	0.995	0.716	1.518	1.809	**05.025**
	2010-11	0.365	1.043	0.561	1.196	1.994	**05.159**
	2011-12	0.244	0.944	0.323	1.050	1.616	**04.177**
	2012-13	0.189	0.965	0.393	0.871	1.644	**04.062**
	2013-14	0.239	0.955	0.416	1.164	1.443	**04.217**
	2014-15	-0.021	0.983	0.498	2.000	1.499	**04.959**
	2015-16	-0.091	0.993	0.591	1.607	1.392	**04.492**
	2016-17	-0.103	0.991	0.647	2.135	1.358	**05.028**
	2017-18	-0.151	0.980	0.630	2.706	1.364	**05.529**
	2018-19	-0.034	1.022	0.554	1.920	1.393	**04.855**
Tata Motors Ltd	2009-10	-0.249	0.389	0.152	0.680	0.689	**01.661**
	2010-11	-0.177	0.501	0.092	0.880	0.877	**02.173**
	2011-12	-0.186	0.487	0.049	0.962	0.986	**02.298**
	2012-13	-0.252	0.496	0.049	0.987	0.849	**02.129**
	2013-14	-0.290	0.521	0.277	1.545	0.682	**02.735**
	2014-15	-0.283	0.399	0.155	2.129	0.719	**03.119**
	2015-16	-0.144	0.557	0.099	1.386	0.748	**02.646**
	2016-17	-0.178	0.487	0.221	1.609	0.745	**02.884**
	2017-18	-0.187	0.461	0.148	1.128	0.983	**02.533**
	2018-19	-0.191	0.494	0.228	0.586	1.124	**02.241**

(Source of variables from the annual reports of selected companies)

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Analysis of Factors that Affect Coffee Value Chain Development in the Upstream Supply Chain Members in Gudeya Bila District, Oromia, Ethiopia

Matiwos Ensermu*

Abstract

Purpose – The study analyzed factors that contributed for coffee value chain underdevelopment in the upstream supply chain members (farmers) in Ethiopia in terms of factors related to coffee value chain governance, coffee value redistribution among actors, and the level of government support to develop coffee value chain in the area. *Design/Methodology/Approach* – The survey of 202 respondents was made in East Wollega Zone, Gudeya Bila District, Ganda Gute Canco coffee farmers located in the West of Addis Ababa, Ethiopia. In addition, observation and two key informant interviews were made to triangulate the surveyed data from farmers to enable conclusion about coffee value chain development in the study area. *Findings* – The findings indicated that factors attributed to the underdevelopment of coffee value chain are mainly explained by: value chain governance dominance in the downstream coffee supply chain, lack of subsidy and hedging to coffee farmers, high logistics cost to market due to poor accessibility to road infrastructure to coffee farm site, long coffee cash-to-cash cycle time, low margin to farmers in the coffee value chain, no value addition to intrinsic coffee value chain up to export gate but increased price at downstream coffee value chain, and low level of mechanization and innovation. *Research Limitation/Implications* – The findings of the survey on reasons for coffee value chain underdevelopment are generalizable for other agricultural commodity value chain in Ethiopia and developing countries. *Practical Implications* – The way coffee value chain is governed in the upstream supply chain member can be optimized through policy intervention by government through coffee value chain development. Originality/value – The paper has significant contribution in terms of case observation in the area, and the way coffee value is redistributed among coffee supply chain members in the absence of governance.

Keywords: Coffee Value Chain, Subsidy, Hedging, Value Chain Governance, Coffee Farmers

Introduction

Logistics system should be built and led as a system instead of fragmented activities from source to end. The logistics system demands the coordination of inbound to outbound logistics activities. About 85% of all Ethiopians are employed in agriculture (Hanna & Stefan, 2015). However, Ethiopia stands in the extreme end of the continuum of value chain. Structurally, it means that the Ethiopian economy is mostly dependent on agricultural product of export commodities like coffee and sesame with little to no intrinsic value addition on the extreme left side of the continuum of value chain, and finished goods import like vehicle, edible oil on the extreme right side. The non-value addition of the export commodity (low value farm products) has negatively affected Ethiopia's trade balance with limited capacity to generate more export earning as compared to the high-end finished goods to be imported to Ethiopia. This requires restructuring the position of Ethiopia in the continuum of the value chain by focusing on transformation of agricultural commodities

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into finished goods (high value products) as a branded Ethiopian product in the international trade market and at the same time, the production of import substitute finished goods in the industrial parks through domestic assembly or domestic manufacturing of imported goods with local materials. This directly affects the way logistics functions are built across the value chain in the Ethiopian context to shift the value chain position of Ethiopia to the center through additional value-added services by logistics companies like third-party, fourth-party, and fifth-party logistics service providers (Matiwos, 2015).

To support Ethiopian coffee value chain, logistics function is also an important factor which should be developed in terms of infrastructure, regulation, and operation. The logistics function development mainly relies on the way Ethiopian economy is structurally developed. Ethiopian economy is mainly agriculture driven, which is underdeveloped in terms of many aspects; say low-value addition, low productivity, low mechanization, no automation (backward technology), low irrigation practice (from household to commercial scale or state farm), lack of innovation, small land size holdings by the household farmers with scattered location that hampers large scale production; little to no support by the government in terms of incentives to the household farmers, no subsidies, and no hedging from mostly natural risks to their agricultural products. This underdevelopment of the sector negatively affected the way Ethiopian economic structure is developed even if sustained double-digit economic growth is registered for more than a decade. This structural flaw in the economic development of Ethiopia is characterized by low value of agricultural products at the production site with low return and low wealth creation for the household farmers. Household coffee farmers are the ones who actually created the commodity value, contrary to no intrinsic value transformation with high wealth creation at the retail end of the agricultural products in Ethiopia. On the other side of the economy, developed agriculture should lead into developed industrialization in terms of transforming the inputs to outputs through value addition at manufacturing sites. Ethiopian economy is characterized by structural problems due to underdeveloped agriculture. The reason behind underdeveloped Ethiopian agriculture in the value chain is its complexity in terms of number of coffee supply chain as explained for example by (Alemayehu, 2014), as "coffee supply chain is for example, complex and small farmer's sale to local traders, local trader's sale to big coffee milers and exporters, after processing local trader sale to international exporters and primary cooperatives purchase a number of coffees and sale to cooperative union the union process it and sale to exporters on behalf of cooperatives".

A study made by Dubale (2018) also revealed that the absence of a license, lack of enough working capital, higher completion, and lack of trading experience are the main barriers of entry in the wheat market. In addition, the price of wheat production in the market is determined by the farmer, market through negotiation, and traders. In addition, long wheat value chain actors were also identified in the study made by Nefisa (2018) as: input suppliers, producers, rural assemblers, wholesalers, flour factories, retailers, primary cooperatives, bakeries, flour wholesalers, flour retailers, consumers, and supportive actors. For example, a study made by Matiwos (2015) on 'Teff' value chain analysis recommended on the need to govern teff value chain price via maximum price setting at retail shop and technology enabled tracking system.

In addition, the study made on '*Teff'* farmers' production and marketing constraints were double taxation, shortage of fertilizer and seed supply, price setting, and access to credit whereas that of teff traders were double taxation, absence of infrastructure, capital shortage, access to credit, farmer reluctance to sell, lack of demand, absence of storage facility, and absence of government support (Efa et al., 2016). On the other hand, based on large-scale primary surveys, we find significant changes in the last decade. First, there is increasing adoption of modern inputs (chemical fertilizer, improved varieties, and herbicides) by farmers, especially by those living close to urban centers. Second, quality demands are rising and there are important shifts from the cheap red varieties to the more expensive white ones. Third, we see an increasing willingness-to-pay for convenience in urban areas, as illustrated by the emergence of one-stop retail shops—that provide sales, cleaning, milling, and transport services—as well as by a sizable foodservice industry. Fourth, the share of rural-urban marketing, urban distribution, and milling margins in final retail prices are declining, indicating improved marketing efficiency over time (Minten, 2013). The actor making the biggest profit is the wholesaler. The farmers have a higher profit per kg of onions, but the fact that they only get three harvests per year makes the annual profit low. The wholesalers have (by far) the highest sale rate and the second highest profit per kg (Akalu & Durr, 2016). Furthermore, value chain development may need a multidimensional strategy of awareness creation between all stakeholders, specific nutrition-sensitive extension services, infrastructural and technical improvements, and market development as well as political support from the local to the national level (Hanna & Stefan, 2015). The low productivity of Ethiopian agriculture will persist in the near medium term unless there is a policy shift in the way the current agricultural operation is managed by the government. For example, the study by Dzomeku (2017) showed that factors which were responsible for quality deterioration of coffee in Ethiopia include variety, environmental conditions, agronomical practices, diseases and pest, post-harvest factors and poor marketing infrastructure, crop replacement, and adulteration of high-quality coffee. This is contrary to the behavior of Ethiopian government as it pursues developmental state where government plays an active and dominant role in key economic sectors. The study on fruits and vegetables also identified the following horticulture value chain challenges. The main drivers, bottlenecks, and potentials for the intensification and/or diversification of fruit and vegetable production include: on the supply side, seasonal constrained production systems, competition with cash crops (mainly coffee), crop damages through wild animals, lack of nutrition-sensitive farming systems, gender division in horticultural production, lack of research and extension supports, marketing problems, and non-availability of improved technologies; on the demand side, lack of awareness for nutritional issues, existence of underutilized crops, reluctance to consume indigenous fruits and vegetables, and low purchasing power; and on the intermediation side, technical problems with storage, processing and packaging, existence of weekly markets in the nearby towns but with inadequate infrastructure for perishable products, seasonal unavailability of products in the market (Hanna & Stefan, 2015). A study made by (Trienekens, 2011) revealed that major constraints for value chain upgrading in developing countries found to be: market access restrictions, weak infrastructures, lacking resources, and institutional voids. Similar study made by Ashenafi et al. (2016) in developing country (Ethiopia) on ‘*Warqe*’, which is a multipurpose perennial plant, domesticated and grown as a food crop only in Ethiopia identified major constraints in ‘*Warqe*’ value chain” as: poor information flow, poor transportation system, using perishable packaging, lack of cooperation between actors, a poor infrastructure such as road and warehouse services, and poor policies concerning the *warqe* market.

