Chapter 3: Research Methodology

3.1 Overview

Research Methodology is a philosophy or general principle to systematically solve the defined research problem, whereas ‘epistemology’ on the other hand is the study of the characteristics of tacit knowledge and justification. Combining both ‘qualitative’ and ‘quantitative’ research is known as ‘triangulation’, (Dawson, 2002). This approach is better because it overcomes the weaknesses from both qualitative and quantitative research and obtains purpose of epistemology as well as research methodology adopted.

For the qualitative research, the ability to generalize the work to the entire research population is not intent and may not be feasible also. It is better to describe or elucidate the happenings within a smaller functional group of associated people. Because it might be possible to provide insights into the behavior of the wider research population, but the situation is different and if the research were to be conducted with different group of people, the result might be different or even contradictory. Hence identifying the commonality and making it generic to relate to the population is a real challenge.

Research objectives (Kothari, 2008) can be broadly grouped as

1. Diagnostic research studies: To count the occurrence of events or correlate it with other parameters

2. Descriptive research studies: To outline the features of an individual, situation or a group accurately

3. Hypothesis-testing research studies: To test a hypothesis for a association between parameters or for threshold limits

4. Exploratory or Formulative research studies: To gain familiarity with a phenomenon or to achieve new knowledge about it

The research objective of study predominantly belongs to descriptive research studies.
3.4 Key Words

Primary Data: Data observed or collected directly with first-hand experience or experiment.

Secondary Data: is the data that have been already collected by and readily available from other sources.

Instrument: Tool / Technique used to collect the primary data systematically; generally questionnaire is the best instrument to collect the primary data through survey.

Population: is a set of similar items or events which is of interest for some question or experiment.

Sampling: selection of a subset of items from within a statistical population to estimate characteristics of the whole population.

Hypothesis: A hypothesis is a specific statement of prediction.

Null Hypothesis: that proposes that no statistical significance exists in a set of given observations.

Pilot Study: is a preliminary small-scale study that researchers conduct to take decision to conduct a large-scale research project; it is like prototype.

Hypothesis Testing: Hypothesis testing is the use of statistics to decide the probability that a given hypothesis is true. It is useful to make inferences.

Parametric Tests: one that makes assumptions about the parameters (defining properties) of the population distribution(s) from which one's data is drawn.

Non-Parametric Tests: is one that makes no assumptions about distribution of population.
3.3 Research Process

As shown in the Figure 3.1 the steps involved in the research process are followed.

3.4 Statement of Problem

Specifically following two issues made the requirements of this study germane

- **Failure Paradox:** The contrast between huge investment in IS for obvious advantages and constant failure rate; and
• **Perpetual Need:** Demanding trends in business and advancements in production technology and rapid and continuous changes in technology, which does not provide readymade solutions from past learning's. Hence the need of study in this area is summarized and vindicated as follows.

• **Continual rate of ISM failures**

• **Exiting solutions are obsolete and inapt**

These research problems are converted into two main research questions as follows:

1. **To establish the verity:** Is application of ISM really improving the performance? If yes how much?

2. **To correlate the parameters:** Which individual Critical Success Factors (CSFs) improves which performance indicators? How much?

With assumption that every IS implementation need not be always successful and does not necessarily result in improving the productivity and quality.

### 3.5 Objectives of the Study

There can be various objectives to substantiate the formation and existence of any organization or corporate. Manufacturing sector is not an exception to this; barring some of charitable trusts most of the corporate have inherent generic key business objective as to make the more and more profit possible by optimizing resources and deploying various tools and techniques. ISM implementation is one of the major initiatives in this context.

To ensure the success of ISM it is essential to establish the impact of ISM in terms of some common measurable performance parameters and study the cause factors that affecting the performance.

#### 3.5.1 Primary Objectives

The primary objectives are based on foundation of ‘perpetual need’ and ‘failure paradox’ concepts. First tells that though there is huge literature available on the subject, continuous technology changes and incessant changes in business practices makes the study still meaningful; whereas ‘failure paradox’ is all about the contrast between
obvious advantages of ISM and constant failure rate of ISM. Based on these the following primary objectives are formed

1. To establish the impact of ISM application on the performance improvement in terms of productivity and quality
2. To comprehend the contribution of Critical Success Factors (CSF) in performance improvement while application of ISM

