CHAPTER 3

RESEARCH METHODOLOGY AND DESIGN

This chapter deals with the preliminary view of WCMS, research framework, hypotheses formation, area of study, population overview, research instrument development, pilot survey, instrument validity and reliability, data source, sampling procedure, sampling frame, challenges encountered during the phase of data collection and summary.

3.1 PREAMBLE

The present study is undertaken primarily to analyze the competitive edge of WCMS implemented by Chennai manufacturers and its effect on operational performance of an organization. This research is designed as an empirical study, which is based on manufacturing organizations located in and around Chennai. The heart of this thesis will focus on the proposed model and associated hypotheses. The goal of this study is to gain a better understanding of WCM practices, principles and techniques currently adopted by Chennai manufacturers to achieve a world class standard in their business operations. Both the survey and the proposed model were derived from the literatures on the domain of WCMS.

3.2 RESEARCH FRAMEWORK

As stated earlier, the main objectives of this research are, first, to explore the critical driving forces toward the effective implementation of WCMS in a manufacturing context, and second, to identify the effect of WCM Practices, Key Business Priorities, Lean Initiatives, TQM Principles
and IT Systems/Applications implemented by Chennai manufacturers on organization’s operations performance (competitive advantage). In order to realize objectives, the research framework is developed as shown in Figures 3.1 and 3.2. This framework is a simple linear model of relationship between the independent and dependent variables.

In Figure 3.1, the competitive advantage as the dependent variable and the WCM Practices and Key Business Priorities as independent variables. In figure 3.2, the competitive advantage as the dependent variable and TQM Principles, Lean Initiatives and IT Systems/Applications as independent variables. The arrows in Figures 3.1 and 3.2 represent the relationships to be tested in order to achieve these two research objectives. Figure 3.1 indicates that there are three main research variables to be analyzed: WCM Practices, Key Business Priorities and Competitive Advantage and Figure 3.2 indicates that there are four main research variables to be analyzed: TQM Principles, Lean Initiatives, IT Systems/Applications and Competitive Advantage. Within each of these research variables, a set of concept variables (or indicator statements) are included based on related literatures.

To indicate the degree or extent of each item, as practiced by the business unit, a five-point Likert scale (Rossi, Wright and Anderson 1983) was used, ranging from ‘highly considered’ to ‘not highly considered’. Each concept variable is measured on a five-point Likert scale of 1-5, where level 5 indicates the highest degree of consideration, while 1 indicates the lowest. In determining the measurement properties of the constructs used in the statistical analysis, reliability and construct validity were assessed (Dick and Hagerty 1971), using respectively, Cronbach’s alpha and Principal Components Analysis.
Figure 3.1 The impact of WCM Practices and Key Business Priorities on WCMS Implementation, which in turn is used to achieve competitive advantage in the manufacturing operations.
Figure 3.2 The Effect of TQM Principles, Lean Initiatives and IT Systems on Competitive Advantage (Operations Performance) of an organization
3.3 HYPOTHESES FORMULATION

The previous figures portray theorized relationships between the components of WCM and the operational performance. These proposed relationships form the basis of the hypotheses to be tested. This research is empirical in nature and this characteristic stems from its objectives. Thus, in order to shed light on the status of the manufacturing firms toward achieving world class, the implementation of WCMS (i.e., WCM Practices, Principles and Techniques), the driving forces which may influence the adoption of WCMS and the barriers that might prevent or delay the application of WCMS by manufacturers operated in Chennai are required to be focused for this study. Based on the theoretical framework, the following hypotheses are investigated in the empirical analysis:

H$_1$: Manufacturing firms in Chennai are more inclined to adopt modern WCM Practices, Key Business Priorities (KBPs), Lean Initiatives (LIs), TQM Principles, IT Systems/Applications and Maintenance Practices for effective implementation of World Class Manufacturing System (WCMS).

H$_2$: The firms that undertake WCM efforts are also likely to adopt Key Business Priorities, Lean Initiatives, TQM Principles and IT Systems/Applications for effective implementation of WCMS.

H$_3$: There is an impact of WCM Practices, Key Business Priorities, Lean Initiatives, TQM Principles and IT Systems/Applications on achievement of competitive advantage in operations performance of the firms and world class status.

