A Dissertation Entitled

Effect of Manufacturing and Information Processing Competences on

Realized Manufacturing Strategy and Performance

by

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An Abstract of

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This is an empirical investigation in the area of manufacturing strategy implementation. This research investigates the relationship of manufacturing and information system competencies with the implemented manufacturing strategy and with performance. Since implementations of manufacturing strategies are carried out at the plant level, this research will confine itself to the manufacturing context at this level.

This research is an attempt to fill the research gap in different arenas in manufacturing strategy research. First, it will add to the very few empirical investigations in the manufacturing strategy area. The lack of such investigations is considered a hindrance in the theory building efforts. Secondly, the interactions between the manufacturing and information processing technologies are vital to

understanding manufacturing strategy in modern manufacturing entities. There is paucity of empirical research in this arena. Thirdly, although it has been realized that superiority in technology does not guarantee superior capabilities and, resource based view can be utilized adequately define capabilities, only few manufacturing strategy researchers have actually adopted this view. There is one (to the best of our knowledge) empirical research (with large-scale date collection) in this important subject. Aside from those, this research also clearly distinguishes between the implementation and the formulation of strategy, and investigates the role of competencies and their impact on the strategy in the implementation. It also develops a well rounded performance measure, to incorporate all the financial and non-financial performance.

This research reviews literature in areas including manufacturing strategy, resource- based view and performance measures, and develops a model. According to this model manufacturing competence and information system competence directly affect implementation of manufacturing strategy at the plant level and in turn, the performances are impacted by the extent to which manufacturing plants are able to implement the manufacturing strategy. The model is empirically tested with the data collected from 207 manufacturing plants in the mid-west region of the United States of America.

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Chapter One

Introduction

This is an empirical investigation in the area of manufacturing strategy implementation. This research investigates the relationship of manufacturing and information system competencies with the “implemented” manufacturing strategy and with performance. Since implementations of manufacturing strategies are carried out at the plant level, this research will confine itself to the manufacturing context at this level.

1.1 The need for Empirical Research in Manufacturing Strategy:

Although Skinner’s (1969) study revealed that the manufacturing strategy was the missing link in the corporate strategy (Skinner, 1969), manufacturing strategy research picked up speed only after the 1990’s (Dangayach and Deshmukh, 2001). Even then, many studies were conceptual and prescriptive in nature (Minor et al., 1994), and the need for empirical research in manufacturing was strongly felt. Lack of “empirical research” had effectively hindered “theory building” in manufacturing (Adam and Swamidass, 1989; Minor et al. 1994; Swamidass, 1991). Empirical research seems to have increased recently, but still many of the studies are exploratory (Dangayach and Deshmukh, 2001), indicating that empirical research (and hence “theory building”) in manufacturing is in its early stage.

1.2 Competition and the Role of Technologies and Capabilities

Before 1990’s when research in manufacturing started to gain momentum, American manufacturers had already lost their dominance in the world and also the domestic steel market (Grant, 1991). Similar stories can be repeated for the consumer electronic industry and the auto industry. The auto industry, which was dominated by giants and pioneers like General Motors and Ford, lost ground to the smaller and nimbler Japanese competitors like Toyota and Honda, who happened to début very late (Womack, Jones and Roos, 1990; Chanaron and Lung, 1999). It was observed that the “technological supremacy” of American manufacturers could not stop the erosion of their dominance in the marketplace (Grant, 1991).

A rise in competition among the manufacturers has emboldened customers and made them increasingly demanding and, as a consequence the level of competition itself is elevated. Before, manufacturers could focus either on low cost or on high quality. Now cost leadership, high quality, delivery speed, flexibility and new product development have all become increasingly important priority issues for manufacturers (Fine and Raff, 2000; Pine, 1993; Baldwin and Clark, 1990; Hill, 1994; Berry and Hill, 1992; Doll and Vonderembse, 1987).

Newer technologies (computer integrated manufacturing (CIM), advanced manufacturing technology (AMT)), which besides carrying out the manufacturing activities also use the power of the computer to manage, track and supervise them (i.e. Manufacturing activities), are being developed and deployed (Boyer et al., 1997). Many authors have strongly emphasized the potential of such technologies to provide flexibility, shorter production cycle, low cost and high quality, and suggested that these technologies should be used to effectively ward off the pressures brought in by foreign competitors (Doll and Vonderembse, 1987).

Examples of brilliant successes with the adoption of these technologies have been widely publicized. As a result, manufacturers invested millions in acquiring these technologies. However, for every publicized success story there are many failures and disappointments (Boyer et al., 1997; Frohlich, 1998). Besides losing millions of dollars in misconceived projects, these failures have left the managers scrambling for means to effectively defend themselves against challenges posed by foreign competitors (Economist 2003; Stratman and Roth, 2002; Hayes and Pisano, 1994).

Because of these confusions, it is important for manufacturing strategy research to focus on the specific issues, such as competencies, and see how these competencies lead to the achievement of the specific priorities (Hayes and Pisano, 1994; Minor et al., 1994). Superior capability in manufacturing is not guaranteed by superiority in technology alone (Grant, 1991), and similarly, excellence in communication, coordination and control is not assured just by the deployment of advanced computers (Bensaou and Earl, 1998). On the other hand, Japanese with seemingly inferior technologies (when compared to their American counterparts) developed superior competencies in manufacturing as well as in information systems (communication, coordination and control) (Grant, 1991; Bensaou and Earl, 1998; Womack et al., 1990). Technologies, on their own, can only be poor proxies of the competencies.