### 3.5.2 Secondary Objectives

1. To study and understand the existing vibrant Business Practices in SMEs, Role & Scope of ISM and Project Management techniques related with successful ISM implementation in SME
2. To identify the Research Gaps in the ISM literature and its implementation in the changing scenario
3. To study the various Types of existing ISM applications and its association with performance improvement in terms of productivity and quality
4. To Confirm and Assess the impact of ISM on improving the productivity and quality performance parameters
5. To Explore and Identify the Critical Success Factors (CSFs) for various ISM software to meet essential business needs, unique for different types of SMEs
6. To Rate the impact of individual identified CSF on the productivity and quality performance parameters
7. To Provide a generic roadmap with suggestions for SMEs by using the innovative methods to follow in order to avoid making critical but often underestimated Information System (IS) mistakes

### 3.6 Hypotheses of Study

Based on the primary research objectives two specific research hypothesis are as follows

**H1**: Application of Information System Management (ISM) has positive impact in Improving the Productivity and Quality.
H2: Identified Critical Success Factors (CSFs) Contributes positively in the performance improvement.

Because these two ‘research hypotheses’ consist of many parameters, to prove these hypotheses subsequent detailed ‘testing hypotheses’ were formulated further.

3.7 Scope of the Study

The big corporate have their own special purpose and customized software information system management where generalization is difficult. Whereas micro industries had implemented their software in pieces in pockets for unstructured content in which case integration is not there. Therefore manufacturing industries producing engineering goods or SME (Small and Medium Enterprises) sector is selected for the study.

The scope of study is restricted with following criteria

**Location:** Industries in Pune District

**Industry Types:** Manufacturing (Machine, Machine Tools, Fabrication, Metallic Product, Automobile and Ancillary)

**Size of Industries:** Small and Medium Enterprises (Having no. of employees less than 100).

**Type of ISM:** Structured Enterprise content with major information system management (ERP, CRM and SCM).

3.8 Limitations of the Study

- The study has the common limitations of making it **generalized and replicable.** A continuous changes and its speed in the fields of information technology makes the environment so vibrant and dependent that the study results cannot be made generic and cannot be applicable as it is after some period of time. Hence replication of the results after some period of time is meaningless because technology changes make it absolute. Also variety of ISM and influence of local factors makes it difficult to generalize the conclusion. Hence frequently making such studies at different locations and various business sectors can be the solution.

Table 3.1: Enterprise Content Type

<table>
<thead>
<tr>
<th>Enterprise Content</th>
<th>Structured Content</th>
<th>Unstructured Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ERP</td>
<td>Desktop Content</td>
</tr>
<tr>
<td></td>
<td>CRM</td>
<td>eMails/Fax</td>
</tr>
<tr>
<td></td>
<td>SCM</td>
<td>Documents</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Logs &amp; Records</td>
</tr>
</tbody>
</table>

66
• The time-span needed to effectively conclude the results is shorter than the actual period required realizing the benefits of ISM. Generally it takes many years (Nicolaou, 2004) to accrue the business benefits of any ISM implementation. Therefore research is based on counts (survey), which are based on subjective responses, instead of measurements (records), which were suppose to be more realistic and objective.

• There is no very accurate, authentic and updated information accessible to define to target population. Updated list of only SMEs (manufacturing industries producing engineering goods) registered with MCCIA is taken as basis; there is a little chance that population figure may not be very accurate.

• Operations Management have two basic objectives as follows
  o Performance Objectives: Which includes Productivity (i.e. output per unit of input), Effectiveness (i.e. right set of outputs is being produced), Quality (i.e. the extent to which the product or services that satisfies the customer needs), Lead-Time (i.e. time elapsed in the conversion process), Capacity-Utilization (i.e. percentage utilization of resources such as manpower and machinery etc.), Flexibility (i.e. the extent to satisfy a variety of customer needs)
  o Cost Objectives: There are two types of cost objectives
    ▪ Explicit (i.e. visible) cost that includes material, direct and indirect cost, scrap, rework and maintenance cost
    ▪ Implicit (i.e. invisible / hidden) cost that includes costs of inventory carrying, stock-out, shortage, back-logging, lost sales, delayed deliveries, material handling, inspection, grievances, dissatisfaction, downtime and opportunity cost

From these two objectives only applicable ‘Performance Objectives’ (i.e. productivity and quality) are considered for the study. Because companies are reluctant to share their cost related data, although ‘Cost Objectives’ are important were excluded from the study.
• Placebo Effect: a beneficial effect produced by a placebo application of ISM, which cannot be attributed to the properties of the placebo (ISM) itself, and must therefore be due to the user’s belief in that application (i.e. ISM).

There are limited empirical evidences of exploring and adopting this concept in practice; hence collection of sufficient evidences and accurate measurement of ‘business performance’ (precisely in terms of productivity and quality) can be the limitations. Due to confidentiality curb, there may be limitation on usage of historical data.