H$_4$: Basic drivers of WCM positively affect the implementation of the WCM principles and techniques by manufacturing firms in Chennai.
H₅: Basic barriers of WCM negatively affect the implementation of the WCM principles and techniques by manufacturing firms in Chennai.

H₆: To test for a significant difference in the extent of WCM practices, principles and techniques considered to be a key focus for achieving world class status between SSEs and MSEs.

H₀: μ₁-μ₂ = 0; i.e., there is no significant difference between SSEs on each of the WCM practices, principles and techniques considered to be a key focus for achieving world class status and those of MSEs.

Hₐ: μ₁-μ₂ ≠ 0; i.e., there is a significant difference between SSEs on each of the WCM practices, principles and techniques considered to be a key focus for achieving world class status and those of MSEs.

H₇: To test for a significant difference in the extent of WCM practices, principles and techniques considered to be a key focus for achieving world class status between MSEs and LSEs.

H₀: μ₁-μ₂ = 0; i.e., there is no significant difference between each of the WCM practices, principles and techniques considered to be a key focus for achieving world class status of MSEs and LSEs.

Hₐ: μ₁-μ₂ ≠ 0; i.e., there is a significant difference between each of the WCM practices, principles and techniques considered to be a key focus for achieving world class status of MSEs and LSEs.

H₈: To test for a significant difference among demographic profile of the manufacturing companies with regard to the implementation of WCMS (i.e., WCM Practices, Lean Initiatives, TQM Principles, and IT Systems/Applications)
\( H_0: \) There is a significant difference on the achievement of competitive advantage between small, medium and large scale manufacturing plants in Chennai.

Note that the hypotheses are stated as alternative hypotheses. These hypotheses will be tested empirically in the following sections based on data collected within the research study.

3.4 AREA OF STUDY: CHENNAI-THE PANORAMA

Tamil Nadu is amongst the well developed states in the country in terms of industrial development. Tamil Nadu is the southern-most state of India, which lies in the peninsula between the Bay of Bengal in the East, the Indian Ocean in the South, the Western Ghats and the Arabian Sea on the West. Tamil Nadu adjoins Karnataka, Andhra Pradesh and Kerala in the North and West. In the post-liberalisation era, it has emerged as a front-runner for attracting a large amount of domestic and foreign investment. The state’s literacy rate is one of the highest in India. The robust overall economic development has been significantly aided by industrialisation. The state has always had a strong manufacturing culture, which has been instrumental in attracting investments in the manufacturing sector, in particular automobiles, electronics and textiles. Several multi-nationals such as Ford Motors of USA, Hyundai of Korea, St. Gobain of France and Nokia of Finland have established their units in Tamil Nadu. Chennai is emerging as a South Asian manufacturing hub in South Asia. The Chennai is home to one of the largest automotive component industries in India.

A sizeable number of international auto giants have made Chennai their manufacturing base. Hyundai, Ford, BMW, Nissan, etc have set up their manufacturing facilities in and around Chennai. Electronics manufacturing has also seen significant activity in the recent past in Chennai with companies
like Nokia, Flextronics, Motorola, Sony-Ericsson, Foxconn, Samsung, Cisco, Dell, Ericsson, etc have chosen Chennai as their South Asian manufacturing hub. The state capital is considered an ideal location for manufacturing projects.

Chennai has been successful in spreading economic activity across all areas, which has enabled all-round development. The state government has implemented a number of policy initiatives to facilitate growth in the manufacturing sectors. Infrastructure has also been upgraded to meet the spurt in industrialisation. Chennai has become the chosen destination for FDI into India, thanks to a number of investor-friendly policy measures such as single window clearance. The state capital has modern ports (with container handling facilities) and airports with direct links to Europe and East Asia. Chennai Harbour is rated number one in terms of efficiency with turnaround time of less than a day. Chennai occupies a vantage position for trade and commerce. The following are its locational advantages:-

- A modern harbour with container handling facilities, with an additional port at Ennore to handle dirty cargo like coal and iron ore;
- Climate that permits port operations throughout the year;
- International airport connecting Europe, USA, Middle East, and the Far East;
- A network of excellent financial institutions and banks;
- Modern telecommunication facilities;
- Convenient connections to the rest of the country through air, rail and highway network.
The state capital has a well dispersed manufacturing base. It also has a fair share of both public and private sector units. Many heavy engineering and manufacturing-based companies are centred in and around Chennai. The state capital boasts the presence of global vehicle manufacturing giants like Ford, Caterpillar, Hyundai, BMW and Mitsubishi as well as large domestic players like MRF, TI Cycles of India, Ashok Leyland, Royal Enfield, TAFE Tractors, and TVS. The state capital is at the forefront in attracting many key industries having business potential as: automobiles and heavy vehicles, auto components, electronics, railway coaches, power pumps, cement, textiles, etc.