Research Methods

Description of Study Area

Location

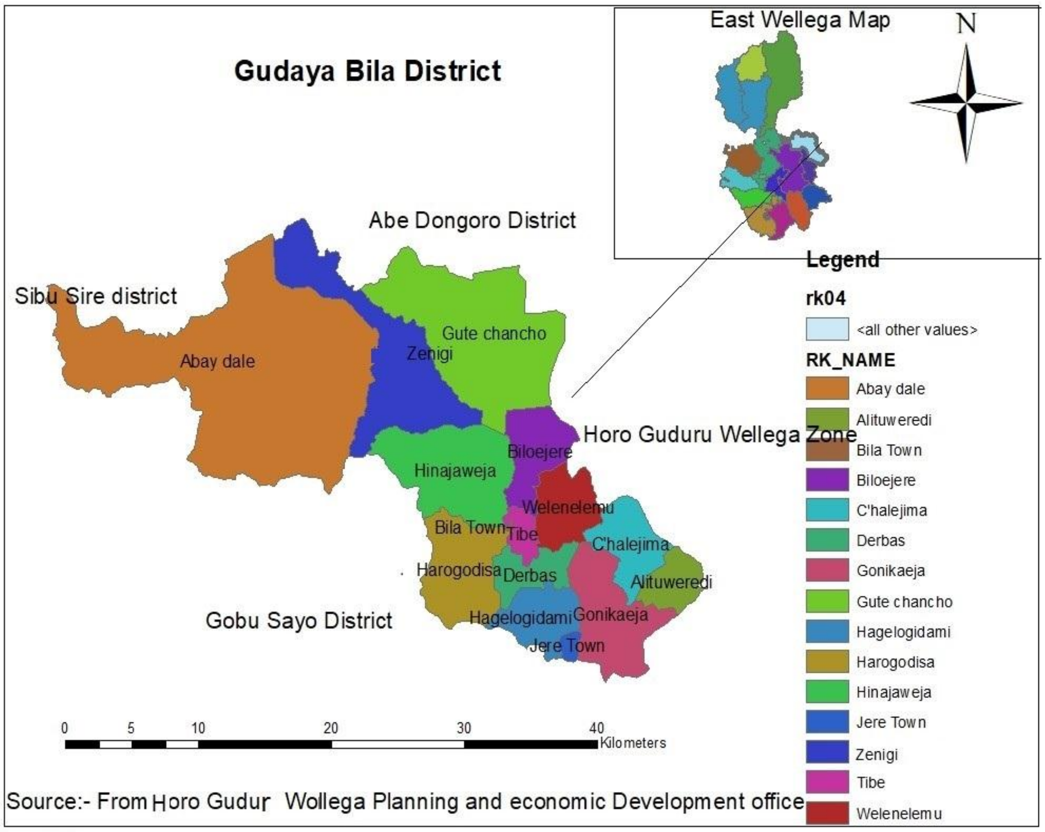
The study was conducted in *Gudeya Bila* District, Eastern *Wollega Zone*, Oromia, and Western Ethiopia of the coffee producing farmers. *Gudeya Bila* was found in the Western of Ethiopia in Oromia State. It is the recent district established in 2002. *Gudeya Bila* was situated at of 274-km West of Addis Ababa and it is 105 km far from Nekemte town and it was part of formerly named *Bila Sayo* district. It is bounded by *Abe Dongoro* district in the North, *Gobu Sayo* district in the South, Horo Guduru Wollega Zone in the East, and *Sibu Sire* district in the West. It was located at Longitude and Latitude of 9° 17’25” and 37°01’28” South and North, respectively[1]. The district has three-agro ecologies *Kola* 26.6%, *Weina Dega* 55.8%, and *Dega* 17.6%, (low land, mid land, and high land, respectively). Majority of the land possesses loam and clay loam soil type and some of sand, silt and clay soil type with well drainage. Generally, the climate of *Gudeya Bila* is very suitable for life, because of its high humidity and low-winds. Specifically, the district is endowed with natural resource around these areas, like *Bosona Bolale* (*Bolale* Forest) which has huge number of forests especially indigenous trees.

Gudeya Bila has different rivers used for irrigation purpose: like *Laga Gorochan, Laga Tokir, Llaga Jare, Laga Alaltu,* etc. However farming system of *Gudeya Bila* depends on rain-fed agriculture. Cereal crops growing are mostly maize, sorghum, teff, wheat, cash crops like

[1] Report of Eastern Wollega Zone, Gudeya Bila District, 2018

coffee, sesame, pulse (Niger), soya bean, haricot bean, fruits (banana, avocado, mango, Ttiringo, papaya, etc.), and vegetables (cabbage, onion, tomato, potato, sweet potato, *anchote,* beetroot, carrot, and pepper) are also cultivated in *Gudeya Bila* district. Around 3322 hectare of land was covered by coffee production by private farm and local farmers in the area. This area is famous for coffee production known with the brand name '*buna lagie'* or *lagie* coffee.

Map of the Study Area



Source: Gudeya Bila District Coffee and Tea Plantation report, 2019

Fig. 1: Map of the Study Area

Sample

Sample survey of selected coffee farmers located in Oromia States, East Wollega Zone, Gudeya Bila District, Ganda Gute Canco were used for data collection. The total number of household farmer population in *Ganda Gute Canco* is found to be 426[2]. Based on sample size-determination formula with confidence level of 95% and confidence interval of 5% the sample size considered for this survey is 202[3]. The case unit, *Ganda Gute Canco*, is purposively selected from the Woreda as it is characterized by surplus capable of producing agricultural products that can be stocked at least for two years by the farmers.

Instrument and Measurement

Fourteen-item questionnaires is distributed to randomly selected 202 coffee farmers in Ganda *Gute Canco*, of

[2] Gudeya Bila District Coffee and Tea Plantation report, 2019

[3] https://www.surveysystem.com/sscalc.htm (access date:29/06/2020

Gudeya Bila District of Oromia using locally trained enumerator to ask in local language, *Afan Oromo*, and all of the distributed 202 questionnaire are successfully filled and returned from the respondent farmers. The measurement used for the factors identified is perception of the coffee farmers on the degree of agreement on the statement for each factor in affecting coffee value chain development in that particular *Gute Canco*, in a Likert scale of 5, where 1 = strongly disagree to 5 = strongly agree, and 3 is the mean score. Furthermore, in addition to observation, key informant interview with two commercial investors on the coffee value chain actors were made. And accordingly, content analysis was made from the qualitative data through coffee value chain mapping.

Data Analysis

Based on enumerator-based data collection from the survey, a response rate of 100% (202 respondents) was correctly and completely filled that can be used for analysis using descriptive and inferential statistics.

Results

The results of the study are presented based on the analysis of 14 variables attributed to the factors that explain coffee value chain under development in upstream supply chain members in Ganda Gute Canco of Oromia State, Ethiopia.

Source: Own Observation, 2020

Fig. 2: Coffee Product at *Ganda Gute Canco* Farmer's Site

Table 1: Factors for Underdeveloped Coffee Calue Chain in *Ganda Gute Canco*

Descriptive Statistics			
	N	*Mean*	*Std. Deviation*
Coffee price is regulated	202	2.8416	1.17801
Coffee value chain well developed	202	2.5297	1.36830
There is high productivity of coffee	202	2.4505	.77268
Coffee price at Traders is low	202	2.3663	1.02915
Coffee price at Farm gate is high	202	2.2723	.84649
There is high coffee innovation	202	2.0693	.79498
There is subsidy to coffee producing farmers	202	2.0693	.56880
Coffee chain actors are few in numbers	202	2.0050	1.01969
There is low logistics cost	202	1.8762	.70501
Coffee value chain governance	202	1.8614	.69868
Cash to cash coffee cycle time is short	202	1.8614	.69868
There is adequate availability of improved coffee seed	202	1.8564	.70123
Coffee farm is mechanized	202	1.6139	.48807
Farmers are protected against price fluctuation(hedged)	202	1.6139	.50805
Valid N (listwise)	202		

Source: Own survey, 2020

As depicted in Table 1, based on their experience, 202 farmers were asked by enumerator to show and rank their degree of agreement on the statements based on the factors that contributed to coffee value chain activities in their area and the responses were analyzed and discussed as follows.

The first variable, coffee price regulation, across the coffee value chain was found to be below average with mean of 2.8 and standard deviation of 1.2, implying coffee price is not mostly regulated across coffee value chain from farm site to consumption site. Due to small-scale farm size (on average below 2 hectares of land in the stated area) will give low bargaining power to farmers to negotiate on the price of coffee due to small amount of production from their farm land, if left unregulated and left to the market. This will ultimately give power to the collectors (consolidators) of coffee to have more bargaining power against farmer's offer that lead to underpricing of coffee price at farm gate.

Farmers' engagement on coffee farm activities didn't result in improvement of their livelihood or accumulation of wealth as shown in their perceived response of below average (mean of 2.5 and standard deviation of 1.4). This implies that underdeveloped coffee value chain couldn't create wealth for the farmers and their livelihood remains at subsistence level throughout generations. The third variable, coffee productivity, as measured in terms of average yield of quintal per hectare is 1.75[4]. Consistent to this data, farmers rated their level of disagreement on the high level of productivity of coffee production per hectare as rated with mean of 2.45 and standard deviation of 0.8 implying low productivity of coffee in the production area. On the other hand, farmers were asked to rate their level of agreement on coffee price on how value created is equitably distributed according to the contributions (efforts) made by coffee chain actors; mainly farmer and traders. Coffee product development requires an average of five years period for the farmers. Due to long cash to cash cycle time and low productivity of coffee per hectare for farmers, it is reasonable for the farmers to expect a high profit margin from coffee commodity sale. However, it is to the contrary that retailers got higher margin due to quick coffee turnover and consolidation benefit by buying from different farmers and selling a higher profit margin than the coffee farmer does. However, farmers rating were found to be in disagreement category for both variables indicating contrary to the value chain profit margin equitable distribution being there is high profit margin for traders and low profit margin for coffee farmers. Based on the analysis, low price of coffee at coffee farm sites is the reason behind low profit margin and low wealth creation for coffee farmers as compared to other coffee supply chain actors in the area.

