1.1 Overview

Productivity improvements have long been identified as the principle source of economic growth, improvements in standard of living and increased wages (Eilon, 1985). There has been considerable disagreement, concerning the measurement of productivity and sources of productivity growth. The productivity improvement concept has captured attention of researchers’ in different ways. In spite of importance attached to productivity improvement, research contribution for measurement of productivity attributes has been still incomplete.

Successful productivity improvement strategy requires the identification of various attributes affecting productivity, and a measuring tool to measure these attributes for setting causal relationship among them to develop productivity model. Predicting the attributes accurately enable the productivity development team to set the managerial strategy “first time right” thereby avoiding or at least minimizing costs associated with redesign.

It is also found that identification of the productivity attributes has received much attention in the past four decades. However, different scholars have investigated productivity issues independently. Unavailability of measuring tool to assess the wide range of productivity attributes is one of the potential reasons for the lack of integration. The research conducted with universal set of attributes can result into more fine-grained changes to work. There are, however, potential problems associated with this way of designing a productivity strategy. The problems are as follow:

1. There is a loss of abstract and implied information as the productivity strategy passes from one phase to another. Each phase receives a different interpretation of the productivity improvement requirements. Thus there exists some risk that the final strategy will not completely satisfy the improvement requirements.
2. There is significant loss of time and effort in returning the managerial strategy to the initial phase from the post-design phases to correct the mistakes or shortcomings discovered in these phases.

3. By finalizing the strategy in the initial phase, the managerial team utilizes only its knowledge of the limited productivity attributes. The knowledge of the maximum attributes affecting productivity cannot be incorporated into the strategy. As a result, opportunities for optimizing the productivity strategy are missed due to the lack of integration of productivity attributes.

Research conducted with universal set of attributes can results into more fine grained changes to work. Beside the research work of several productivity modelers and management teams, the contribution of this study can be viewed in two ways.

Firstly, the research methodology adopted to carry out this study. It includes: identification of attributes affecting productivity, grouping them in five key productivity factors, developing questionnaire on productivity attributes, structural equation modeling for causal relationship among factors, causal loop modeling, detailed system dynamics (SD) modeling and analysis. The methodology may find useful to replicate in other settings or provides insights for future productivity improvement strategy.

Second view is analysis of the SD model to set a managerial strategy for productivity improvement. The SD model explains the supply and distribution growth dynamics observed for five factor conceptual framework. The organizational culture (OC) factor plays a crucial role as a driver while remaining four factors including human resource management (HRM), management strategy (MS), production methodology (PM), and performance (PER) behave as system elements. These driver and system elements of framework help to achieve better results in terms of improved productivity through proper implementation. In this model, the organizational culture, human resource management, and performance factors are found most dominating from other remaining two factors, although they are interrelated. This construct may be useful in modeling other large-scale industries for productivity improvement strategies. The time span for achieving productivity maturity level can be reduced by application of proposed SD model.
1.2 Methodology

The study is conducted to construct the system dynamics model for productivity improvement in manufacturing industries. The methodology attempts to reach an optimal combination of various methods. It includes the integration of contribution of various productivity attributes as well as the derivation of the model used to measure these attributes. As shown in figure 1.1, the following section provides a brief introduction to research approaches and strategies for the present study.

1.2.1 Identification of Attributes Affecting Productivity

Initially, a pervasive literature review on productivity is conducted. The research papers are analyzed and the various attributes affecting productivity are identified. Further, to help organize research work, the study has adopted the ten-factor framework developed by (Gupta et al., 2013), for lean manufacturing paradigm. It has been observed that five factors are very relevant for attribute based productivity study out of those ten factors.

1.2.2 Design and Development of Questionnaire on Productivity Attributes

Literature review reveals that the measuring tool for productivity attributes is largely ignored. To fill this gap, the questionnaire on productivity attributes (QPA) based on five point scale is developed by conducting a pilot study among academic and industrial experts. The major focus was on improving clarity, readability, construction, understandability, and applicability of the questionnaire. In the next level, field survey is launched among 311 employees working in small to medium manufacturing industries. The selected respondents were managers (89), engineers (144), and workers (78), who have adequate experience and educational qualification. The collected responses are analyzed statistically to develop a significant five factor conceptual framework. The basic statistics measures, mean score and standard deviation are calculated to check differences among respondents’ data. One-way analysis of variance (ANOVA) is also performed to examine differences among occupational sectors for understandability and applicability of the questionnaire. Further, the descriptive item fit statistics measures: infit and outfit mean square statistical measures are calculated to decide misfitting items. Facet version 2006 software is used to calculate these statistical measures for all items. For confirming the five
Figure 1.1: Methodology adopted to carry research study.
factor conceptual framework across all occupational sectors, exploratory factor analysis (EFA) is performed. This study have adopted three major steps for following EFA which includes the assessment of suitability of data followed by factor extraction and the factor rotation (Pallant, 2005). Similarly, in this research work Facets version 2006 program has also been used to develop rating scale model. Finally, a statistically significant conceptualized frame work is developed.

1.2.3 Causal Relationship among Key Productivity Factors

One of the goals of the study is to provide a structural equation model of productivity showing causal relationship among key productivity factors for productivity improvement in manufacturing industries. According to Schumacker et al (2010), the measurement model should be assessed by the five steps. This includes the model specification, model identification, model estimation, model testing, and model modification. Initially, the conceptualized framework confirmed through statistical analysis of responses is specified as a model. Exploratory factor analysis of specified model is carried out which in turn investigates convergent validity of the conceptual model. Similarly, Cronbach’s alpha values are also calculated to increase confidence in the conceptual model. The Malcolm Baldrige National Quality Award (MBNQA) framework was used to build up basic productivity model. The basic model is checked for its goodness of fit (GOF) indices. Further confirmative factor analysis is conducted to develop a best fit measurement model showing acceptable GOF indices to achieve construct validity of the measurement model. The study is extended to develop a structural model for conceptualized five productivity factors by using MBNQA framework. Finally an improved productivity model showing acceptable GOF indices has been constructed to examine key factors enhancing productivity.