Competencies, which are the unique combination of technology, learning, knowledge, experience and skills, allow organizations to achieve their competitive priorities (Grant, 1991; Coats and McDermott, 2002; Schroeder, Bates and Junttila, 2002). This is the resource-based view of the firm (Wernerfelt, 1984; Barney, 1991; Barney, 2001; Barney et al., 2001; Grant, 1991; Dierickx and Cool 1989; Cooner, 1991). Two competencies that are required for manufacturing plants are manufacturing competence and the information system competence (which is managing, tracking and supervising manufacturing activities) (Boyer et al., 1997; Kotha and Swamidass, 2000).

Although there is agreement among researchers that manufacturing strategy can best be analyzed taking the resource-based view (Grant, 1991; Gagoon, 1999; Dangayach and Deshmukh, 2001), there is still a dearth of empirical research that actually operationalizes this concept.

1.3 Manufacturing Strategy: Formulation and Implementation

Manufacturing strategy can be defined in terms of competitive priorities, which are cost, quality, delivery speed, flexibility and new product development (Skinner, 1969; Fine and Hax, 1985; Kotha and Swamidass, 2000; Minor et al., 1994; White, 1996; Droge et al., 1990). Cost and quality are together considered "qualifiers" for plant when competing in the marketplace for receiving "orders" (Hill, 1994; Berry and Hill, 1992). Now, since companies place orders only to the plants that belong to their network of supply chains, the supply chain integration has effectively become another important "qualifier" (Ching et al., 1996). Consequently supply chain integration issues should be included in the competitive priorities at par with other priorities (Rosenzweig, Roth and Dean, 2003).

Manufacturing strategies are formulated at headquarters. Implementations are the responsibility of the plant managers (Swamidass, 1986). Implementation of strategy is the realization of the goals set in terms of competitive priorities. It is only the implementation of strategies that leads to performance (Dobni, 2003). It is thus surprising that there is scarcity of empirical research that inquires manufacturing managers, at the plant level, about strategy implementation (Kathuria, 2000). Our research makes a clear distinction between "formulation" and "implementation" of strategy (Mintzberg, 1978; Roth and Miller, 1992), and focuses the empirical inquiry on implementation.

1.4 Performance

Finally, another very important aspect in manufacturing strategy research is to measure performance. There are as many performance measures as there are studies. Some have measured performance in terms of manufacturing productivity (example Narasimhan and Jayaram, 1998), and others have used customer satisfaction for the same purpose (example Tu et al., 2001). In spite of the keen interest of manufacturing managers, not many studies have addressed the impact of manufacturing strategy on the financial performance (Minor et al. 1994). Recent studies such as Kotha and Swamidass (2000) measured performance in terms of financial performances.

Aside from that, it is not necessary that improvement in one aspect of performance (for example productivity) leads, by default, to improvements in other (customer satisfaction or financial performance) aspects of performance. All three performances (productivity, customer satisfaction and financial performance) are related but not always in the same way. Therefore, multidimensional scales (measuring productivity, customer satisfaction and profitability) have been suggested to measure performances in strategy studies (Hitt and Brynjolfsson, 1996; Anderson, Fornell and Rust, 1997).

It was suggested some time ago that strategy research should include, in its measurement of performance, a measure that monitors the overall business (Venkatraman and Ramanujam, 1986). Recently the concept of “real option” has been put forward as the measure to assess such concerns (Amram and

Kulatilaka 1998), which it is said, also represents a major portion of the value of business in many instances (Venkatraman and Henderson, 1998). For example, if the organization has acquired “option” on the basis of its product development ability, it can bring out the new product and enter the new market at the time of its choosing, but it is not under any obligation to do so. Option gives flexibility to organizations to make and implement strategies. This research will also develop a multidimensional performance measure taking note of all these facts.

In short, this study is a step towards addressing the current gap in manufacturing strategy research. Theoretical, as well as practical, significance of this research depends on its ability to operationalize the concept of (manufacturing and information system) competencies, and show their relationship to the “implemented” manufacturing strategy and hence the performance.

Chapter Two

Literature Integration and Model Development

In this chapter we first present the conceptual model. Then, the theoretical rationale behind this model is disused. The model shows the relationships between strategies, competencies and performance, strictly within the context of a manufacturing organization. While doing so, it clearly distinguishes between "formulation" and "implementation" of manufacturing strategy. Aside from that, the model also breaks down the competencies that are available into "manufacturing competence" and "information system competence."

Once the model is developed we present hypotheses (and rationale behind those hypotheses) for the part of the model which is empirically tested.

2.1 The Conceptual Model

The conceptual model is presented in figure 2.1. According to this model formulated manufacturing strategy, whose dimensions are cost leadership, quality, flexibility, delivery speed, new product development and supply chain integration, affect the firms' decision to acquire and / or develop resources. Resources consist of technology, skills and experience. These resources together form competencies. Competencies that are of concern in this research are "manufacturing" and "information system." Each of these competencies is expected to have direct and positive impact on organizations' abilities to realize manufacturing strategy. The realized manufacturing strategy will directly affect the performance. Performance consists of customer satisfaction, productivity, growth, profitability and acquisition of real option.