In summary the research is limited to the study of application of information system management for the mid-sized manufacturing industries producing engineering goods sector in Pune district only.

3.9 Collection of Secondary Data

Secondary data are the data picked from repository, may not be related to the research study but collected for some other purpose and at different time in the past.

<table>
<thead>
<tr>
<th>Characteristics of Secondary Data</th>
<th>Applicability to Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary data analysis involves the use of accessible data, collected earlier for a prior study, in order to check a research interest which might be distinct from that of the original work.</td>
<td>Because of rapid technology changes specifically in Information Systems domain, the compatibility of existing data becomes an issue. Hence there is a perpetual need to collect primary data.</td>
</tr>
<tr>
<td>The approach has not been widely used in relation to qualitative data.</td>
<td>The approach adopted for qualitative data, hence secondary data is inappropriate.</td>
</tr>
<tr>
<td>Secondary data analyst should be a part of the research team.</td>
<td>This might be possible for limited case-study based approaches, but not feasible to get involved in number of industries.</td>
</tr>
<tr>
<td>Further work to develop is essential to realize the potential benefits.</td>
<td>The scope of study is limited to conclusion recommendations only.</td>
</tr>
</tbody>
</table>

Table 3.2: Applicability of Secondary Data
From the table it is evident that this study is based on the primary data, however the literature review to collect the secondary data was useful in order to identify the initial research gap and adopt commonly accepted approaches such as role of CSFs.

### 3.10 Collection of Primary Data

Data collection is expected from various sources. Structured questionnaire is prepared and tested with main intention to collect the quantitative data.

The users were expected to select appropriate options from multiple choices objective options provided in the questionnaires. The responses received from interviews and observations also converted into structure designed for questionnaire to ensure data uniformity.

A questionnaire consists of a set of structured questions probed to the respondents. Questionnaires were developed, tested, and debugged and were administered for all surveys.

A majority of closed-ended questions with multiple choices were used in the Questionnaire. There were a few open-ended questions. Closed-end questions specify all the possible answers and provide options to 'select' that are full-proof, easier to interpret and tabulate. Open-ended questions allowed the respondents to have subjective answer freely in their own words and often revealed the innate desires of the customers.

Care was taken to avoid prejudice and jargon, making questions simple with the usage of common words and close to the manufacturing experience of customers and engineering executives.

Major source of data collection is questionnaire, which is planned to send to identified sample organizations across mail as attachment, with appeal to respond the same within stipulated time frame with contact numbers in case of seeking any clarifications.

The client sites where the researcher is involved in actual implementation work the soft copy of questionnaire was made available on laptop which is filled by client online. Filled questionnaires also planned to collect on pen-drive, where personal reach is there.

Most of the responses received online from questionnaire hosted in google-form.
3.10.1 Sampling Plan

3.10.1.1 Universe / Population
The first step in developing any sampling plan is to clearly specify the set of objects, technically known as the Universe, to be studied. The universe can be finite or infinite. In finite universe the number of items is certain, but in case of an infinite universe the number of items is infinite.

The industry database created by MCCIA (Maharatta Chamber of Commerce Industries and Agriculture) Pune, was taken as basis.

- Number of Industries registered in Pune: 3229
- Number of industries in manufacturing sector: 841
  (Machine, Machine Tools, Fabrication, Metallic Product, Automobile and Ancillaries)
- Number of industries in district Pune: 759
- Number of manufacturing industries producing engineering goods in Pune District: 586
  (Having block investment less than Rs. 100 crore or number of employees less than 100) This is taken as population size for the study and referred as SME.

3.10.1.2 Sampling Unit
A decision has to be taken concerning a sampling unit before selecting sample. Sampling unit may be a geographical one such as state, district, village, etc.

The sampling unit for the study is ‘Manufacturing SMEs for District Pune’.

3.10.1.3 Source List
It is also known as ‘sampling frame’ from which sample is to be drawn. It contains the names of all items of a universe (in case of finite universe only). A list obtained from MCCIA is comprehensive, correct, reliable and appropriate. It is extremely important for this source list to be as representative of the population as possible.
3.10.1.4 Sampling Method
The purpose of sampling method is to obtain a sample that is representative of the target population. Sampling methods are classified as either probability or non-probability. For the research simple random sampling method, which is the simplest and purest form of probability sampling is adopted. Because complete listing of SMEs in Pune district (sampling frame is available) and population is homogeneous.

This simple random probability sampling method adopted ensures that every unit in population has equal and known chance of being included in sample so that it shall be free from sampling bias.

The simple random probability sampling method was adopted anticipating that issues of non-response may occur. However this issue was justified considering the merits of random sampling method as it is a scientific method without bias, economic still ensures accuracy.