1.2.4 System Dynamics Modeling to Measure Productivity Index

In this study, a productivity system dynamics model is designed to help explain the supply and growth distribution dynamics as observed in the causal relations developed among key productivity factors. The criterion weights of each factor and productivity maturity levels suggested by Chinda (2012) are used to construct this model. The suggested levels are stepped into five levels: initial (0-120 points), repeatable (121-240 points), defined (241-360 points),
managed (361-480 points), and optimized (481-600 points). These criterion weights are later used together with a productivity index (PI) to assess the organization’s current productivity maturity level. Before developing a stock-flow diagram, the causal loop diagram (CLD) with key variables and essential stocks and flows is worked out. The basic causal loop diagram of the productivity index (PI) consists of three closed loops ‘driver loop’, ‘system loop’, and ‘PI loop’. A complete stock-flow based productivity dynamics simulation model for the CLD is designed. The model captures the interactions among the five constructs where the PI represents the sum of the ‘driver’ and the ‘system’ scores with an overall targeted score of 600 points. This dynamics model reflects the assumption that the PI can be healthier provided that the organization focuses on improving the five constructs to achieve better results. Finally improved SD model is constructed which is useful to set managerial strategies for productivity improvement program.

1.3 The Scope and Coverage

The scope and coverage of the research study broadly includes the following aspects.

a) The classical literature review on productivity improvement techniques in the context of strategy transfer and innovation management issues.

b) The study of various attributes affecting productivity and grouping them into major key productivity factors.

c) The role of identified attributes in improving productivity, quality, and technology of manufacturing industries.

d) The role of productivity measuring tool and its effectiveness through questionnaire survey in manufacturing industries.

e) The structural equation modeling approach to develop causal relations among key productivity factors as a managerial tool in planning of productivity enhancement policy. It can also be a helpful base for comparative study in future research.

f) There is the vital role of system dynamics model towards understanding the dynamics of the key productivity factors in manufacturing industries. The productivity index developed through the dynamics model is used to indicate the current maturity level of an organization.

g) Factual study of simulated results to develop improved productivity dynamics model is giving strategy for management to contribute their efforts in right manner.
1.4 Objectives

The significant research objectives of this work are reported as follow:

1. To identify and understand various pioneering and inventive attributes affecting productivity in manufacturing industries.
2. To develop conceptualized framework for identified attributes by grouping them into five major key productivity factors.
3. To examine the importance of productivity measuring tool at the lowest possible cost by conducting a questionnaire survey in manufacturing industries.
4. To find out ways and means for developing optimum constructs of measuring tool justifying responses.
5. To develop a structural equation model (SEM) for exploring key productivity factors to overcome some of the issues related to productivity enhancement and measurement in manufacturing industries.
6. To establish the causal relationship among key productivity factors showing maximum utilization for improving productivity.
7. To construct a productivity system dynamics model to help explain the supply and growth distribution dynamics as observed in the causal relations developed among key productivity factors.
8. To develop productivity dynamics model for productivity index (PI), to assess the current productivity maturity level, and plan for productivity improvement.
9. To highlight the simulated results of dynamics model which sets an optimal strategy for any organization.

1.5 Organization

This thesis is organized as follow:

Chapter two takes a stock of literature review. It surveys the literature from the major area as a productivity improvement. The research work under consideration is the productivity improvement in manufacturing industries. So, major literature pertains to these areas. The carried literature review aims to find various attributes affecting productivity.

Chapter three devotes to design and development of questionnaire on productivity attributes (QPA) as a productivity measure. This research work in developing questionnaire is in
tandem with an aim to provide a managerial tool for productivity improvement. The avenues for further work are opened by developing a conceptual framework based on the attributes.

The research work undertaken is a rising area in productivity measurement and its management. Chapter four is for development of causal relationship among key productivity factors by using structural equation modeling. Causal relationships are developed on the basis of driver and system elements. The execution of driver and system framework can be expressed mathematically to achieve productivity improvement as an output. These causal relations can be used to develop better strategies for productivity improvement in many business organizations.

System dynamics modeling approach for productivity improvement in manufacturing industries is introduced in chapter five. System dynamics is a tool to crystallize the complex problem and to set the scenario for real time simulation. System dynamics frame-work for productivity index at various productivity maturity levels is attempted. The frame-work is progressed by developing causal loop diagram showing various feedback loops to explain the structure and behavior (over time) of the system. Another step followed in this work is to develop a productivity system dynamics model to help explain the supply and growth distribution dynamics as observed in the causal relations developed among key productivity factors.

Chapter six is for discussion of case study carried out in a small scale manufacturing industry. Initially, a developed system dynamics productivity model is executed to measure PI and current maturity level of the firm. Further, every productivity attribute considered in model is assessed. From assessment of attribute gaps are found out and necessary recommendations are suggested for setting managerial strategy to decide where to focus more attention for improvement.

Chapter seven summarizes the work carried out as a part of this research study. Further, it lists significant research contributions of the work. Further, it also gives the conclusions of the research study following directions for future work for advancing the work presented here towards expansion of the productivity improvement strategy. The chapter ends with some concluding remarks on the productivity improvement methodology presented throughout this thesis.