As discussed above, competencies at the manufacturing plant level determine the extent to which the strategy is implemented, and performance is influenced by the extent to which manufacturing strategy is implemented.

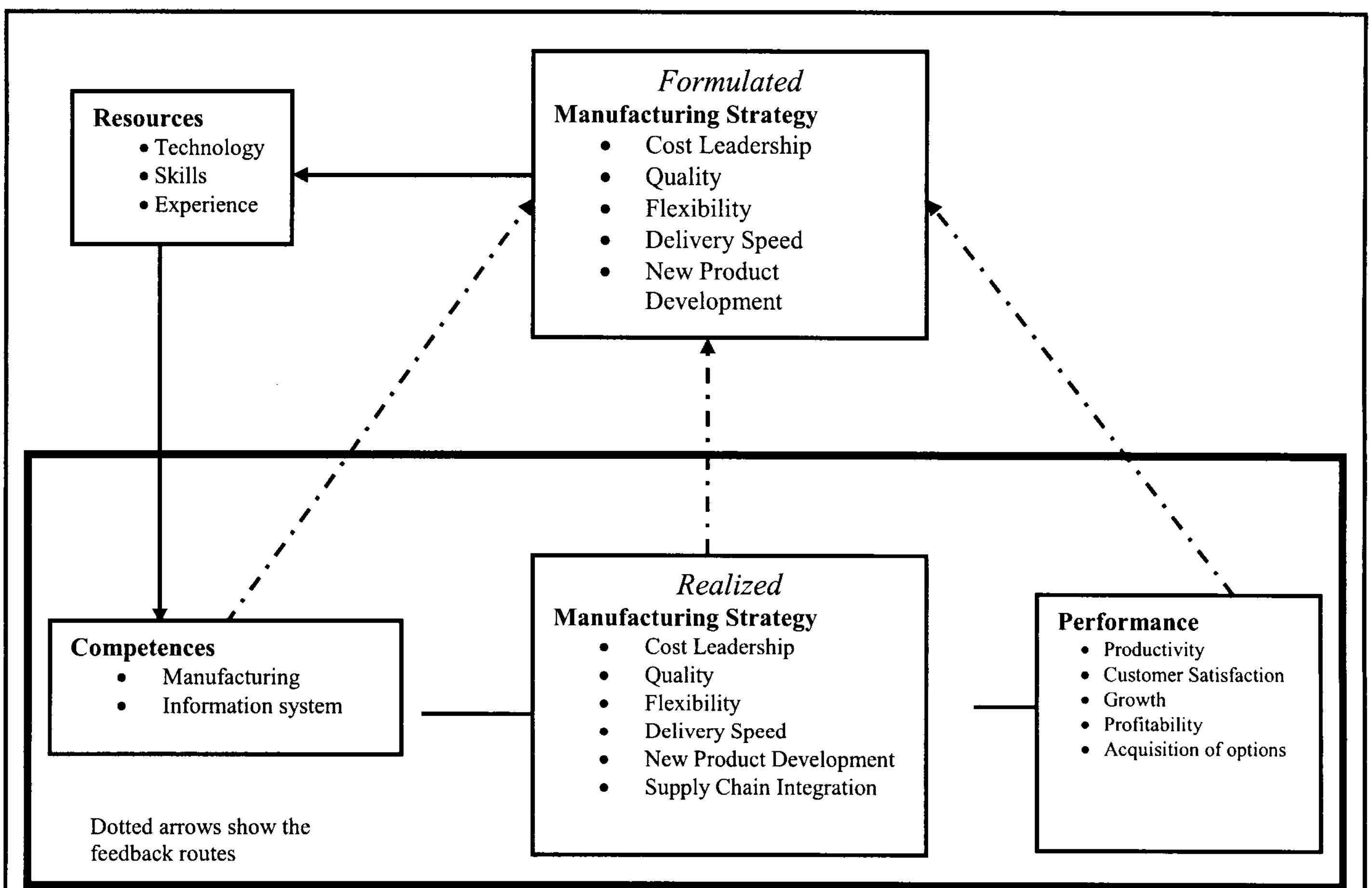


Figure 2.1: The Conceptual Model

The part of the model inside the dark box is tested empirically in this study. The rationale for focusing empirical examination in this part only follows. First, even though manufacturing strategies are realized at plant level, there is paucity of research from the plant perspective (Kathuria, 2000). Second, research into implementation aspect of strategy is conspicuously absent. And, there has been abundance of research relating formulated strategy to performance, notwithstanding the fact that the direct relationship is between the strategy implementation and performance (Dobni, 2003; Dobni and Luffman, 2003).

2.2 Manufacturing Strategy Content

Manufacturing strategy was described in terms of cost, quality, delivery speed and flexibility by Skinner (1969) in his seminal article. Many studies taking their cue from this article have described manufacturing strategy in terms of this strategy content (White, 1996b). Studies by Fine and Hax (1985) or Narsimahan and Jayaram (1998) are some of the examples.

It is also found that manufacturers in different parts of the world (United States, Europe and Japan) described their competitive priorities in terms of this strategy content (cost, quality, delivery speed and flexibility), although the principal priority of manufacturers in one geographic region is different from those in other regions. Europeans seem to give highest priority to “quality” while the Japanese preferences are “flexibility” and “cost.” Priority depends on the level of excellence already achieved by the manufacturers. Ability to supply high quality outputs consistently is the first step in achieving excellence in manufacturing (DeMeyer et al., 1989; White, 1996).