It was debated whether the population is heterogeneous and should be divided into two subgroups as SMEs with ISM and SMEs without ISM. However it was confirm that all SMEs having their own ISM setups and almost all of them having CBIS (Computer Based Information Systems), hence there is no need to espouse ‘Stratified Sampling’ method.

3.10.1.5 Sample Size
This refers to the number of items to be selected from the universe to constitute a sample. This is really a challenging task for a researcher. The size of sample should be optimum. An optimal sample is one which fulfills the requirements of efficiency, representativeness, reliability and flexibility (Kothari, 2008). While deciding the size of sample, researcher must determine the desired precision as also an acceptable confidence level for the estimate. The size of population variance needs to be considered as in case of larger variance usually a larger sample is needed. The size of population must be kept in view for this also restricts the sample size. The parameters of interest in a research study must be kept in view, while deciding the size of the sample. Costs also dictate the
size of sample that we can draw. As such, budgetary limits must invariably be taken into consideration when we decide the sample size.

For this study the sample size for the universe or population defined in the scope is determined by simple random sampling method. In the context of study the medium sized manufacturing industries in Pune District producing engineering goods, implemented ISM is considered as universe.

Sample size is determined based on population size

\[
\text{Sample size (n)} = \frac{NZ^2(pq)}{NT^2 + Z^2(pq)}
\]

\[Z = \text{Level of confidence: @95\%} = 1.96\]

\[T = \text{Allowable tolerance of variation} = 0.05\]

\[N = \text{Population size} = 586\]

\[p = \text{Probability of occurring the event} = 60\% \text{ or } 0.60\]

\[q = \text{Probability of non-occurring the event} = 40\% \text{ or } 0.40\]

Hence the sample size \(n\) = 226 ~ 230 representative questionnaires.

Sampling adequacy derived from the formula above was confirmed using KMO (Kaiser-Meyer-Olkin) Bartlett’s Tests.

3.10.1.6 Parameters of interest

In determining the sample design, one must consider the question of the specific population parameters which are of interest.

Productivity Improvement is measured:
1. in terms of increase in production output (i.e. number of items produced)
2. in terms of reduction in production cycle-time (i.e. time needed to produce)

Quality Improvement is measured:
3. in terms of increase in quality-yield (i.e. i.e. no. of items produced correctly first-time)
4. in terms of reduction in number of defects / rejections (i.e. scrap and rework)
The contribution of following CSFs is measured as follows

Organizational Factors:

5. Top Management Support (TMS) in terms of
   - Providing the infrastructure, resources & communication channels
   - Setting the clear goals objectives from Information System, taking ownership

6. The Need of User Support and Involvement (USI) in terms of
   - Participation of number of users in implementation of Information System
   - Need of competency or requirement of skills (from external consultant)
   - Need of user allocation for training / education for implementation

7. The Need of Training and Education (TRE) in terms of
   - End-users training, to gain the know how to operate the system
   - Technical training, for trouble-shooting and smooth operation of IS
   - System Administration, for effective use of ISM

8. Effective Project Management (EPM) in terms of
   - Requirement analysis with determining strategies whether 'as-is' or 'to-be'
   - Activity planning, estimation and resources scheduling
   - Risk management, tracking and monitoring with MIS report generation

9. Organization Culture (ORC) in terms of
   - Motivated and enthusiastic employees with willingness to adopt ISM
   - Leadership and ownership to accept and take responsibilities
   - Formal organizational structure is existing to implement IS

Technical Factors:

10. Business Process Reengineering (BPR) in terms of
    - Identifying the business processes for further improvement
    - Optimizing the process flows for better productivity
    - Enhance / modification of processes as impact of ISM
11. Pre-Implementation Analysis (PRA) in terms of

- Identifying the business needs from all stakeholders to adopt ISM
- Taking stock of budget and existing processes, impact & resources availability
- Evaluation of appropriate ISM type for functional / domain needs and vendor

12. Project Team Competency (PTC) in terms of

- Function skills needed with the domain knowledge to operate ISM
- Technical competency and IT literacy
- Communication skills for interpreting the ISM results

13. Data Security and Accuracy (DSA) in terms of

- Data security includes Confidentiality, Integrity and Availability
- Involvement of client's confidential data & Intellectual property
- Level of accuracy, correctness, privacy and updated data needed

14. Specific need of Hardware & Software Infrastructure (HIS) in terms of

- Specific Memory requirement for processing
- Specific Memory requirement for data storage (with backup facility)
- Specific networking requirement for accessing the IS

Based on these parameters of interest the impact of ISM application on the performance improvement in terms of productivity and quality shall be established and the contribution of Critical Success Factors (CSF) in performance improvement while application of ISM shall be comprehended.