Coffee farmers were also asked to rate the level of coffee farm innovation and mechanization and found to be in the disagreement category for both with mean of 2.1 and 1.6, and standard deviations of 0.8 & 0.5, respectively, implying low level of innovation and mechanization of coffee farm in the area. This is mainly attributed to lack of comprehensive agricultural development policy support and lack of tailored support by the government to boost coffee production at small-scale land size owned by household farmers.

[4] Gudeya Bila Agriculture and Rural Development, Coffee Production Office Report of 2018

Other related factors contributed for coffee value chain development are subsidy and hedging to farmers and their ratings were found to be among the lowest indicating strong disagreement on the availability of support in the form of hedging and subsidy to farmers with mean of 1.6 and standard deviation of 0.5 for hedging; and mean 2.1 of and standard deviation 0.6 of for subsidy to farmers. In the absence of regulated coffee price, and traders' (downstream coffee supply chain members) dominance in coffee value chain, coffee value chain governance through support by government for small holder farmers (upstream coffee supply chain members) is critical. Among government's intervention to balance the coffee value chain governance is to support household coffee farmers through subsidy by providing improved seed, fertilizer, and working capital. Besides, the government should also hedge farmers against the risk of coffee development by insuring in the areas of price fluctuation, bad weather, fire and other manmade and natural risks.

Finally other factors like improved seeds availability, short coffee cash-to-cash cycle time, and availability of few value-adding coffee value chain actors we all rated in the disagreement category by farmers implying that supply of improved seeds by the district to the household farmers is not to their satisfaction. In addition, coffee production takes long cycle time (average of five years to get yield in the area). As a result, the money famers invested to buy improved seeds of coffee for plantation and their waiting time of five years to get yield, sell, and get back their cash considering time value of money is not yielding benefit in the form of wealth accumulation to the coffee farmers in the area. Coffee value chain actors from farm site by coffee household farmers to consumers at coffee shape has many players, as some of them do not add value on the intrinsic component of coffee commodity, but sharing profit margin from the farmers without their fair share.

Table 2: Variance Explanation

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	.807[a]	.652	.630	.83277

a. Predictors: (Constant), seed, regulation, hedging, mechanization, coffee actors, Trade price, subsidy, innovation, farm price, logistics, productivity, governance

As depicted in Table 2, the twelve factors, namely: improved seed, coffee price regulation, hedging to coffee price fluctuation, number of players in the coffee value chain, price set at traders, subsidy provided to coffee farmers, level of coffee farm innovation and mechanization, farm gate coffee price, logistics cost, productivity of coffee at household farm site, and coffee value chain governance together explain 63% of variation in coffee value chain development. Though these factors significantly explain the overall development of coffee value chain in that particular area, other factors that are not accounted in the study like climate variability, soil, pests, and coffee variety may have their own share to explain the coffee value chain development as intrinsic component of coffee value chain development.

Table 3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regres-sion	245.249	12	20.437	29.470	.000[b]
	Residual	131.073	189	.694		
	Total	376.322	201			

a. Dependent Variable: CVCD
b. Predictors: (Constant), seed, regulation, hedging, mechanization, coffee actors, Trade price, subsidy, innovation, farm price, logistics, productivity, governance

As shown in Table 3, model fitness was checked for the data and found to be fit (F=29.470, p=0.000), which is eligible for regression analysis.

Table 4: Predictors and their Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.457	.770		5.791	.000
	Regulation	.002	.062	.002	.039	.969
	Hedging	.036	.157	.013	.227	.820
	Subsidy	1.124	.215	.467	5.227	.000
	Mechanization	1.619	.173	.578	9.345	.000
	Logistics	.217	.188	.112	1.150	.252
	Innovation	.250	.165	.145	1.519	.131
	Farm Price	.116	.159	.072	.731	.466
	Trade Price	.534	.115	.401	4.650	.000
	Productivity	.012	.219	.007	.057	.955
	Coffee Actors	.115	.082	.086	1.406	.161
	Governance	2.208	.961	0.127	2.298	.023
	Seed	1.854	.968	.950	1.915	.057

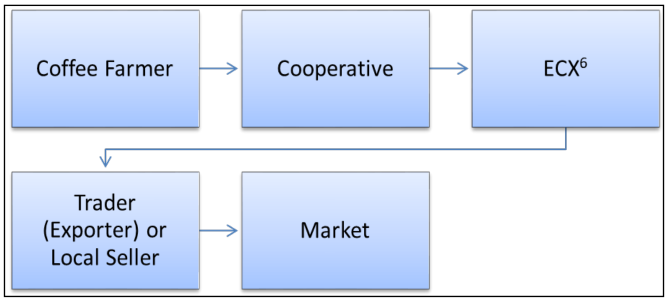
a. Dependent Variable: coffee value chain development

As portrayed in Table 4, four variables, namely: subsidy, mechanization, coffee price by trader, and coffee value chain governance have statistically significant effect on coffee value chain development with value $\beta = 0.467$, $p = 0.000$, $\beta = 0.578$, $p = 0.000$, $\beta = 0.401$, $p = 0.000$, and $\beta = 0.127$, $p = 0.023$, respectively, for the three variables. On the other hand, availability of improved coffee seeds has a statistically significant positive effect on coffee value chain development at $p < 0.1$. However, the remaining variables, namely: regulation, hedging, logistics cost, innovation, coffee price at farmer site, productivity, and coffee value chain actors have a statistically insignificant (weak) relationship with coffee value chain development based on the surveyed data. Based on the identified four factors, it can be inferred that more exogenous factors like governance, downstream coffee supply chain actors, and government support through subsidy, mechanization, and provision of improved seeds to household coffee farmers in the area have significant effect on coffee value chain development in the area.

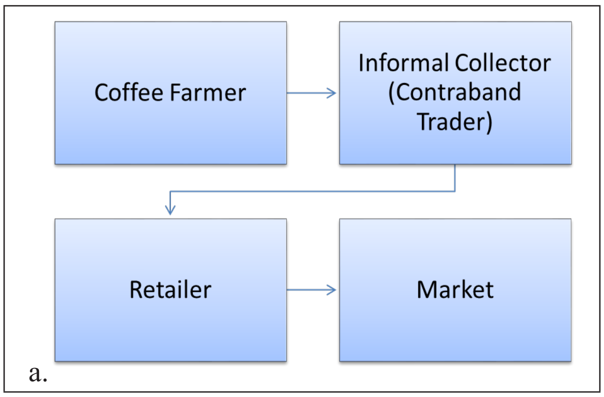
Analysis of Coffee Value Chain Actors in Ganda Gute Canco

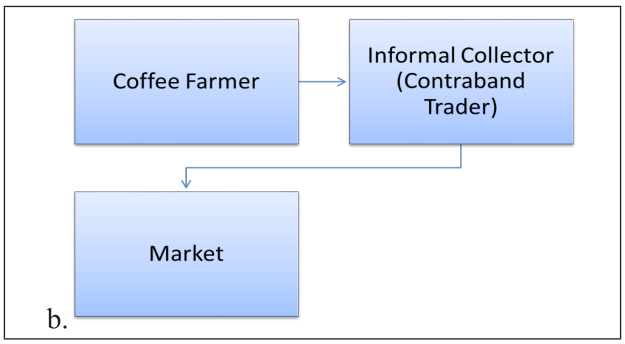
Based on the interview made with two commercial coffee farmers at *Ganda Gute Canco*, six coffee supply chain actors (the longest) for the formal coffee supply chain and three to four coffee supply chain actors in the informal coffee supply chain were identified as shown in the following distribution channel.

1. Formal Coffee Supply Chain Actors



2. Informal Coffee Supply Chain Actors





As per the interview data from the coffee farmers, the first approach (formal coffee supply chain using ECX as intermediary) was found to be constrained by several eligibility factors to trade at ECX, *Nekemte* branch, which demands the coffee farmer to produce and supply minimum of 30 quintals of coffee. Furthermore, grading the quality of coffee supplied from farmers was frequently rejected due to four factors; absence of close coffee-hauling machine, lack of standard storehouse at farm site, lack of standard packing material for coffee at farm site, and lack of dedicated vehicle to transport coffee to ECX warehouse. The minimum closest hauling machine is available at *Gimbi* town, which is 215 kilometer from the farm site, which is found to be infeasible from logistics cost point of view for small amount of coffee production at household farming. On the other hand, in the absence of coffee cooperatives in the area and as household farmers do not qualify to most of the criteria set by ECX of the high standards to maintain quality of coffee for export standard, they resort to the second-best option to sell to coffee informal collectors (coffee contrabandists) at a lower price than the formal price they get at ECX. As a result, the informal coffee supply chain is the common distribution practice in the area to reach the market where traders secure over 100% profit margin from informal coffee trading at the expense of coffee farmers who developed the intrinsic coffee product in the area.

Discussion

Based on the results of the study, value addition on Ethiopian coffee product by the trader, for example, will give the benefit of creating a higher value product which is positively correlated with higher price and higher profit margin accounting the cost factors. On the other hand, coffee farmers producing coffee products up to commodity level with no further processing to add value to the existing product contributes to low profit margin for household coffee farmers. It also has long cash-to-cash cycle time for the farmer to get their cash investment back after coffee plantation. This is a comparably longer period of return on investment at the upstream supply chain (coffee farmers) as compared to the high turnover of the commodity itself in the downstream supply chain players (retailers). Furthermore, the long-chain created to trade coffee product by household farmers in the domestic or export market further created inefficiency due to the involvement of many coffee value chain actors from ultimate source to ultimate end without adding value on the intrinsic commodity of coffee until it reaches the household consumers.