Chennai has made significant progress in developing both social and physical infrastructure. There is a significant rise in the levels of education and healthcare. With the state government’s thrust on encouraging private sector participation in the process of infrastructure development, there has been a rapid expansion of highways, and capacity enhancement of ports. Chennai is the known as the healthcare capital of India with world-class hospitals and specialty clinics. It is emerging as an important medical hub in South Asia. Chennai international airport, the third largest in India, has a separate domestic terminal. Chennai has a well established Suburban Railway network and is in the process of developing a metro.

3.5 POPULATION OVERVIEW

The population for the study consists of the total number of manufacturing firms located in and around Chennai. Therefore, the study was confined to the responses and opinions given by the respondents of the manufacturing sites taken for the survey in Chennai. The area of Chennai was taken for the formal survey as Chennai is emerging as a ‘South Asian Manufacturing Hub’ in South Asia. Chennai, the state capital of Tamil Nadu,
has always had a strong manufacturing culture, which has been instrumental in attracting investments in a plethora of manufacturing sectors.

3.6 RESEARCH INSTRUMENT DEVELOPMENT

The purpose of this study was to investigate the level of implementation of WCM practices, principles and techniques by manufacturing companies in Chennai and to highlight their myopic impressions of what world class manufacturing means to them and how far they come towards achieving that accreditation. In order to achieve the objectives of the study, a survey instrument was developed by the researcher. A total of ten facets was proposed in the questionnaire and they were felt to be most important for the implementation of WCM principles and techniques for achieving world class excellence in the manufacturing operations. They include (i) Understanding of WCM; (ii) Current business priorities; (iii) Current lean initiatives; (iv) Quality management and TQM principles; (v) Information technology; (vi) Equipment and maintenance; (vii) Supplier relationships; (viii) Employee skills; (ix) Competitive advantage; (x) WCM Implementation: Benefits and Obstacles. The constructs and items of the research instrument on WCMS were adapted from previous surveys administered by Flynn et al (1999), Anand Sharma (2005), Ismail and Riyad Eid (2007) and Phan et al (2011). For scoring purpose, a five-point Likert scale was employed with a score of 1 relating to lowest value and 5 relating to highest value.

The development of the research instrument was mainly based on new scales, because the researchers could not identify any past studies directly addressing all of the issues discussed in this research. However, and wherever possible, the researchers used validated measures that have been previously applied. The constructs, scale items and factor loadings obtained from exploratory factor analysis are presented on the data analysis section.
Two consecutive rounds of pre-testing were conducted in order to ensure that the respondents could understand the measurement scales used in this study. First, the questionnaire was reviewed by the academic researchers experienced in questionnaire design and development and next, the questionnaire was piloted with WCM experts known to the researchers. The process of developing the questionnaire also included a pilot study.

3.7 PILOT SURVEY

The purpose of the pilot study was to ascertain whether the data collected has any relevance to the objectives framed for the study and also to test the validity of the questionnaire and its responses. A pilot survey is a small scale replica and rehearsal of the main survey. The pilot study enables the researcher to acquire prior knowledge about the population to be sampled. In pilot study, the researcher may do some field observations and undertake some sort of preliminary survey. This pilot study was used to modify and eliminate the number of research variables needed for the study. Experts from industries and academics were also consulted during the pilot survey.

Having validated the questionnaire through expert validation, a pilot survey of 13 production engineers and 12 plant supervisors was conducted in 15 manufacturing sites to check the validity of the questionnaire and to draft an effective questionnaire. All the selected companies for the pilot study had implemented at least one of the WCM principles and techniques at least one year ago. The pilot work took in the form of personal interview/face-to-face interview where the participants were first handed a copy of the questionnaire and asked to complete it followed by a discussion on any comments or questions they had with respect to major issues of this study.
The outcome of the pre-testing process was a slight modification and alteration of the existing scales, in light of the scales context under investigation. The pilot work was undertaken at manufacturing sites located in Chennai. Based on the results and comments from the pilot tests, revisions were made to the questionnaire design. A structured questionnaire was used for this complex research project. A copy of the self-administered questionnaire was appended in Appendix 4.