### 3.10.2 Instrument Design

Questionnaire is main instrument used for collection of primary data. For constructing the questionnaire following parameters are used
Figure 3.2: Parameters for Questionnaire

Based on the objectives the questionnaire prepared in MS-Excel is also classified into two parts:

1. Questions to establish & measure the improvement in the performance due to application of ISM
   - Responses collected in terms of improvements on 4 identified productivity and quality parameters

2. Questions to study & assess the contribution of Critical Success Factors (CSFs) while implementation
   - Responses collected against 10 identified CSFs parameters contributing in ISM implementation

The questionnaire is designed and being tested for verification of following factors
• Fitness: achieving the research objective
• Feasibility: possibility to get the data
• Simplicity: questionnaire is easy to understand
• Completeness: questionnaire covers all required parameters
• Consistency: the data collected is reliable & stable

The questionnaire is being reviewed by few experts for validity and reliability and also tested using Cronbach's alpha tool.

Cronbach's alpha (extension of KR-20) is a basically measure of internal consistency, i.e. how closely related a set of parameters are as a group. It is treated to be a measure of scale reliability. A "high" value for alpha need not imply that the measure is one-dimensional. If, in addition to measuring internal consistency, you wish to provide evidence that the scale in question is one-dimensional, additional analyses can be performed. Exploratory factor analysis is one method of checking dimensionality. Technically speaking, Cronbach's alpha is not a statistical test - it is a coefficient of reliability (or consistency).

Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. The questions related to ISM impact have both positive (after) as well as negative (before) responses. Hence CSF related 40 questions were selected for the test.

Figure 3.3: Cronbach's alpha Result
The alpha coefficient for the forty items is **0.870**, suggesting that the items have relatively 'mostly' internal consistency. (Note that a reliability coefficient of .70 or lower is considered as "acceptable" in most social science research situations.) Therefore the questionnaire is fit for internal consistency.

### 3.10.3 Pilot Study

There are number of 'success factors' contributing for successful implementation of any ISM. However during pilot study the need to restrict these success factors to limited number of Critical Success Factors (CSFs) was evolved.

**TOPSIS** Method of **Multi-Criteria Decision Making** was adopted to restrict the CSF objectively. TOPSIS (Technique of Order Preference by Similarity to Ideal Solution) is a method generally considers three types of attributes or criteria as follows

- Qualitative benefit attributes/criteria
- Quantitative benefit attributes
- Cost attributes or criteria

In this method two artificial alternatives are hypothesized as

- Ideal alternative: the one which has the best level for all attributes considered.
- Negative ideal alternative: the one which has the worst attribute values.

TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal alternative.

With this method CSFs were restricted to 10 and classified them into two categories as Organizational Factors and Technical Factors. With this the questionnaire is finalized and restricted to total 53 MCQ were asked with enough spaces for qualitative comments.

It was noticed during pilot study that the people were reluctant to fill the questionnaire. Based on the pilot study learning the questionnaire was modified to get the better responses without compromising the objectives as follows

- The CSFs were restricted to ten to make the questionnaire concise.
• The identity of respondents in terms of name, designation, contact number and even organization name made optional to eliminate the threat to confidentiality.

• Few SMEs from Pune district but not registered with MCCIA were also considered for obtaining the primary data.

3.10.4 Data Collection

3.10.4.1 Getting the Questionnaire Filled Remotely

Soft-Copy of Questionnaire on eMail: This is the most optimized way of primary data collection. The questionnaire is e-mailed as attachment to the targeted industries with the request and instructions to fill the questionnaire.

Hosting the Soft-Copy of Questionnaire: Google Forms were created to avoid the mail attachment; only URL of questionnaire (http://goo.gl/forms/hDgcW5f4vL.U6qP4s1) was shared with appeal to fill the questionnaire online. The responses collected in central database were extracted and merge with responses collected from other sources for analysis purpose.

Distributing the Hard-Copy of Questionnaire: Few respondents prefer to share their feedback on the printed hard-copies of questionnaire.

Finally all the responses received on questionnaire is consolidated in single database.

3.10.4.2 Participative Observation

Participative observation is much more effective method of survey used in qualitative research. The issues of the obtrusiveness is minimized as the researcher himself is involved in ERP development, consultation and implementation activity for more than two decades; his notes and observations while actual implementation of ISM (specifically in ERP implementation) is source of information. It was not feasible to visit each identified SME to collect the data; however preference is being given to participate in the survey to understand the situations better. A direct observation reduces distortion between the observer and what is observed that can be produced by an instrument.
3.10.4.3 Expert Group Discussions

Experience of researcher in the area generated contacts with number of functional groups of professionals in the industry sector; their valuable comments and feedback were collected as major source of information. This technique is proven efficient because the researcher was able to gather the information from several people in one session.