Wealthy distribution in the coffee value chain governance is to the advantage of coffee traders. In contrast, coffee farmers' benefit in the coffee value chain governance is meager. This is mainly attributed to: small land size holding of the coffee farmer that results in small amounts of product supply to the market and coffee farmers' low bargaining power in coffee price-setting at coffee farm sites. Instead, they transfer the profit margin that should have gone to the farmer to themselves at the expense of the coffee farmers. Coffee farmers are the ones who created the intrinsic value of coffee commodity and remain the same until coffee is further processed (roasted) for coffee or macchiato making, but coffee farmers are rewarded less with low price setting from the traders, which made them, remain poor as the profit margin they get from their product is meagre to help them accumulate wealth and in turn help invest to modernize their agricultural activities. Besides, the informal coffee supply chain is the common distribution practice in the area to reach the market where traders secure over 100% profit margin from informal coffee trading at the expense of coffee farmers who developed the intrinsic coffee product in the area. This common trading practice by coffee farmers in the area is due to the high standards and criteria set by ECX to be eligible to trade at ECX. Furthermore, coffee supply chain is, for example, complex and small farmer's sale to local traders, local trader's sale to big coffee milers and exporters, after processing local trader sale to international exporters and primary cooperatives purchase a number of coffees, and sale to cooperative union the union process it and sale to exporters on behalf of cooperatives (Alemayehu, 2014). To justify why coffee value chain should be governed in Ethiopia (which requires a regulated market by the government on how wealth is distributed based on the value created on the product), it took the farmer five years to produce coffee, which is laborious, high cost of household labor at family level which in most of the case unaccounted for in the Ethiopian context, long year of cash-to-cash cycle time with high degree of risk, like low yield, coffee disease, etc., and finally sell at the rate of 60 Birr per kilo at *Ganda Canco* coffee production area. The same product is sold at the rate of 150 Birr[5] per kilo at retail shop at Addis Ababa market, with high profit margin and daily turnover contrary to five years for the farmer. That is why wealth should be redistributed for agricultural commodity. Wealth redistribution can be undertaken by the government policy intervention in two ways: 1) With the objective of value maximization for the customer setting maximum retail price for the consumers, which should be competitive price as perceived by the customer, and 2) Considering the contribution that the farmer makes in the intrinsic value creation of the agricultural product, setting maximum profit margin to go to the farmer equitably. This will in turn discipline the middle-level players to stick to the theoretical lowest profit margin to secure from the agricultural commodity transaction in the entire supply chain activity in the domestic market.

A closer look in to agricultural commodity value chain analysis in Ethiopia revealed the following: Considering the supply chain inefficiency created as a result of multiple players involved in the chain without justified activity as a value addition, the current retail price sold to the consumers in Ethiopian market is artificially kept low or subtly low priced by the government at the expense of the farmer. Here is why? Almost all rural agriculture carried out at household farmer with small land size ownership is done manually or plough with traditional animals, mostly oxen or donkey for which daily labors and animal costs are unaccounted for (not calculated as part of production cost). In the agricultural sector, labor cost is supposed to be expensive (at least theoretically), as it is laborious and demanding diligence than intelligence, with the low conducive work environment. This should be compensated for high pay and accommodation costs for this type of work design. However, in the context in which coffee farm and agriculture in Ethiopia, in general, is considered as a family business and the family is not paid for its contribution, hence the coffee production cost is not clearly accounted for, and the farm gate price is set like 60 birrs per kilo in the coffee case is arbitrary. Hence, the set price is arbitrary and doesn't reflect the real cost and profit margin of the product for the coffee farmer. Or, it is an imposed price by the trader to keep the price low to help the trader expand the remaining pie from the coffee farmer to take the lion's share of the profit margin at final selling price to the consumer market. If

[5] 1USD = 35Birr, June 2020

all costs be accounted for during the long cash-to-cash cycle time from coffee development to harvest and selling time, it is logical to expect the farm gate price of coffee be higher than the current arbitrary price set at 60 Birr per kilo which will naturally push the current retail price even higher. So, the way coffee value chain governance is dominated and hence benefited the downstream coffee supply chain members (trades) in the coffee value chain of Ethiopia.

On the other hand, there is little to no support by the government in terms of financial incentives and subsidies for the household coffee farmers, except for the commercial investors or downstream supply chain members. However, agriculture is an important sector in holding over 20 million household employments in Ethiopia including their rural livelihood, which is directly attached to agriculture for a population of over 80 million. Hence, special attention should have been given by the government to transform this underdeveloped sector through infrastructure development, innovation, mechanization, and provision of improved seeds to coffee farmers.

Lack of financing, incentives, and subsidies to the large household coffee farmers in Ethiopia has stifled them from wealth creation, which could help them to accumulate money for further investment, and to mechanize and modernize their agricultural activity. As a result, most rural coffee farmers continue to pursue subsistent economy with little or no progress in meaningful way in quality of life in general. By its nature, agriculture is a risky business vulnerable to mostly natural risks like fluctuation of weather conditions. Ethiopian farmers depend mostly on rain to conduct their agricultural activity and any deviation of season from expectation results in yield loss or low productivity. As most of the rural farmers do not have adequate capital or credit financing for the next season, they dare risk (entrepreneurial) to access to credit informally through informal loan, which most of the time put them in poverty trap. Besides, lack of working capital during the farm season, the long cash to cash cycle time to get the money back from investment on agriculture, puts the farmers in speculative behavior (again entrepreneurial) to sell their crop in advance while on farm (before harvesting the actual crop) for shortage of working capital or life expenses. In this situation, negotiation is made at individual level, and most of the time brokers buy it at a very low price and sell it at market price in most of the case high profit margin goes to the broker at the expense of the farmer. Therefore, coffee value chain development for smallholder farmers like the case of *Ganda Gute Canco* of Oromia State, Ethiopia, needs to be supported through value chain governance with the support of subsidy and hedging to enable coffee farmers create wealth and protect them against price fluctuation and exploitation by downstream coffee supply chain members. Finally, as household coffee farmers are spatially scattered in the rural areas, poor logistics infrastructure especially all-weather roads and inaccessibility of warehouse to stock coffee production contributed to high logistics cost to the nearby market (six hours' walking distance from the district market) that has ultimately affected the benefit they theoretically expected to reap from coffee harvest.

Conclusions and Recommendations

With a small landholding of coffee farmers in the area coupled with low productivity due to lack of improved seed, mechanization and innovation have made coffee farmers to remain poor and they have found it difficult to create wealth as a result of long cash-to-cash cycle time and from the low price of coffee sold at farm gate price to retailors, who in turn sell it with high profit margin and quick turnover in addition to consolidation benefit from many small coffee farmers at farm site. This has resulted in underdeveloped coffee value chain for the upstream supply chain members (farmers). This mainly characterized by lack of value chain governance to be played by government institutions to drift the wealth-creation mechanism in the intrinsic coffee commodity from traders to coffee farmers by redistributing wealth (profit-sharing formula) according to the value created to coffee commodity, cycle time, and risk factors. This is possible through setting coffee commodity maximum retail price (MRP), which should be regulated through theoretical wholesale and retail price setting. The difference between the cost of producing coffee at farmer site and the maximum retail price set for coffee should be distributed through coffee value chain governance by arranging joint profit sharing scheme according to the value creation at each stage of coffee value chain from source to end.

Furthermore, the government could involve in supporting the coffee farm sector through financing (subsidizing) of inputs like improved seeds and fertilizers, chemicals, etc., and provide tax incentives for household farmers to buy modern agricultural tools and farms for mechanization and innovation. In addition to subsidy, if Ethiopian coffee farm in particular and agriculture, in general, should develop, Ethiopian farmers like the European Union or US farmers should be hedged (insured) from price fluctuations of their agricultural products. In addition to the financial incentives and subsidies, the government should intervene and buy farmers' product and stock at warehouses to mitigate the problem of price fluctuation. If the market price of the commodity falls below the cost of production, the government should buy it at fixed price which accounts for cost of production and fair profit margin for the farmer, regardless of current market price. If the market price of the coffee is competitive for the farmer, the government should allow the farmer to sell it at market price as far as the profit margin is to the advantage of the household farmer. Finally, rural roads to the farm nodes for agricultural commodities should be accessible and regular logistics services primarily transport, warehousing should be available at least at district and at best at Ganda level of coffee farm area at an affordable price. This, however, demands policy makers to shift resource allocation to rural livelihood development, which in turn generates huge employment, rural urbanization, and in the long run freeing rural space for commercial farming and mechanization that will ultimately increase agricultural productivity of Ethiopia.

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Exploring Private Sector Initiatives for Adaptation to Climate Change Impacts on Water

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Abstract

It is now well known that climate change will have significant negative impacts on development, poverty alleviation, and the achievement of the Millennium Development Goals (MDGs) as new threats threaten water and food security, agricultural production, nutrition, and public health. Since water is the primary medium through which climate change influences the Earth's ecosystems and therefore people's livelihoods and well-being, the urgent need for all communities is to look for avenues to adapt to water-related impacts. Since Climate Change will have a significant impact on water related concerns, today's world needs to address water management issues in an urgent manner. This is especially true in developing countries. This paper explores the awareness and possibility of involving the private sector to initiatives among practicing managers in India. Using an empirical approach and applying structural equation modeling for data analysis, the paper concludes that awareness to adaptation needed in the area of disease and health, significantly leads to private sector taking up adaptation initiatives to water-related impacts of climate change. Higher the level of awareness to adaptation needed in the area of disease and health, higher will be the propensity to take up adaptation initiatives to water-related impacts of climate change.

Keywords: Climate Change, Adaptation, Water, Corporate Initiatives, Structural Equation Modelilng

Introduction

The Paris Agreement on climate change, adopted in December 2015, calls for action on both the causes and consequences of the climate change. The causes of climate change are to be addressed through a drastic reduction in greenhouse gas emissions (mitigation) and its consequences are to be addressed through an equal emphasis on investment in climate resilience (adaptation) (Jain, 2011, Halady & Rao, 2010).

In 2007, a joint initiative of the United Nations Foundation and Global Leadership for Climate Action (GLCA) published a Framework for a post-2012 Agreement on Climate Change, which called for four negotiating pathways focused on mitigation, adaptation, technology, and finance. This paper focused more specifically on adaptation and its links to addressing water shortage, floods & droughts, development & poverty alleviation, need for healthcare, crop production, etc. with an emphasis on action at the local level (Asian Development Bank (ADB), 2007, 2008).

Given the far-ranging adverse impacts of climate change, adaptation must be an integral component of an effective strategy to address climate change, along with mitigation. The two are intricately linked—the more we mitigate, the less we have to adapt. However, even if substantial efforts are undertaken to reduce further greenhouse gas emissions, a large extent of impacts of climate change is unavoidable and will lead to adverse effects, some of which are already being felt. The world's poor, who have contributed the least to greenhouse gas emissions, will suffer the worst impacts of climate change and have the least capacity to adapt. Since water is the primary medium through which climate change will influence the Earth's ecosystems and therefore people's livelihoods and well-being, the urgent need for all communities is to look for avenues to adapt to water-related impacts [(The) World Bank (2003), Poverty and Climate Change: Reducing the Vulnerability of the Poor Through Adaptation, Part I, The World Bank, Washington, DC. Smit, B. & Wandel, J. (2006)].