Similarly, Hill (1994) suggests that good quality in production within reasonable cost used to be an “order winner.” Now since all the major players have achieved “quality,” it is merely a “qualifier” for manufacturers to be in the game. With time, importance of priorities like “delivery speed” and “flexibility” is increasing, along with those of “cost” and “quality.”

Meanwhile, competitive priority has been elaborated and extended. First, extensive research has been carried out focusing on individual priorities, especially “quality” and “flexibility.” As a result, quality itself has been extended to eight dimensions, which are performance, features, reliability, conformance, durability and perceived quality (Garvin, 1984). Similarly, dimensions of flexibility are volume flexibility, materials flexibility, mix flexibility, modification flexibility, change over flexibility, rerouting flexibility and flexibility responsiveness (Gerwin, 1993; DeSouza and Williams, 2000; Zang et al., 2003). And secondly, researchers investigating the manufacturing strategy as a whole have extended the list of competitive priorities to include priorities besides cost, quality, delivery speed and flexibility.

One of the important additions to the list of competitive priorities is “new product development” (Dangayach and Deshmukh, 2001). Recent manufacturing strategy research (Kotha and Swamidass, 2000; Noble, 1995) has included this along with other priorities. It is found that Japanese automakers are ahead of their American counterparts not just in cost, quality, delivery speed and flexibility, but also in “new product development.” And, their strength in new product development, have enabled them to wrestle market share and improve profitability significantly (Clark and Fujimoto, 1991; Womack et al., 1990). Recently, Toyota has overtaken Ford as the number two automaker in the world (in terms of number of cars sold) (BBC, 2004). In terms of profit margin (per car) it has been ahead of both GM and Ford since many years (Shimokawa, 2000). Innovation (new product development) has been described as a new “religion” for industry (Economist, 1999).

The list of competitive priorities includes other priorities as well. One prominent study, done by Miller and Roth (1994), lists eleven priorities. This list consists of low cost, design flexibility, volume flexibility, quality conformance, product performance, speed of delivery, delivery dependability, after sales service, advertising, broad distribution and broad product line.

Similarly, Droge et al. (1994) came up with an extensive list of priorities, including those listed above and more. They had total of thirty-one competitive priorities in their list. In their research they also asked manufacturers to rate each of those priorities, on the basis of importance and the extent of their responsibility. From the analysis of the research we can find that some priorities such as design and volume flexibility can be considered as one. In addition, other priorities such as advertising are not the responsibility of manufacturing. At the same time, manufacturing on its own has almost total responsibility for conformance quality. For “new product development” even if marketing bears heavy responsibility, manufacturing’s responsibility is significant as well (Droge et al, 1994; Vickery, 1991; Vickery et al., 1993). So, cost, quality (conformance), delivery speed, flexibility and new product development are the competitive priorities that manufacturers deemed sufficiently important, and also felt implementation of which are within the domain of their responsibilities.

Porter grouped strategy into cost leadership and differentiation (Porter, 1980). Empirical researchers who have operationalized Porter’s generic strategy have used these competitive priorities (cost, quality, delivery reliability, flexibility and new product development) as the underlying dimensions (Dess and Davis, 1984, Kotha and Swamidass, 2000; Frolich and Dixon, 2001).

There may be a question as to whether manufacturers should strive to achieve excellence in each of these priorities simultaneously. Skinner (1969) and Porter (1980) argued for “tradeoff”, asserting that no firm can excel in multiple dimensions of priorities simultaneously. But, Deming (Deming, 1994, 1994b and 1993) argued that low cost and high quality can be achieved simultaneously. DeMeyer et al. (1989) and Hill (1994) at the same time imply that manufacturers build excellence in their priority areas sequentially. For example, achievement of excellence in quality can lead to the excellence in delivery speed, and then flexibility and so on. The concept of “qualifiers” and “order winner” points out that manufacturers should strive for excellence in each of the priority areas. Success of Japanese manufacturers in realizing leadership positions in cost, quality, delivery reliability, flexibility and new product all at once (Womack et al., 1990) supports these arguments, and also sets the standard for all the manufacturers.

Therefore, cost, quality, delivery speed, flexibility and new product development will be the competitive priorities that will be considered in our paper. We have also added “supply chain integration” in the list of competitive priorities, the rationale of which will be discussed below.

2.3 Supply Chain Integration

The important issue in supply chain is that of integration between buyers, suppliers and customers. Many organizations have come to identify the time and cost associated with acquisition of supplies from market as a waste. This process strains the information processing capacity of the organization by increasing the processing need (Mendelson and Pillai, 1998) and, the cost associated with this makes the process economically unviable as well (Womack et al., 1990).

On the other hand, the so-called “Dell model” minimizes the cost described above, by maintaining a coordinated channel of order, production and delivery (Fine and Raff, 2000; Chakravarty, 2001; Rosenzweig, et al., 2003; Frohlich and Westbrook, 2001; Frohlich, 2002; Narasimhan and Jayram, 1998; Vickery et al., 2003).

As a result, organizations have purged the number of suppliers they deal with, and buy only from those who belong to the network of supply chains (Sako and Helper, 1999; Ching et al., 1996). As a result plants have to be part of supply chain networks. Being part of supply chain networks can also be considered another "qualifier," along with "cost" and "quality," for selling products. For this reason, we have proposed that supply chain integration be part of the competitive priority of plants, besides the other five (cost, quality, delivery speed, flexibility and new product development.)