Projective techniques adopted to encourage the participants to reveal in detail deeply suppressed attitudes, opinions, feelings and experiences.

3.10.4.4 In-Depth Interviews

This person-to-person or group interview type of data source is most prevalent in qualitative studies. Open-ended questions are asked and the responses are recorded. Telephonic interviews are proven most economic from time and cost aspect, is adopted.

Finally all the responses were consolidated in single database for further analysis.

3.11 Research Survey

The population survey for the study is being carried out for the SMEs fitting in the criteria specified in the scope of the study. Well prepared and tested questionnaire with appeal was circulated (preferably in softcopy MS-Excel format) to collect the responses and responses consolidated in single database were coded and analyzed.

Data collected from all the sources are being uniquely identified, classified, coded and consolidated in central database for further analysis.

3.11.1 Sources of Data

Though most of the data is planned to be collected from the users of ISM, data input from various representative SMEs from identified population is being collected.
Analysis of the information in the form of the data collected is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information making suggesting and arriving at conclusions.

- Data was carefully edited, coded, transcribed, and verified so that it could be properly analyzed during this phase of the research process
- Verification ensured that the data from the original questionnaires was accurately transcribed, while data analysis gave meaning to the data that has been collected
- Bias was avoided when interpreting data because only the results (not personal opinion) would be taken into account

Microsoft-Excel used as a best tool for data analysis which is planned to consolidate analyzes and present the collected data.

3.12 Data Testing Plan

There are two basic types of significance used for hypothesis testing.

**Parametric Tests:** The tests are depends upon the parameters of population. In which the population from which the samples are drawn are assumed to be normally distributed and data collected are of interval level.

**Non-Parametric Tests:** The tests are known as distribution free tests as they are not based on the characteristics of the parent population.

Considering the fact that the part of data collected in the questionnaire is of ‘ordinal level’ though the parametric tests are very powerful, non-parametric tests for testing the hypothesis based on data collected on ‘ordinal level’.

Following statistical tests were planned for analyzing the collected data

- t-test is based on t-distribution and is considered an appropriate test for judging the significance of a sample mean or for judging the significance of difference between the means of two samples in case of a small sample when the population variance is not known. The relevant test statistic, t, is calculated from the sample data and then compared with its probable value based on t distribution (to be read from the table)
that gives probable values of t for different levels of significance for different degrees of freedom) at a specified level of significance for concerning degrees of freedom for accepting or rejecting the null hypothesis.

\[ t = (X - \pi_o / s) \times \sqrt{n-1} \]

Where, \( X \) = mean of the distribution

\( \pi_o \) = assumed mean (3 in this research)

\( s \) = standard deviation

\( n \) = number of observations

- **z-test** is based on the normal probability distribution and is used for judging the significance of several statistical measures, particularly the mean. The z test statistic is worked out and compared with its probable value (to be read from table showing area under normal curve) at a specified level of significance for judging the significance of the measure concerned.

\[ z = (X - \pi_o / s) \times \sqrt{n-1} \]

Where, \( X \) = mean of the distribution

\( \pi_o \) = assumed mean (3 in this research)

\( s \) = standard deviation

\( n \) = number of observations

- **\( X^2 \)-test** is based on chi-square distribution and as a parametric test is used for comparing a sample variance to a theoretical population variance.

\[ X^2 = \Sigma \left( \frac{O_i^2}{E_i} \right) \times N \]

Where, \( E_i = \) row total * column total / N

\( O_i = \) observed frequency,
Ei = expected frequency

N = total of frequency

Generally the majority of hypothesis tests making inferences about population parameters such as mean and population. Parametric tests and parametric statistics of samples that come from the population are being tested. The tests are formulated with restrictive assumptions about the population, from which samples are being drawn, with assumptions that the sample size is large enough or sample is taken from normally distributed populations.

In this study the populations may not be always normally distributed; even-if a goodness-of-fit (Chi-Square) test indicates that a population is approximately normal; the test cannot be 100 percent reliable. Therefore for this study the normal curve is not appropriate.

Assuming that distribution of population may not be normal distribution the following distribution-free or non-parametric tests were planned

In the data analysis step coding, tabulation and then drawing statistical inferences is done. Hypothesis testing is done to check whether the collected data is supporting the hypotheses or not? Statistical tests were deployed for the purpose of responding this question. Hypothesis-testing will result in either accepting the hypothesis or in rejecting it. Generally the majority of the hypothesis tests making inferences about population parameters such as mean and proportion. Parametric tests and parametric statistics of samples that come from population were being tested. The tests are formulated with restrictive assumptions about the population from which samples are being drawn, with assumptions that the sample size is large or came from normally distributed population.