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Urgency to Adapt to Climate Change Impacts on Water

Every year World Economic Forum asks about 1000 decision-makers from public sector, industry, academia, and civil society around the world to assess the risks facing the world in the decade to come. Since 2012, water crisis has been consistently ranked as one of the most important threats facing the world having the highest potential impact (Berggren, 2019). The crisis is perceived to be due to extreme weather conditions caused by climate change and other natural disasters.

Already, water-related climate change impacts are being experienced in the form of more severe and more frequent droughts and floods. Higher average temperatures and changes in precipitation and temperature extremes are projected to affect the availability of water resources through changes in rainfall distribution, soil moisture, glacier and ice/snow melt, and river and groundwater flows; these factors are expected to lead to further deterioration of water quality as well. The poor, who are the most vulnerable, are also likely to be affected the most (UN water, Climate change is mainly about water).

Under the present climate variability, water stress is already high, particularly in many developing countries, and climate change adds even more urgency for action. Without improved water resources management, the progress towards poverty reduction targets, the Millennium Development Goals, and sustainable development in all its economic, social and environmental dimensions, will be jeopardized (Rao & Thamizvanan, 2014, Sustainable Development Goals, 2016).

Recognizing that adaptation to climate change is mainly about better water management, responding to it appropriately is urgently needed in todays' world (UN water, http://www.unwater.org/). This need also presents various development opportunities, which expectedly would help communities especially in developing countries. Appropriate adaptation measures build upon known land and water management practices to foster resilience to future climate change, thereby enhancing water security (Rao & Thamizvanan, 2014). Innovative technologies and integrated solutions are needed at the appropriate scales, for adaptation as well as mitigation. Any adaptation measures, however, need to be assessed for inadvertent adverse effects, in particular on the environment and on human health (Palaksha, Nachiketas & Rao, 2017).

Literature Review on Adaptation

Among many other things, climate change threatens well-being of communities in ways that are numerous and profound. The thinking right now is strengthening developing countries' initiatives to address the impacts in whichever areas these are felt … and this is where private sector can come in (Palaksha, Nachiketas & Rao, 2017). Already, the impacts have grown to an extent much above what was forecasted (Halady & Rao, 2010; Jain, 2012). Many policies and roadmaps have been designed to address the impacts but it is ultimately up to the leaders, managers, and public at large to take it upon themselves to translate the policies into action plans, implement them in real terms, and bring about actual changes in abatement. For this to happen, leaders, managers, and the public will have to be aware of the phenomenon and its drastic implications first; this awareness would perhaps lead to a behavioral change in terms of taking up initiatives, which could address the climate change concerns (Biagini & Miller, 2013).

Building Resilience and Reducing Risk

Climate change increases risk in many different ways, particularly for those who rely on weather patterns, soils, water, and other natural resources for their livelihoods, which includes more than one billion of the world's poor. The magnitude, timing, and location of these climate impacts are inherently unpredictable (Jain, 2012; Wilk, & Wittgren, (Eds.) (2009). Given these uncertainties, adaptation strategies should be based on interventions that will yield benefits sometimes regardless of specific, climate-related events, and sometimes on specific events. Examples of such broad win-win strategies include developing more diverse crop strains tolerant of a variety of different conditions (heat, drought, salt, etc.); bolstering social capital and resilience; increasing storage capacity for fresh water by building reservoirs or recharging aquifers; creating early warning systems and preparedness plans; improving public health infrastructure; and enhancing disease surveillance. This will be in accordance to GLCA Framework, which identified adaptation as one of the key building blocks for a strengthened response to climate change, along with mitigation, technology, and financial resources (UNFCCC, 2008).

The following sections address adaptation in key sectors that are crucial to sustainable development: ecosystems and natural resources, food and agriculture, and health. They are closely linked; for example, the degradation of ecosystems affects water availability for agriculture and food production, thus affecting nutrition and public health. National adaptation and sustainable development plans should deal with all of these sectors in an integrated manner.

Impact Climate Change on Ecosystems and Natural Resources

Climate change will impact ecosystem changes that could result in droughts, floods, and famine. In this phenomenon, the poor will suffer the most as they are dependent on ecosystem like farmland and lack alternate employment (Mitchell & Tanner, 2006, IFC, 2010). The economies and people of many developing countries depend on ecosystem services, and their capacity to mitigate and adapt is contingent on the resilience of these ecosystems. Adaptation strategies will play a key role in strengthening the resilience of communities affected by climate change in such areas as coastal zones, agriculture, forests, water, health, and infrastructure—each of which presents its own challenges. Centers for Regional Adaptation in Agriculture, striving to develop and disseminate technologies for adaptation (for example, salt- and drought-resistant crop cultivars), should be established (Handshake, June 2011).

Unlike the wealthy, poor people often lack access to alternative services and are highly exposed to ecosystem changes that could result in droughts, floods, and famine. The poor often live in locations that are vulnerable to environmental threats, and lack financial and institutional buffers against these dangers. Climate change can lead to ecosystem failure and large-scale population displacement (Skoufias et al., 2011; Jain, 2011, Palaksha, Nachiketas & Rao, 2017).

The degradation of ecosystems disproportionately affects children and women who are increasingly playing a key role as heads of households and primary producers of food (Acosta-Michlik, L., Espaldon, V., 2008). Thus, empowering women and providing them with adequate access to education, credit, health care, and reproductive services will not only reduce their vulnerability, but also improve the well-being of their communities (World Bank, 2010; Adger, Kelly, 1999; Brookes, et al., 2010).

Impact of Climate Change on Food and Agriculture

Climate change is a serious threat to food security in many developing countries, adversely affecting food availability, access to food, stability of food supplies, and food utilization. Agriculture, affected by rising temperature, heavy downpours, and extreme heat and drought, is feared to affect food production in different parts of the world (http://www.climatechange-foodsecurity.org/). The associated heat waves, flooding, and drought have constituted a global food security emergency to communities all over. The rising temperatures and variable precipitation are likely to decrease the production of staple foods in many of the poorest regions. This will increase the prevalence of malnutrition and undernutrition, which currently cause 3.1 million deaths every year.

To address this shortfall, scientists suggest that they start with best agricultural practices, which applies to all regions, integrating the best practice for both food production and best practice to addressing climate change, leading to organic agriculture. The best form of this integration is agro-forestry (http://www.climatechange-foodsecurity.org/solutions.html).

Another very effective remedy for both emissions and food availability is changing from meat-based to plant-based diet. The single most effective and readily available fast-acting part of the solution is changing to the healthy plant diet. This, we have known for a long time, is the healthiest diet for people and our planet (http://www.climatechange-foodsecurity.org/solutions.html).

Impact of Climate Change on Health

Climate change threatens human health in ways that are numerous and profound. Many parts of the world will experience more extreme events such as droughts, heat waves, altered exposure to infectious disease, and more frequent natural disasters that will put added strain on an already overstressed health system. For example, extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. Also, most experts agree that climate change will exacerbate water scarcity and threaten agricultural productivity and global food production.

Climate change is expected to alter exposure to infectious disease in many different ways. Waterborne disease outbreaks caused by a variety of organisms are more common following extreme precipitation events, and these events are expected to become more frequent. Food poisoning events increase with higher ambient temperatures and may become more common with climate change. In addition, the distribution of vector-borne diseases, which affect nearly half the human population, is expected to change as a result of changes in temperature, humidity, and soil moisture (https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap20_FINAL.pdf). High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease.

Pollen and other aeroallergen levels are also higher in extreme heat. These can trigger asthma, which affects around 300 million people. Ongoing temperature increases are expected to increase this burden (https://www.who.int/en/news-room/fact-sheets/detail/climate-change-and-health).

Adaptation Needed in India on Water Impacts

In India, the major rivers get their water flow from the snow and glacier, and melt in the seasons before the summer monsoon. If this trend of temperature rise continues, the river flow in Himalayan basins may initially increase but when the reservoirs of snow and ice continue to deplete, the variability of downstream run-off will increase and water flow will subsequently reduce. This will seriously affect the livelihood of people in the river basin including fisheries and agriculture (Grail Research, 2009; Wick & Wittgen, 2009). To address many such water-related threats in India, coping mechanisms in the form of adaptation strategies are urgently needed.

In India, climate change impacts have been one of the main causes of water hazards as felt over last two decades (Water the India Story, 2009). Decreasing glaciers, sudden, unexpected floods, intense heat-waves, and long and prolonged droughts adversely impact both water quality and quantity, leading to huge scarcity of water, spread of disease both water use and water washed, mass migration in search of water, decrease in irrigation and crop production, decrease in volume of available water for use in industry and in availability of clean drinking water and for basic human hygine (Brookes et al., 2010; Halady & Rao, 2010). Because of this, India is currently viewed as being "water-stressed". Scientists warn that by 2050, India is likely to slip down the ladder to become a "water-scarce" country (Jain, 2012; Thakkar, 2010; Bhooj, 2009).

The adaptation initiatives which are expected to help in water-related impacts of climate change have been in existence in many different sectors in India. For instance, in agriculture irrigation and drainage systems have been enhanced, to bring in more water when needed and drain out excess water in flooding situations (Samui & Kamble, 2011; http://xueshu.baidu.com/usercenter/paper/show?paperid=60341ae9fd6c20f9afbfe3f77c74580a).

Also, Integrated Watershed Management has been introduced to improve agricultural productivity as well as quality. Exhaustive rainwater harvesting has been introduced in rain-fed regions; the components include Grade line Bund, Drainage Line Treatment, Ground Water recharge, etc. At the same time, Micro Irrigation techniques have been put to improve water-use efficiency. More resilient seeds, to withstand floods and droughts, have also been introduced (Ramakrishna & Rao, Water Management Water Use in Rain Fed Regions of India, CRI, file:///C:/Users/Dell/Documents/new%20research/water/water=india/water%20initiatives=%20see=India=agri.pdf).