2.4 Formulation vs. Implementation of Manufacturing Strategy

In this part we distinguish between the "formulation" and "implementation" of manufacturing strategy. We conclude that formulation of strategy directs the acquisition of resources, which in turn determine the level of "competencies" available to plant managers. Competencies are instrumental in a plant manager's ability to implement strategy. Strategies (both formulated and implemented) are described in terms of competitive priorities discussed above. Strategy implementation is the ability of a plant to achieve these priority goals.

Deming's cycle (Deming, 1994, 1994b; 1993), which consists of plan, do, check and act, clearly distinguishes between planning (formulation of strategy) and doing (implementation of strategy). Mintzberg (1978) conceptualizes strategy as "intended" and "realized." His scheme also shows that not every intended strategy will ultimately be realized. There will be intended strategies that are realized, and there will be those that will not be realized. There will also be those realized strategies that were never intended. Taking a cue from Mintzberg's (1978) study, Roth and Miller (1992) divided the manufacturing strategy into "formulated" and "implemented."

The difference between the intended and implemented strategies can be stressed by a few facts. Strategy implementation has always been more challenging than the formulation (Dobni and Luffman, 2003), and many formulated strategies fail to get implemented. One study shows the rate of failure to be as high as seventy percent (Sterling, 2003). Priorities for strategic goals that are set in a company's headquarters are not found always to be consistent with the priorities of implementers at the floor level. That has been the case for the service sector (Heide et al., 2002) and, also more importantly for our study, the manufacturing sector (Swamidass, 1986; Sterling, 2003). In manufacturing, manufacturing managers at the plant level are the ones who implement strategy (Kathuria, 2000). More importantly, implemented strategy alone leads to performance (Dobni, 2003).

Mintzberg (1978) described the strategy formulation as the outcome of the formal process of defining goals, and also determining actions to be taken in order to achieve these goals. Many researchers in manufacturing strategy described it in the same way (example, Skinner, 1969; Fine and Hax, 1985; Wheelwright and Hayes, 1985). They discussed formulation of manufacturing strategy without making clear the distinction between formulation and implementation. There is also agreement among the researchers that the outcome of this strategy formulation exercise is to acquire and allocate resources (Wheelwright and Hayes, 1985; Minor et al., 1994). This opinion is also consistent with Grant's (1991) resource-based view.

Unlike formulation, implementation of strategy is said to be the outcome of the “pattern of decision making” (Mintzberg 1978). Decision requires the deployment of resources. It is deployment and hence utilization resources that are supposed to be affecting the implementation of manufacturing strategy (Roth and Miller, 1992; Hayes and Pisano, 1985). This view is consistent with the resource-based view of Grant (1991), which states that resources acquired and deployed, as the outcome of strategy formulation processes, will be a determinant of the competencies being employed and that will in turn affect the strategy (implementation). Manufacturing strategy implementation has always been described in terms of manufacturing firms’ ability to achieve the competitive priority goals (Kathuria, 2000; Roth and Miller, 1992).

Competencies available in the plant are utilized to translate the formulated strategy to the implemented one. Strategy formulators (headquarter) as well as plant managers should understand the depth and range of available competencies. This understanding along with plant managers’ ability to exploit the competencies will determine the extent to which the formulated strategy will eventually be implemented (Dobni, 2003).

From these discussions, one can surmise that manufacturing strategy formulation, done at the headquarters level, determines the priorities in strategy goals and also allocates resources. These resources, which will determine the competencies available at the plant, will influence the plant’s ability to implement strategy.

2.5 Manufacturing and Information Processing Competencies:

Manufacturing plants require competence in manufacturing as well as in information system. For example, advanced manufacturing technology, besides affecting the manufacturing activities (designing products and process, and producing), uses the power of computer and information technology in controlling, tracking, planning and supporting these activities (Boyer et al., 1997; Kotha and Swamidass, 2000).

The distinction between competence and technology has been made by researchers for many years. They have pointed out the inability of American manufacturers to translate the superiority of technology to the superiority in competence in manufacturing (Grant, 1991; Womack et al., 1990) as well as in information system (Bensaou and Earl, 1998). Grant (1991) suggested that competence in designing, producing and integrating different skills was what mattered.

Studies have shown that technologies work better when combined with management approaches that utilize teamwork, enhances workers' skills and their empowerment (Boyer et al., 1997, Zuboff, 1988). Others point to the complexity of the advanced manufacturing technology, and suggest different types learning approaches (Frohlich, 1998).

Japanese manufacturers, on the other hand, seem to incorporate technologies that are less complicated (hence easier to learn and adapt) and encourage workers to learn, experiment and adapt. Their workers are empowered, work in teams and possess a much wider range of skills (Ahire and Dreyfus, 2000; Womack et al., 1990). Similarly, Japanese manufacturers seem to be more skilled in identifying opportunities to learn and adapt new skills and technologies, and utilizing such opportunities for the benefit of their organization (Tyre and Orlikowski, 1993).

"Resource-based view" takes note of the facts described above and focuses on the competence available in an organization. Competence, according to this view, is created by different organization's ability to uniquely combine all the resources- technology, experience, knowledge and skills. Therefore, even if the technology may be generic, the competence is unique to each organization (Conner, 1991; Grant, 1991; Wernerfelt, 1984; Diericks and Cool, 1989; Barney, 1991; Barney, 2001). We will use this view and elaborate on manufacturing and information system competencies in the following paragraphs.