In this case of study the populations (the SMEs from where the data is being collected) are NOT always normal; even if a goodness-of-fit (Chi-Square) test indicates that a population is approximately normal, the test cannot be completely reliable. In such situations the use of the normal distribution curve is not appropriate.
The ‘distribution-free’ or ‘non-parametric’ tests were planned, which are concern with parameters other than the value of population parameters.

Following non-parametric test were planned where found appropriate to test the hypothesis

1. **The Signed Test for Paired Data:** Where positive or negative signs are substituted for quantitative values. Since the range of data collected from questionnaire is limited, this test for the research is proven very appropriate. Wilcoxon Signed-Rank-Test is non-parametric test, alternative to paired t-test which is parametric test. However considering the fact that ‘range of responses values’ is not sufficient, where the ‘ranking’ (for Wilcoxon Signed-Rank-Test) can be meaningful. **Therefore simple signed test for paired data was planned.**

2. **The Rank Sum Tests:**

   2a. The Mann-Whitney U Test: Used to determine whether two independent samples have been drawn from the same population. It uses more information than the sign test. In case of only two populations were involved in the study.

   2b. The Kruskal-Wallis Test: This generalizes the analysis of variance to enable us to dispense with the assumption that the populations are normally distributed. In case of more than two populations were involved.

   **Since for the case of study the sample is planned from single population these tests are not relevant.**

3. **Chi-Square Test:** for goodness of fit, for homogeneity and for independence of data. Alternatively the Kolmogorov-Smirnov Test which is a method for determining the goodness of fit between an observed sample and a theoretical probability distribution as non-parametric test.

4. **Correlation Analysis:** To study and analyze the association between independent parameters (i.e. CSFs identified) and dependent variables (i.e. productivity and quality parameters).
5. **Tabulation and Graphic Presentation:** The raw data coded, tabulated and presented in graphical / visual format.

The research hypotheses consist of number of parameters. Based on the main two research hypotheses for all the parameters involved following **'testing hypotheses'** were created as follows:

1. **H1a:** Implementation of ISM has a positive impact on productivity parameter by increase in number of output produced  
2. **H1b:** Implementation of ISM has a positive impact on productivity parameter in terms of reduction in cycle-time hours  
3. **H1c:** Implementation of ISM has a positive impact on quality parameter by increasing quality yield  
4. **H1d:** Implementation of ISM has a positive impact on quality parameter in terms of reduction in scrap-rework  
5. **H2a:** CSF Top Management Support has a positive impact on productivity parameter by increase in number of output produced  
6. **H2b:** CSF Top Management Support has a positive impact on productivity parameter in terms of reduction in cycle-time hours  
7. **H2c:** CSF Top Management Support has a positive impact on quality parameter by increasing quality yield  
8. **H2d:** CSF Top Management Support has a positive impact on quality parameter in terms of reduction in scrap-rework  
9. **H3a:** CSF User Support and Involvement has a positive impact on productivity parameter by increase in number of output produced  
10. **H3b:** CSF User Support and Involvement has a positive impact on productivity parameter in terms of reduction in cycle-time hours  
11. **H3c:** CSF User Support and Involvement has a positive impact on quality parameter by increasing quality yield  
12. **H3d:** CSF User Support and Involvement has a positive impact on quality parameter in terms of reduction in scrap-rework
13. H4a: CSF Training and Education has a positive impact on productivity parameter by increase in number of output produced
14. H4b: CSF Training and Education has a positive impact on productivity parameter in terms of reduction in cycle-time hours
15. H4c: CSF Training and Education has a positive impact on quality parameter by increasing quality yield
16. H4d: CSF Training and Education has a positive impact on quality parameter in terms of reduction in scrap- rework
17. H5a: CSF Effective Project Management has a positive impact on productivity parameter by increase in number of output produced
18. H5b: CSF Effective Project Management has a positive impact on productivity parameter in terms of reduction in cycle-time hours
19. H5c: CSF Effective Project Management has a positive impact on quality parameter by increasing quality yield
20. H5d: CSF Effective Project Management has a positive impact on quality parameter in terms of reduction in scrap- rework
21. H6a: CSF Organization Culture has a positive impact on productivity parameter by increase in number of output produced
22. H6b: CSF Organization Culture has a positive impact on productivity parameter in terms of reduction in cycle-time hours
23. H6c: CSF Organization Culture has a positive impact on quality parameter by increasing quality yield
24. H6d: CSF Organization Culture has a positive impact on quality parameter in terms of reduction in scrap- rework
25. H7a: CSF Business Process Reengineering has a positive impact on productivity parameter by increase in number of output produced
26. H7b: CSF Business Process Reengineering has a positive impact on productivity parameter in terms of reduction in cycle-time hours
27. H7c: CSF Business Process Reengineering has a positive impact on quality parameter by increasing quality yield
28. H7d: CSF Business Process Reengineering has a positive impact on quality parameter in terms of reduction in scrap-rework
29. H8a: CSF Pre-implementation Analysis has a positive impact on productivity parameter by increase in number of output produced
30. H8b: CSF Pre-implementation Analysis has a positive impact on productivity parameter in terms of reduction in cycle-time hours
31. H8c: CSF Pre-implementation Analysis has a positive impact on quality parameter by increasing quality yield
32. H8d: CSF Pre-implementation Analysis has a positive impact on quality parameter in terms of reduction in scrap-rework
33. H9a: CSF Project Team Competency has a positive impact on productivity parameter by increase in number of output produced
34. H9b: CSF Project Team Competency has a positive impact on productivity parameter in terms of reduction in cycle-time hours
35. H9c: CSF Project Team Competency has a positive impact on quality parameter by increasing quality yield
36. H9d: CSF Project Team Competency has a positive impact on quality parameter in terms of reduction in scrap-rework
37. H10a: CSF Data Security and Accuracy has a positive impact on productivity parameter by increase in number of output produced
38. H10b: CSF Data Security and Accuracy has a positive impact on productivity parameter in terms of reduction in cycle-time hours
39. H10c: CSF Data Security and Accuracy has a positive impact on quality parameter by increasing quality yield
40. H10d: CSF Data Security and Accuracy has a positive impact on quality parameter in terms of reduction in scrap-rework
41. H11a: CSF Hardware and Software Infrastructure has a positive impact on productivity parameter by increase in number of output produced
42. H11b: CSF Hardware and Software Infrastructure has a positive impact on productivity parameter in terms of reduction in cycle-time hours
43. H11c: CSF Hardware and Software Infrastructure has a positive impact on quality parameter by increasing quality yield