In Forest sectors, again irrigation facilities have been improved and suitable canals have been constructed from large rivers (Deshingkar et al., 2008; http://xueshu.baidu.com/usercenter/paper/show?paperid=ac0c40e379cd74487743aacdc6ac7689).

In the areas of flood control caused by rivers and water bodies, many infrastructure initiatives have constructed in the form of embankments, dams, barrages, etc. (Jain, 2012). In the coastal zone, multiple options have been considered to overcome water-related problems. These options can protect, adapt, or relocate. We can build new projects and "climate proof" the existing infrastructure;

we can try to change our lifestyle to better live with changes; or people can be moved to other safer places (Jain 2012).

Jain, (2012) describes adaptation measures divided into several groups, "hard" and "soft". A combination of measures usually would be most applicable. One such option, for example, is the 3R measure: recharging the groundwater; increase retention by watershed management, and reuse and recycle of water.

To enumerate some of the areas in India where adaptation will be most appropriate, either by public sector or by private, are:

Water Related Adaptation will be Related in Following Areas:

- Due to warming temperature as a result of climate change there will be higher water demands from the population,
- Due to change in hydrological cycle there be too much rain in some months (resulting in floods) and too little rain in others (resulting in droughts),
- In India more areas and hence more population will fall under severe water stress,
- Crop production will suffer due to water shortage and increasing temperature,
- Shortage in water supply will affect power generation and other industry which need large volumes of water,
- There would be increased disease and heat stress due to water shortage ,
- Mass migration in search of water will become commonplace,
- Irrigation, consuming 70% of total water need, will suffer drastically,
- Water washed diseases will increase,
- Water related diseases will increase,
- Natural habitats of water borne diseases likely to expand,
- Brackish water would affect aquaculture.

(Grail Research, 2009, Jain, 2011, Wick & Wittgen, 2009).

In many of these areas, where adaptation is required, private sector can come in a big way to help.

Involving Private Sector

Private Individuals can undertake adaptations along with or collaborating with local communities, national governments or international organizations.

In India, help required to address climate change impacts on water, is really enormous. Our country to set up the infrastructure to protect populations from floods, health-care systems to address prevalence of disease, invest in agriculture, water availability, sanitation facilities, and so on. Given this huge task involving the private sector might work, in addition to government support which is present always. Their involvement would immensely help in addressing help build the capacity for the communities affected by water-related calamities to survive the adversities caused by climate change.

Corporate managers are known to have been effective in planning and carrying out successful projects to bring about efficiency from the organizational perspective. Hence, the same effectivity can now come in to address impending climactic disaster, this time with the goal of enhancing resilience and minimizing vulnerability (http://unfccc.int/adaptation/workstreams/nairobi_work_programme/items/4623.php).

Thus, in the face of any kind of disasters and calamities, private sector can be catalyzed to help through their involvement in the wider adaptation and building up resilience of communities. The unique expertise of the private sector, leadership, its capacity to innovate and produce new technologies for adaptation, and its financial leverage can form an important part of the multi-sectoral partnership that is required between governmental, private and non-governmental actors (http://unfccc.int/adaptation/workstreams/nairobi_work_programme/items/4623.php).

In order to predict autonomous adaptations and provide an input to adaptation policies, there is a need for improved knowledge about processes involved in adaptation decisions. This knowledge includes information on steps in the process, decision rationales, handling of uncertainties, choices of adaptation types and timing, conditions that stimulate or dampen adaptation, and the consequences or performance of adaptation strategies (Burton, 1996).

So far, there is surprisingly little analysis of adaptation initiatives on the part of private sector, certainly in the peer-reviewed literature (Linnenluecke et al., 2013). A good summary of the available evidence is an OECD survey by Agrawala et al. (2011b). The authors find that most firms manage current climate risks and many are aware of future climate change. However, few firms consciously engage in adaptation to climate change. Instead, climate risks are addressed under different areas such as business continuity planning and supply chain management (Biagini & Miller, 2013).

In relation to the areas where adaptation will be required, following strategies on behalf of private sector, may be implemented (Moss et al., 2003; WBCSD, 2005, 2007).

Possible Adaptation Strategies for Industry

Private sector options to climate change adaptation relating to water.

Adaptation to Reduce Water Demand in the Face of Shortage

In the face of water shortage, private sector can help in :

- Industry Investment in recycling and treatment of industrial wastewater,
- To reduce water demand,
- Incorporate efficient water usage practices,
- Promote conservation of water,
- Practice rain-water harvesting
- Invest in waste water treatment plants to reduce water demand,
- Start incorporating 3R: reduce, reuse, recycle ,
- Incorporate sewage water management and recycling,
- Start monitoring of water consumption,
- Promote Optimization of operations such as cooling tower operations.

Adaptation to Help Communities have Access to Water

Under the title Adaptation to Help Communities have Access to Water, the paragraph can be changed to:

Industry can help in

- Providing irrigation water and increase agricultural production,
- Incorporate community based Watershed development,
- Set up drinking water and purification systems,
- Develop community water management to reduce water demand,
- Promote Water conservation equipment,
- Set up used water cleaning and recirculation systems,
- Incorporate program for thermal stations to reduce usage,
- Help farmers halt watershed erosion and grow more food,
- Improving infrastructure and sanitation facilities in neighboring residential areas,
- Improving sanitation and availability of drinking water in communities,
- Promoting waste-water treatment plants for groups of small companies.

Raising Awareness for Water Conservation for Communities

Holding awareness seminars for water conservation for schools Holding awareness seminars on water conservation for employees Optimization of processes to reduce water Striving to make the industry 0-water demand industry.

Adaptation Strategies to Address Healthcare Impacts

Climate Change is a global issue having impacts in varied different areas. One such affected area is health sector where climate change has had severe impacts. Many health hazards are caused by water-borne, water-washed, and other diseases caused by water-related problems, shortage, and lack of clean water. These can be addressed by extensive healthcare facilities which should be made available to affected communities (Bhooj, 2009).

The initiatives which the private sector can take up may emerge in different formats … in the form of corporate social responsibility, in the form of PPPs, Public Private Partnerships, or as their own Outreach Programs.

To assess the awareness of private sector to different areas where adaptation is needed in India, we considered an empirical research using a database which was generated with the use of a survey. The database was used to explore the extent of awareness to :

- Adaptation needed in addressing higher water demand,
- Addressing change in hydrological cycle resulting in floods and droughts,
- Existence of water stress,
- Crop production suffering due to water shortage and higher temperature,

- Industry operations suffering due to water shortage,
- Mass migration in search of water,
- Irrigation needed urgently due to shortage of water, and
- Prevalence of water-washed diseases, water Bourne diseases, water related diseases and diseases caused by water stress.

The Research Question

This research was conducted with the objectives:

- To assess the awareness of private sector to different areas where adaptation related to water is needed in India, and
- To assess if the awareness would indeed inspire the private sector to take up the initiative to help in the adaptation to climate change impacts on water.
- To address the research question, the empirical research was conducted using database which was generated with the use of a survey. Three different areas where awareness to adaptation needs were required were:
    - Awareness to adaptation needed in the area of ecosystem and natural resources.
    - Awareness to adaptation needed in the area of food and agriculture.
    - Awareness to adaptation needed in the area of disease and health.

Empirical Research

In the empirical research, the researchers explored to assess the awareness of corporate managers on adaptation areas which needed their involvement and attention, such as described above. The research was implemented on a population of Indian managers working in different organizations in the private sector. The research instrument was a questionnaire, which measured awareness to constructs as detailed below. The data collection was non-probability sampling. The questionnaire was digitalized and the link was sent to a population of middle managers at different levels in the country. The final sample size was 166.

The questionnaire essentially sought awareness from Indian managers in the private sector on a 4-point Likert Scale on adaptation areas which need addressing, such as given above. The 4-point scale on awareness was: NA = Not aware, LA = Little aware, A = Aware, VA = Very aware.

Construct 1: Awareness to Adaptation Needed in the Area of Ecosystem and Natural Resources in Eater Context

Floods and droughts
Water stress: shortage drinking water
Water shortage for community demand because of shortage
Water shortage for industry demand for water due to shortage
Heat stress due to warming oceans

Construct 2: Awareness to Water-Related Adaptation Needed in the Area of Food and Agriculture

Impact on crop production suffer
Irrigation needed urgently
Food storage suffering
Fisheries depleting

Construct 3: Awareness to Adaptation Needed in the Area of Disease and Health in Water Context

Water-wash disease
Water-related disease
Waterborne disease

Construct 4: Adaptation Initiatives to Address Water Impacts

How keen are you to take up water-related initiatives in the CSR (Corporate Social Responsibility) format.
How keen the respondent would be to work towards providing clean water to surrounding communities, etc.

In addition, questions were asked relating to demographic features such as age and income of respondent, number of years of operation in the company the respondent is working for, were asked.

In the last part of the questionnaire, a question on if the respondent is interested to incorporate the adaptation initiative in the organization, was asked. This was on a binary scale, zero or one, Yes or No. This could be on individual initiative or acting as change agent to inspire the organization to take up the cause. Further a question on how keen the respondent would be to take up water-related initiatives in the CSR (Corporate Social Responsibility) format and another question on how keen the respondent would be to work towards providing clean water to surrounding communities, were asked. These last two questions were on a 4-point scale: (Not Keen, Little Keen, Keen and Very Keen). These three questions constituted the fourth construct.

The first three constructs were taken as independent variables and the fourth construct as a dependent variable. These constructs constituted the research model to be validated in the data analysis. In addition to three constructs which were used as independent variables, two other independent variables were also considered which were years of operation of the company the respondent is working for, and income level of the respondent. For data analysis, structural equation modeling (SEM) approach was considered.