Manufacturing Competence: In manufacturing Grant (1991) stated that ability to design, produce and integrate various skills together form manufacturing competence. In one case study by Coats and McDermott (2002) this concept is further elaborated. This study adds the ability to design and enforce quality, and develop software for product testing, to the manufacturing competence list. Software and hardware including machines, tools and equipment (manufacturing infrastructure) have been identified as those embodying the knowledge pertaining to manufacturing (Takeshi, 2002; Fine and Whitney, 1996). One empirical study done in this area (Schroeder, Bates and Junttila, 2002), however, confines the manufacturing competence definition to proprietary knowledge and skills. For our study we have to develop items based on these and other studies and operationalize them.

Information System Competence: The role of information system in controlling, tracking, planning and supporting manufacturing activities has been mentioned above. We are discussing the use of information systems in the context of manufacturing at the plant level. Information system here will be different from the enterprise wide information systems discussed in many studies. Research has shown just having enterprise wide information system does not positively impact the plants' ability to realize the manufacturing priorities. The impact becomes apparent when such a system is utilized in conjunction with the planning, control and operations systems (Hewitt, 1999; Rabionovich et al., 2003). Others have demonstrated that workers' skill level adds to the effectiveness of such systems (Kathuria and Partovi, 2000). Yet, others have found that they become more effective when informal communication methods such as face-to-face meetings and discussions are carried out as well (Boyer et al., 1997).

The "information system competence" is the unique combination of computers and information technologies, planning, control and operation systems, skills, knowledge, experience and informal communication methods. This view can also incorporate the information processing view of Daft and

Lengel (1986) as well. According to the information processing view, data collection and analysis in which computer application is prevalent reduces “uncertainty,” and face-to-face meeting and informal communication reduces “ambiguity.” Reduction of “ambiguity” and “uncertainty” are both required for effective communication.

In the context of manufacturing information systems, both Lee (2003) and Wu and Ellis (2000) have conceptually discussed the attributes of such systems. Other empirical studies have operationalized the information system in a manufacturing context. However, they have done so without subscribing to the resource-based view (e.g. Kotha and Swamidass 2000; Mendelson and Pillai, 1998; 1999). Still others have done the same, while discussing supply chain (Bensaou and Venkatraman, 1995) or new product development (Brown and Eisenhardt, 1995; Koufteros et al., 2002) issues.

In a wider information system context, the need to describe this from a resource-based view has been identified. Bharadwaj (2000) used the resource-based view in the context of management information system. Similarly, Stratman and Roth (2002) developed constructs of enterprise resource planning as per the resource-based views. These studies lend support to our effort in defining the information system with the resource-based view. However, we cannot directly apply their research here because of the difference in contexts on which the information system is used.

We will have to "operationalize" the information system competence, for our study, based on the conceptual foundation and the support of some of the literature discussed above.

2.6 Performance

Implementation of strategy leads to performance. In this section we discuss and find the appropriate performance measures for the manufacturing strategy implementation. We conclude that such a performance measure should be multidimensional, and each dimension should individually influence the value of the business entity. We identify these performance measures to be productivity, customer satisfaction, financial performance (growth and profitability) and the acquisition of options.

As mentioned before there are as many performance measures in manufacturing strategy as there are studies. Some researchers have measured the performance in terms of customer satisfaction (for example, Tu et al., 2001); others have used productivity as the measure of performance (for example, Narasimahan and Jayaram, 1998).

One of the areas, not well addressed in the manufacturing strategy research, is the strategy's relationship with financial performance (Minor et al, 1994). However, it is common for strategy research (other than manufacturing), to show the relationship between the strategy and the financial performance (Capon, Farley and Hoeing, 1990). Therefore, it is just natural that performance measures in the manufacturing strategy research include measures for financial performance as well. Such inclusion also increases the relevance of research from the practitioner's perspective as well (Minor et al., 1994). Some recent studies in manufacturing strategy have used financial performance as the performance measure (example, Kotha and Swamidass, 2000; Kathuria, 2000). Financial performance is mostly represented by profitability and growth (Venkatraman, 1989).

While looking at performance from a financial angle may be a very important consideration, this is not to suggest that this is the only performance measure to be considered. Introduction of technology, and hence the competence related to it, can improve productivity, customer satisfaction, and financial performance. However, the relationships between these different performances (productivity, customer satisfaction and financial performance) are not straightforward, and there is no guarantee that one will lead to the other (Anderson, Fornell and Rust, 1997; Hitt and Brynjolfsson, 1996).

For example, an increase in productivity may lead to an increase in customer satisfaction, but may or may not lead to improved financial performance. One example is in the auto-industry. Parts suppliers in the previous decade have increased their investment in technology (and improved competencies), and they have also improved productivity and customer satisfaction. Because they are dealing with huge and powerful customers (the original equipment manufacturers) they are mostly unable to translate their gains in productivity and customer satisfaction into financial gains. Suppliers have found their profit margin eroding each year (Helper and Sako, 1999).

Therefore, it is suggested that performance measures should be multidimensional, including measures of productivity, customer satisfaction and financial performance (growth and profitability). Each of these performances contribute to the value of organization (Hitt and Brynjolfsson, 1996)

In addition, there is also a suggestion that strategy performance should also be gauged by another measure. This measure should take into account the overall value of business even when there are no changes in productivity, customer satisfaction or financial performance (Venkatraman and Ramanujam, 1986).