44. H11d: CSF Hardware and Software Infrastructure has a positive impact on quality parameter in terms of reduction in scrap-rework

First four hypotheses are related to the four dependent parameters; remaining 40 hypotheses are based on combination of 10 CSF (as independent parameters) and 4 dependent parameters.

3.9 Social Relevance of the Study

It is very apparent that production makes significant contribution to society’s well being. The standard of living of people depends on production of goods and services. More the production is higher the standard of living of the people. Competitive advantage of companies is vital in these days. A firm, strong in competitive advantage, is well balanced to succeed with the constraints or restraints. Firms look to production function to achieve competitive advantage. Competitive advantages with high productivity and quality is one of the keys to high standard of living and is the backbone of a nation's economic progress. It may be stated that the ISM offers vast scope for achieving productivity with effective management of resources, materials and lead time, and with better control of quality, a firm will be able to bring out more output from a given input at optimized budget.

3.10 Presentation and Findings

The hypotheses were tested and upheld several times, to arrive at generalization, i.e. to establish a theory. Because in absence of hypothesis, the findings based on some theory are generally known as interpretation. This study have clearly defined hypothesis, however for achieving the secondary objectives the tabulation, consolidation and graphical presentation is prepared to interpret the data.

The Researcher's objective was the study of the impact of ISM application on the performance improvement in terms of productivity and quality and the contribution of Critical Success Factors (CSF) in performance improvement while application of ISM.
This chapter the methodology used for research was described. It was started with a research process that includes the steps such as research problem and a hypothesis forming with concepts. Next an overview of the research plan is provided. A justification for use of these methods is given. In the next section given the details of the Research Plan, Research Schedule, Sampling Plan, Data collection, analysis and testing plans. The rigorous methodology that was followed in the development of constructs, making it operational through appropriate parameters and finally testing and validation of scales and the overall instrument with a pilot study followed by a confirmatory survey have been described. Lastly the section outlines various tools and techniques used as well as analysis methods used.

The research was a part of the work for the degree of Doctorate of Philosophy from the University of Pune. The website of the University of Pune was referred to for guidelines on how the findings were to be presented. University of Pune Circular No.142 dated 29th August, 2011 regarding Revised Rules for Ph.D. was used for presentation guidelines. The cumulative references were included at the end as per the APA Style.

The research findings are exacted to help the SMEs in formulating appropriate ISM implementation strategies to increase their performance.