3.8 INSTRUMENT VALIDITY AND RELIABILITY

Discriminant validity was assessed using factor analysis. The 57 items (variables or indicators) measuring the WCM Practices, Key Business Priorities, Lean Initiatives, TQM Principles, and IT Systems/Applications were subjected to principal component factor analysis. Eigenvalues and scree plot were used to determine the number of factors to be extracted. Moreover, in order to ensure the use of factor analysis, the Berlett Test of Sphericity (BTS) and Kaiser-Meyer-Olkin (KMO) test of appropriateness were carried out accordingly (Table 4.11).

The results (BTS was 628.716 and the level of significance at P=0.000 for WCM Practices Construct; BTS was 1455.903 and the level of significance at P = 0.000 for Key Business Priorities Construct; BTS was 1098.639 and the level of significance at P = 0.000 for Lean Initiatives Construct; BTS was 1470.772 and the level of significance at P = 0.000 for TQM Principles Construct; and BTS was 996.200 and the level of significance at P = 0.000 for IT Systems/Applications Construct) indicated that the data are appropriate for the purpose of factor analysis. Statistically, this means that there exist relationships between the variables and that they can be appropriately included in the analysis (Bryman 1989). The results of sampling adequacy were 0.916, 0.950, 0.928, 0.958 and 0.905 for WCM Practices Construct, Key Business Priorities Construct, Lean Initiatives
Construct, TQM Principles Construct, and IT Systems/Applications Construct respectively which, following Kaiser-Meyer-Oklin (KNO) measure of sampling adequacy, reflected high degree of sampling adequacy.

The 57 items loaded on the five single factors each as suggested using the criteria of an eigenvalue greater than 1 and the extracted factors account for 54.551 of the total variance for the first single factor construct of WCM Practices, the extracted factors account for 70.802 of the total variance for the second single factor construct of Key Business Priorities, the extracted factors account for 59.812 of the total variance for the third single factor construct of Lean Initiatives, the extracted factors account for 53.655 of the total variance for the fourth single factor construct of IT Systems/Applications and the extracted factors account for 79.106 of the total variance for the fifth single factor construct of TQM Principles (Table 4.11).

A varimax rotation was also performed. All items loaded onto the expected factors as they were originally designed. Factors loading were higher than 0.5 on its own factors. As suggested by Hair et al (1998), a factor loading higher than 0.35 is considered statistically significant at an $\alpha$ level of 0.05. The reliability of the research constructs and concept variables was assessed by the Cronbach $\alpha$ reliability coefficient and exceeded Nunnally’s recommended minimum Cronbach’s alpha coefficient reliability of 0.70 for research (Nunnally 1978), which was used to test the reliabilities of each factor. Thus, the research constructs and concept variables with the alpha value of more than 0.70 show an adequate level of reliability. (Table 4.13).

3.9 DATA SOURCE

In order to achieve the objectives of the study and test the forgoing hypotheses, data were collected from the manufacturing firms on the WCMS. The primary data were collected by interacting with the production
engineers/plant managers or plant supervisors on various facets of World Class Manufacturing System (WCMS). They may include WCM Attributes, Key Business Priorities, Key Lean Initiatives, TQM Principles, IT Systems/Applications, Maintenance Practices, Supplier Relationships, Employee Skills, Competitive Analysis, WCM Drivers and WCM Obstacles. For this purpose, a self-administered questionnaire was used to collect the primary data via personal interview. The questionnaire was fine tuned during the pilot survey. Secondary data about the various facets of WCMS were collected from the rich websites and the research papers carried out previously in this area. The secondary data about the respondent companies were obtained from their websites and directories.

3.10 SAMPLING PROCEDURE

The survey reported here was conducted at manufacturing companies located in and around Chennai. After having validated the questionnaire through expert validation and pilot testing, this study was carried out at 150 manufacturing firms. The survey population of this study was defined as all manufacturing companies located in and around Chennai. The researcher has visited 150 manufacturing companies in different industrial context based on purposive sampling (or) judgmental sampling cum area sampling technique from the Directories of SIDCO Industrial Estate, Ambattur; SIDCO Industrial Estate, Kakkalur; SIPCOT Industrial Park, Sriperumbudur; MSME Development Institute, Guindy; Chennai Metropolitan Development Authority (CMDA), Egmore; and Madras Export Processing Zone (MEPZ), Nungambakkam.