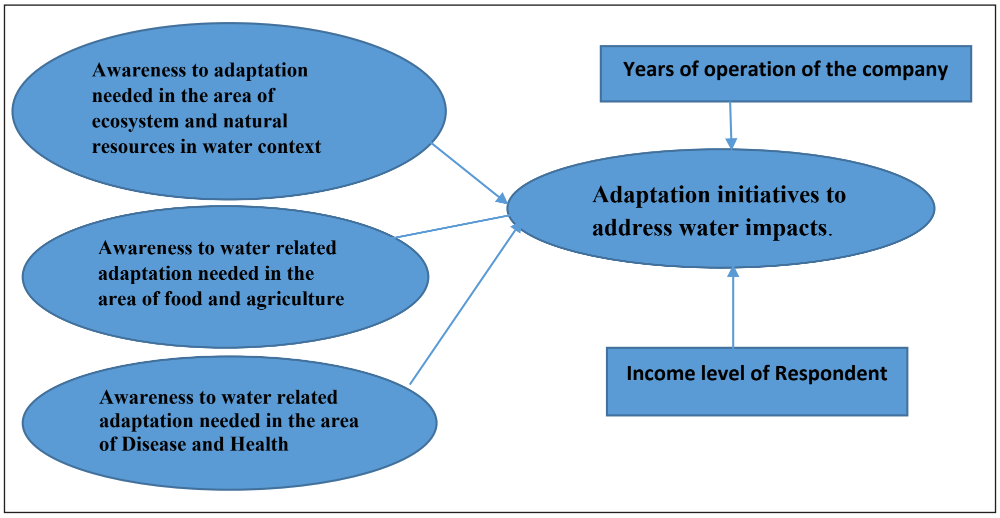

Fig. 1: Research Framework/Model used in the Structural Equation Modeling Approach

Data Analysis by Structural Equation Modeling (SEM) Approach

In the SEM approach, first the construct reliability was assessed for each construct by looking at the levels of Cronbach's Alpha.

Assessing Construct Validity using Cronbach's Alpha

For each of the four constructs, the Cronbach's alpha values were computed as given below (Table 1).

Table 1

Construct	*Cronbach's Alpha*
(1) Awareness to adaptation needed in the area of ecosystem and natural resources	0.776
(2) Awareness to adaptation needed in the area of food and agriculture	0.772
(3) Awareness to adaptation needed in the area of disease and health	0.922
(4) Adaptation initiatives to address water impacts	0.815

The Cronbach's alpha values were highly acceptable assuring the construct validity for all constructs used in the model.

The entire model, as given in Fig. 1, was run several times to arrive at acceptable fit indicators.

The final model had the following Indicators:

Chi-square/degrees of freedom	1.152 (good fit)
Overall model p-value	0.138 (good fit)
Root mean square	0.046 (good fit)
CFI	0.982 (good fit)
GFI	0.887 (acceptable fit)
AGFI	0.834 (acceptable fit)
NFI	0.884 (not acceptable) etc.

Looking at the most important indicators, Chi-square/degrees of freedom (which should be < 2) and overall model p-value (which should be > 0.05), the final model was accepted.

The regression weights and their significances for the structural model were:

Table 2

			Regression Weight	*SE*	*Critical Ratio*	*Significance*
Adaptation food	<---	Adaptation ecosystem	1.131	.196	5.765	***
Adaptation health	<---	Adaptation ecosystem	1.090	.191	5.692	***
Adaptation health	<---	no years	.110	.047	2.348	.019
Adaptation initiative	<---	Adaptation ecosystem	-5.341	33.094	-.161	.872
Adaptation initiative	<---	Adaptation food	5.377	29.454	.183	.855
Adaptation initiative	<---	Adaptation health	.122	.059	2.067	.037
Adaptation initiative	<---	income	.188	.081	2.324	.020
Adaptation initiative	<---	no years	.049	.079	.619	.536

In the Table 2, the significant links were identified as having critical ratio > 1.96 and having individual p-value significance as < 0.05.

Hence, the significant links to adaptation initiatives to address water impacts, are:

- Awareness to adaptation needed in the area of disease and health → Adaptation initiatives to address water impacts,
- Income level of respondent → Adaptation initiatives to address water impacts.

There are three other significant links but not to the dependent variable. These are:

- Awareness to adaptation needed in the area of ecosystem and natural resources leading to awareness to adaptation needed in the area of food and agriculture.
- Awareness to adaptation needed in the area of ecosystem ad natural resources, leading to awareness to adaptation needed in the area of disease and health.
- Years of operation of the company leading to awareness to adaptation needed in the area of disease and health.

Looking at the significant links (1) and (2), one observes that data supports the hypothesis that awareness to adaptation needed in the area of disease and health significantly leads to private sector taking up adaptation initiatives to water-related impacts of climate change. Higher the level of awareness to adaptation needed in area of disease and health, higher will be the propensity to take up adaptation initiatives to water related impacts of climate change. So, we have to raise the awareness of senior managers, higher up in income level to adaptation needs in the area of disease and health.

Further, the managers (respondents) who are higher up in income level have greater propensity to take up such initiatives.

Discussion of Results

As discussed earlier, climate change is one of the greatest challenges of our time. IPCC report 2007 has reported that India will have to face much higher temperatures, frequently occurring heat waves, extreme precipitation, frequent drought, and melting and disappearance of glaciers. The Himalayan glaciers may reduce in size from 500,000 sq. km to 100,000 sq. km by 2030. This receding glaciers will have severe adverse impact on the hydrological system and water resources of the country. Retreating glaciers would also bring about increase in flood frequency and landslides in the Himalayan foothills. It is feared that the per capita availability of water will shrink from about 1,800 cubic m to 1,000 cubic m, making India a water-scarce country and affecting agricultural productivity by around 30%. Going by global norms, India is currently viewed as being "water-stressed". Scientists warn that by 2050 India is likely to slip down the ladder to become a "water-scarce" country (Boojh, 2-9).

This would cause the risk of epidemics due to vector-borne diseases to increase. The sea level rise will have potential impacts in human health in terms of death and injury due to flooding, reduced availability of fresh water due to saltwater intrusion, and contamination of water supply through pollutants from submerged waste dumps. It will also cause a loss in agricultural land, changes in fish catch and a change in the distribution of disease-spreading insects. This would give rise to adverse effects on health and loss of nutrition in food available to masses due to uncertain and unknown effects on food production.

To address these impacts of climate change, our research brings out that the awareness of private sector in these areas of adaptation needed in disease and health would directly and significantly increase the propensity of private sector to take up the adaptation initiatives. In another research (Halady & Rao, 2010), it has been observed that awareness of impact on health is the most important factor which triggers individual initiative on the part of private sector to taking up the cause in promoting sustainability. So, the current research corroborates the earlier research (Halady & Rao, 2010) on the adaptation to water-related initiative on the part of private sector.

In India, already many private sector companies have come forward to voluntarily take up adaptation in water-related impacts (CII 2009). These have been in rain-water harvesting, community/rural drinking water; defluoridization; salinity mitigation for daily water use, etc. All the same, much more involvement of the private sector will be welcome and the purpose of this research is to campaign, promote, and motivate other industries to replicate these efforts and renovate and innovate the present practices to take them to the next level of perfection (CII 2009).

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METRICS - The Management Mantra

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Abstract

This article critically gazes into every aspect of Metrics and how to manage projects using Metrics precisely. Metrics of any kind is interesting to watch but when that is being tied to organizational goals, results would be fruitful to reap more than expected outcome. Metrics shows the journey path and whether organizational needs can be met to not. This would help to take decisions at right time the right decisions, to bring the schedule back on track instead of allowing unknowingly in the wrong path. Any Metrics that's defined should be married to the goals and vision of the organization and the department where the analysis and changes are implemented. What makes interesting is the analysis of data reveals insights, genuine facts and unveils the black box. The key reason why any organization grows and produces great results YoY [year on year] is because the Metrics is the basis for decisions. Measure of metrics may end up producing decisions directing in the wrong pathway if metrics are irrelevant to the business. Historical data, previous project data, organization-level data and industry data are the best sources to predict the future. Industry experts and consulting bodies rely more on large volume of data of different verticals to recommend suggestions to get away from the rut, but also defines the track for prospect (Wohlin et al., 2000).

Keywords: Productivity, Metrics, SMART Goals, Benchmarks, Data Accuracy, Decision Making

Introduction

> "If you don't collect any metrics, you're flying blind. If you collect and focus on too many, they may be obstructing your field of view."
> - Scott M. Graffius

What are the Pitfalls and Why Metrics doesn't Matter?

It's truly interesting to touch upon the other side of the Metrics as well before choosing the metrics that exactly fits the business goals. While we strongly believe the requisite for metrics, it's equally important to discuss the business needs, best practices in industry and benchmarks and the fruitfulness of use of metrics in large corporations for better decision making. The five points given below are likely causes for failure.

- Too many Metrics
- Metrics untied with goals
- Metrics not understood by the team
- Irregular cadence of reviews
- No accountability

In software development, anything that's produced is a snowflake, unique, incomparable and unequal. If so, how the metrics can be used to cognate other metrics, benchmarks and industry standards. Is no single Golden Rule to Recommend a Particular Metric to adopt for a given Scenario. Each member or team is a snowflake with 'N' number of unique characteristics [ex: skills, capability, performance, potential, background, motivation, environment and support structure], which influences highly on the teams or individuals.

So it becomes meaningless to associate metrics of other projects or industry against our projects. Maybe appropriate to compare data [ex: productivity] of an individual with his own data of previous years, but surely not with others data. The opinion of experts and researchers doesn't support this approach, still the researchers are deliberating more on this. The key

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performance indicators [KPIs] can be used for relative comparisons and planning for improvements on a continuous basis for growth. But the argument still remains unanswered why decisions are being taken in organizations on comparative mode. It's quite a thought-provoking study for researchers to provide a solution going forward.

It would be more important to study the metrics on quality aspects also equally important to act based on voice of customers [VOC]. At the end, the satisfaction level of the customer influences critical decisions more than metrics on various occasions. That's why it makes more sense to study the metrics along with VOC all the time for better and right decisions.

The metrics chosen should be done using SMART goals which are Specific, Measurable, Attainable, Relevant and Time-based. A disciplined approach by software professionals using these principles will ensure the purpose and essential need to manage and grow any organizations (Brahm et al., 2018).

> "This thrilled Zuckerberg, whose primary measure of the service's success was how often users returned." - David Kirkpatrick

Data and its Significance

Data quality and accuracy are two most crucial ingredients to ensure higher success rate as the decisions are taken based on facts only and not with gut feelings.

To achieve Data Quality for Project Metrics:

- Continuously coach the team to enhance their knowledge and understand the importance.
- Continue to baseline the metrics and benchmark for continuous improvements.
- Data cannot be used in its raw state but needs translation into presentable format in a way that is readable at appropriate levels so that it can be subjected for analysis.