Acquisitions of options increase the value of business, without directly impacting cash flow. Options give the holders the privilege to exercise them, if the situation is favorable, but the option holders not under any obligation to do so. For example the option to grow gives the firm the privilege to exercise an option that allows it to grow, if the firm decides the situation is favorable, but it is under no obligation to do so. Excess manufacturing capacity, for example, can give such options to the firm. Black and Scholes' (1973) seminal paper showed the world the way to value such options. Since then, many types of options in business strategy context have been identified and valued. Myers (1984) identified growth options and used the option theory to value such options. Similarly, flexibility of the machine and also research and development are identified as options (Kumar, 1995; 1999). All such options are categorized broadly into growth options, flexibility options, learning options, options to wait and options to exit (Amaram and Kulatilaka, 1999).

Even practitioners have realized the overall value of business that option creates. Recently “Merck” pointed out that a major portion in the value of its business is contributed by real option based in its research portfolio (Sender, 1994). Similarly, recent moves by Kodak are another example of the importance of real options. Kodak has been performing superbly when measured in terms of productivity, customer satisfaction and financial performance in its traditional film based photo business. However, it has realized that its viability as a continuing entity will be determined by how well it can convert itself into a major player in digital camera business, while withdrawing slowly from the film based camera business. In addition, Dell’s move to sell not just computers (whose profit margin is declining) but also accessories such as MP3 players and digital cameras is another example where a firm tries to reinvent itself by entering a new market. Abilities to reinvent themselves as discussed above, and create value for the company, are measured by real option.

Recently, when reinventing has started to become routine rather than the exception, researchers have come out strongly in suggesting that real option be part of the measurement (Venkatraman, 1998; Venkatraman and Henderson, 1995; Amaram and Kulatilaka, 1999). In spite of these important theoretical discussions, options have never (to the best of our knowledge) been used as the performance measure, especially in empirical research.

Based on these theoretical discussions we will have five measures of performance, which are productivity, customers' satisfaction, growth, profitability and acquisition of options.

2.7 The Empirical Test:

The focus of the next few paragraphs will be to describe the model and hypotheses. According to this model (Figure 2.2), manufacturing competence and information system competence (which consists of competencies in uncertainty reduction and ambiguity reduction) directly affect plants' manufacturing strategy implementation. It is to be noted that this model is set up in manufacturing context and the competencies discussed here are those available at the manufacturing plant level where manufacturing strategy implementation is done. The model also states that performances are impacted by the extent to which manufacturing plants are able to implement the manufacturing strategy.