Purposive sampling is a form of convenience sampling in which the population elements are selected based on the judgment of the researcher. Area sampling is a common form of sampling technique, in which the areas consist of geographic areas such as districts, states, countries and housing
tracts or blocks. The researcher has adopted purposive cum area sampling technique in selecting the sample elements. For instance, the researcher samples the areas in and around Chennai and then the manufacturing firms within the selected areas are included in the sample size.

The formal survey, through the personal interview/face-to-face interview by the researcher in person and via phone and mailed questionnaire, was carried out within fourteen months from July 2010 to August 2011. Although the response rate was initially not encouraging, various tactics were used to improve the response rate including meeting the respondents in leisured time, providing a stamped self-addressed envelope, and having a constant follow-up for mailing the questionnaire. As a result, a total of 125 usable and productive questionnaires were collected and this procedure resulted in 83.33 percent overall response rate, which the researcher felt to be reasonable for this kind of study. Thus, the sample size of the study is confined to 125 manufacturing companies. Each manufacturing firm represents one sample unit for the study. The analysis was performed using both SPSS Statistic 17.0 and AMOS 18.0 applications.

3.11 SAMPLING FRAME

The first aspect of the sampling frame was that the general profile of the respondents was analyzed categorically. In the business world, manufacturing companies are generally classified as small-scale, medium-scale and large-scale companies. Any manufacturing company across the world can make this classification based on its scale of operations and production capacity. The manufacturing firms involved in this study were ranged from small to medium to large companies.

The data required for the subsequent analyses in the present study were gathered through the field survey using structured questionnaire and
facilitating personal interview/face-to-face interview with the respondents from manufacturing companies focused on company characteristics; WCM practices, principles, and techniques; management style; and organizational cultures to be undertaken for implementing world class manufacturing system effectively. The target respondent in each company was the production engineer/plant manager or plant supervisor. The production engineers/plant supervisors of each sampled plant were contacted and requested to solicit the firm’s participation in the study. On the basis of detailed interactions the researcher had with the respondents in the survey, the questionnaires were field up without having any personal biases. The frequency of sample respondents was normally distributed among demographic profiles of the manufacturing companies.

3.12 CHALLENGES ENCOUNTERED DURING THE PHASE OF DATA COLLECTION

The researcher had faced a lot of challenges in collecting data and information from the production engineers/plant managers or plant supervisors. The respondents whenever the researcher approached were very busy with their day-to-day official commitments and tight schedule. In order to get the questionnaire filled up, the researcher has to meet certain respondents more than five times in spite of fixing prior appointments. Some of the respondents declined to furnish information without the approval of the management. In a few cases, the appointments given by the respondents were abruptly cancelled and the researcher has to seek afresh for the study. Initially the response rate was not healthy, the researcher employed several tactics to improve the response rate from the respondents. They include (i) meeting the respondents in leisured time, (ii) providing a stamped self-addressed envelope, (iii) having a constant follow-up for mailing the questionnaire, (iv) waiting for a long time in the company premises for collecting the filled
questionnaires and (v) Tamil translation was carried out for better understanding of questions by the respondents.

3.13 SUMMARY

The prime objective of this study was to investigate the degree of implementation of WCMS considered to be the key weapon by manufacturers in the journey towards becoming world class. In order to achieve this objective, a survey instrument was developed and modified after having validated the questionnaire through expert validation and pilot testing. A total of ten constructs were proposed, which were felt to be important for WCM implementation. For scoring purpose, a five-point Likert scale was employed. A sample of 150 firms at different manufacturing context was selected based on purposive sampling cum area sampling technique from the directories of SIDCO, SIPCOT, MSME, CMDA and MEPZ. The data used for the subsequent analyses were gathered through a field survey using self-administered questionnaires and facilitating face-to-face/personal interviews with production executives or plant supervisors. This procedure resulted in 125 useful responses or a 83.33 percent overall response rate. Thus, the sample size of the study is confined to 125. Each manufacturing organization represents one sample unit for the study. The responses were analyzed using both SPSS Version 17.0 and AMOS 18.0 statistical packages.