As the data is being gathered from different departments, teams working in various geographies, it's important to translate the data into a specific format for processing. It would help if the teams are trained to be uniform in data gathering processes to avoid errors. In most of the real-time scenarios, the flavor of the data is homogeneous within specific territories or segments. In such cases, it's recommended not to merge non homogeneous data together for decision making. Using accurate data, measurements and decisions will be with high precision (Loshin, 2006).

Significance of Data Accuracy

Data accuracy can be improved by using tools and automated recorders than gathering it via manual process. The cricket statisticians are the best example to mention here. With the help of real-time data that gets recorded over a period of time, various cricket coaches use them to take appropriate decisions for team selection, batting order or various combinations. If the data is inaccurate, the teams end up taking wrong decisions which may result in a disaster. Data related to batsman includes (a) number of balls attended, (b) number of sixes, (c) number of fours, (d) overall run rate and so on. Similarly, data pertaining to bowler is (a) number of wickets, (b) the economy rate per over and so on. Using different permutation and combination, coach will be able to make decisions like who all can be selected for a game in specific venues or countries. This example aptly suits to any organization as well (Loshin, 2006).

"The more data you have, the more you know, data will speaks at its best."

Research Methodology

Approach adopted in this study is direct/real-time data gathered from projects executed over a period of time [6 to 8 months of data] subjected for statistical analysis to examine the pattern and behavior on various aspects in a systematic way. As the data is directly taken from projects, the inferences and recommendations are candid and help to implement recommendations with ease. As the data-gathering approaches and measurements are based on a scientific nature, tools like SPSS or Mini Tab are best research tools to speed up the entire activity.

Empirical Study

An empirical study on introduction of Metrics Program in real-time projects attracted the attention of many in the organization as the outcome and findings started showing the right path and started revealing a lot, which were hidden for long. A sample of the same is given in the Table 1 for a better understanding. These are basics in any software projects but important findings, motivated to continue the journey with metrics to look at more improvements. The key metrics include variance is effort and schedule, density of defects, defect removal efficiency, project size in story points, efficiency of review process, metrics on documentation coverage and above all the measure of productivity. Even though these are at high-level measures at first look, to derive these various parameters, characteristics and behavior of projects, and a lot of real-time data need to be gathered to see the results. In the process of implementing the data-gathering activity itself, a lot of discipline got embedded in the team and the way the work is being delivered. Team members realized the importance and a self-discipline has been in-built at a steady phase. This change itself has been a confidence booster to take many more steps in the journey of measurements.

Table 1 contains few initial measures that were tracked to monitor the progress and gaps in the process and execution methodology (Brahm et al., 2018).

Table 1: Measures and Definition

Measures	*Definition*
Overall Defect Density	DD = Number of Defects/Size of the Project
Defect Removal Efficiency	DRE = Defects in a particular phase/Total Defects including reported post production defects
Schedule Variance	Earned Value (EV) minus the Planned Value (PV)
Effort Variance	Difference between the planned effort and Actual Effort
Project Size [Story Point for Agile Projects]	Size in story Point for Agile Projects
Review Effectiveness [Efficiency]	Review Efficiency = (Total Number of Review defects)/(Total number of review defects + Total number of testing defects) * 100
Documentation Checklist	Checklist Measures Coverage
Productivity	Development Productivity = Development Project Size/Development Effort

Earned Value [EVM] in terms of effort and schedule returns enormous amount of savings if the task is done in advance, otherwise it provides a warning signal to trigger required actions to get back on track. Like a GPS, this tool helps managers to monitor and control the project. At the end, the cost benefits and business benefits attained are innumerable. This is a MUST have TOOL for managers.

The measurement of project size in terms of function point or feature point or story point helps to estimate the effort and cost more closely or within a small tolerance limit. Project sizing helps to measure the productivity and at a later point, the same can be compared against the industry standards. This gives an opportunity for the manager to know exactly where the project stands and what specific actions have to be initiated to plan for improvements.

One of these metrics relates to documentation, is a very good measure helps to meet ISO 9001 or CMMI level or any other audit requirements. Artifacts produced during SDLC process and the deliverables are too critical for any future reference. The processes mandate the review of any deliverable at every stage of the project; but how that can be measured is the question. Is the review good enough or not? The measure of review effectiveness and defect density is an evidence for any actions that the team takes to improve the process. Ultimate need from the customer is to have a working product with high quality. To achieve a high-quality product, it is paramount important for the manager to have real focus on process, product and people. The metrics produced during the SDLC phases should be specific and directly relating to goals of the organization.

Metrics Inferences Reveal More than it Hides

- Metrics demonstrate value such as Project Metrics related to cost, on-time delivery rate demonstrate the value of a team.
- Metrics increases the performance, productivity, refine and improvise.
- Helps to identify the weak spots in the delivery process.
- Enables the team to communicate with all stakeholders the importance of requirements engineering.
- Guides to know the effectiveness of the review process and gaps.
- Removes all the post production defects.
- Ultimately the customer satisfaction improves significantly.
- Reporting to senior management has become effective with metrics.
- Team's morale improves and productivity.

Importance of Review Process

The defect review process delineated below is a recommended process for any delivery across development lifecycle. Gathering data about this review process and deriving metrics would help making appropriate decisions to improve the entire process on a continuous manner.

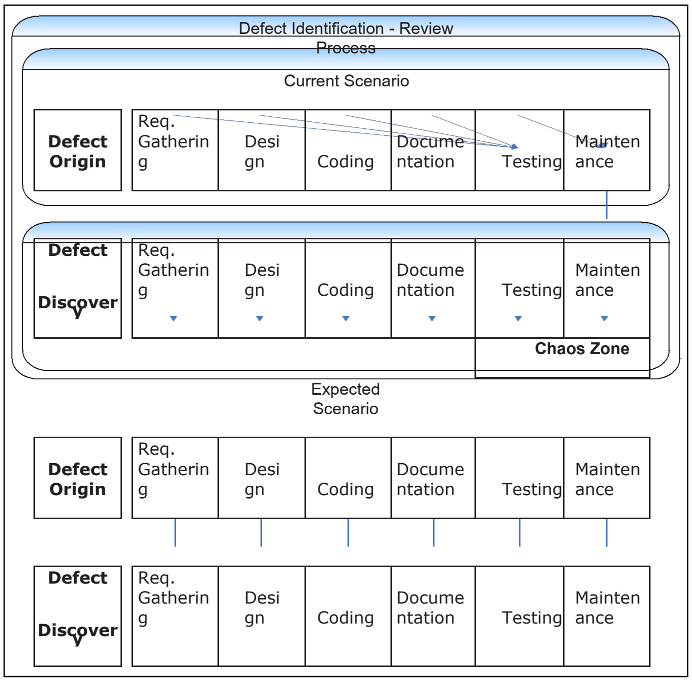

Fig. 1

The following are the key aspects one should follow to achieve defect free software.

- Believe Defect-Free Software is Possible.
- Think Defect-Free Software is Important.
- Commit to Delivering Defect-Free Software.
- Design Your Code for Simplicity and Reliability.
- Trace Every Line of Code When Written.
- Review Code by Programmer Peers.
- Build Automated QA into Your Code.
- Build and Test Daily.
- Use Automated Checking Wherever Possible.

Applying these defect-free methods to an existing project will be worthwhile. Although it is harder to achieve a totally defect-free result with existing code (usually due to the design and volume), applying these steps will result in a significant reduction in an existing project's defect rates. One can deliver defect-free software by following these steps and working constantly towards the defect-free goal, one will see more and more software become defect-free. (Source: Tenberry Software, Inc)

Inference from Outcomes

- Data gathering practice helped the team to support significantly over a period.
- Key measures like productivity, DRE, review effectiveness and coverage, turnaround time to fix the defect, documentation scores, and defects arrested before prod helped the team to learn where they stand.

Fig. 2: Key Parameters Derived from Metrics

- Helps to learn lessons from wrong doings and mistakes which eventually improves efficiency.
- The defects identified belong to what categories during SDLC phase helps to have more focus on defect prone areas.
- Overall helps to make better management reporting and to decide focus areas for future.

Benchmarking

Is benchmarking going to help organizations? Obviously 'YES'; to survive in today's red ocean competitive environment, building internal baselines on various key performance indicators [KPIs] would guide the organizations to prepare for the journey and to beat the competition. Mere survival is not good enough as the competition is always watching to beat and overcome. So need for a metrics is paramount activity and regular comparison against their own previous standards, against industry across the globe. As the competition is across the globe and any organization from any corner can become a challenger at any point of time. So building benchmarks and comparing against competitors is always healthy. Various international quality standards exist [like ISO 9001, CMMI] today for the companies to adopt and practice, which has become a qualification to stay in the market. Interestingly, benchmarks around innovation, value addition, cost savings, re-engineering, artificial intelligence and automation have started coming up as a challenge for all sectors. The need for measuring such new metrics is vital for growth and survival.

Recommendations

- Strongly support projects to start adopting to metrics which are relevant to them.
- Imbed the culture of decision making using data instead of making decisions just with experience and intuitions.
- Use metrics relating to organization goals, mission and vision only.
- As metrics reveals more than what it hides, ensure the data capturing process robust and stable for best results.
- Introduce automation to produce results and inferences free from manual errors.

Conclusion

Various researchers proved in the past the power of metrics and the benefits it reaps to the organizations over a period of time. This article supports the argument of many researchers why should we adopt the best practices and manage projects using metrics to accomplish the organizational goals and vision. Even though the studies support the use of metrics, they equally caution the right choice of metrics and ability to infer appropriately. Tools like VOC, feedback and expert opinion are extremely influential that organizations should adopt at regular intervals to keeping mind the vision, mission and specific goals in making apt decisions to elite metrics for the organizations. The metrics program can be engorged over a period of time based on results of initial period. Use of statistical tools like SPSS or Excel in-built macros will surely enable the researcher to get more insights from the available data.

"The Six Steps to Success by Ken Poirot are 1) Define Success, 2) Devise a Plan, 3) Execute and Overcome Adversity, 4) Measure Results with Key Metrics, 5) Revise the Plan and 6) Work Hard."

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