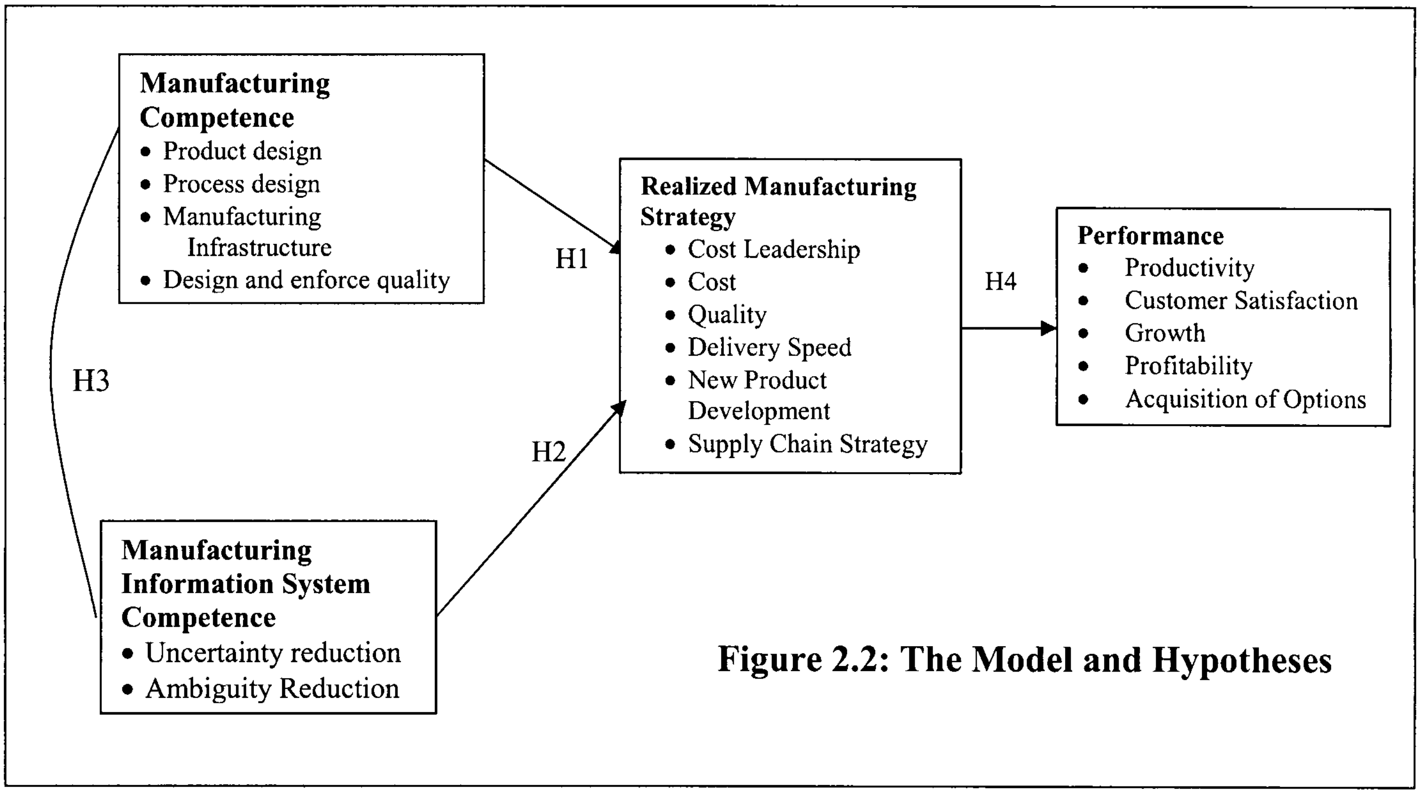


Figure 2.2: The Model and Hypotheses

Realized Manufacturing Strategy:

Kotha and Swamidass (2000) found that manufacturing and information processing systems individually affected the manufacturing strategy. Similarly, others showed that utilization of information systems has direct impact on the supply chain integration (Bensaou and Venkatraman, 1995), and new product development related issues (Bensaou and Venkatraman, 1995; Mendelson and Pillai, 1998, 1999). Other studies also support the notion that information system competence impacts the supply chain management by affecting its integration (Mukhopadhayay, 1998).

Taking the resource-based view, Coates and McDermott (2002), who defined manufacturing competence in terms of ability to design, produce, develop and enforce quality and integrate skills across different disciplines, portrayed it to be the distinctive fundamental competence that determines a firm's ability to achieve competitive priority goals. The competitive priorities were the thirty-one priorities put forth by Droge et al. (1994). Similarly, Droge et al. (1994) also state in their article that competencies should be able to influence an organization's ability to achieve these priority goals.

Fine and Whitney (1996), discussed instances in which manufacturing firms with ability to design and/ or produce goods and also those with the ability to design and/ or produce manufacturing tools, equipments and software have shorter new product development cycles, better quality products or more flexible production systems. These abilities are also shown to have positive impact on a firm's ability to make "make or buy" decision and integrate the supply chain network. These findings and instances lend support for hypothesizing that manufacturing competence directly and positively impact a firm's ability to implement manufacturing strategy.

As already pointed out, these studies differ from ours in important ways. First they took underlying technology, as proxy for capabilities, and second they did not state whether the "strategy" in their case meant implementation or formulation. In spite of these limitations (at least for the purpose of our research), they provide enough support to formulate hypotheses that manufacturing and information system competencies individually have direct impact on the extent to which manufacturing strategies are implemented.

The two hypotheses that our discussion above support are,

H1: Manufacturing competence has direct and positive impact on the implementation of manufacturing strategy

H2: Information system competence has direct and positive impact on the implementation of manufacturing strategy

2.9 Competencies

Literature in "computer integrated manufacturing" or "advanced manufacturing technology" points to the complementary role of "information" and "manufacturing" aspects of technology within them. Both need to grow together; one cannot exist without the other (Boyer et al., 1996; Boyer et al., 1997; Kotha and Swamidass, 2000; Doll and Vondermbse, 1987; Lee, 2003).

One with out the other is incomplete. The low level of manufacturing competence that would spew only standardized output would not require the sophisticated information processing competence that would, for example, estimate the exact demands for every customization. Similarly, a high level of manufacturing competence would not go hand in hand with a rudimentary information system competence. For example, customization is possible because of manufacturing as well as information system competencies. Manufacturing and information system parts of the competencies are required to grow together by influencing and remaining influenced by each other (Fine and Raff, 2000).

Therefore, manufacturing and information system personnel should communicate frequently, and make adjustment to their respective gears and procedures to synchronize with those of others (Gupta, 1999).

Taking the “resource-based view” Conner (1991) stated that, development of manufacturing competence within organizations (which requires interaction between different resources) is also heavily influenced by the operating process, routines and culture prevalent inside it. Similarly, during the process where interaction of resources and experience evolve to give shape to the organization’s manufacturing competence, it also heavily influences operating processes, routines and culture inside the firm.

Based on these discussions, the third hypothesis is

H3: There is a positive correlation between manufacturing and information system competencies.

2.10 Performance

Performance is the outcome of implemented strategy (Sterling, 2003).

Manufacturing strategy (represented by priorities like cost, quality, delivery reliability, flexibility and new product development) has been shown to have positive relationship with the financial performance (growth and profitability) of firms (Swamidass and Kotha, 2000; Kathuria, 2000). Similarly others have demonstrated its positive relationship with customer satisfaction (Narasimahan and Jayaram, 1998; Tu et al., 2001) and with productivity (Narasimahan and Jayaram, 1998).

Other studies have shown the positive relationship between the supply chain and the financial performance (Frohlich and Westbrook, 2001; Frohlich, 2002). Yet others have shown that the supply chain integration is positively related to the productivity (Narasimahan and Jayaram, 1998; Frohlich and Westbrook, 2001) and customer satisfaction (Narasimahan and Jayaram, 1998). The role of new product development to affect growth and profitability has been highlighted by Clark and Fujimoto (1991).

Gerwin (1993) indicated that flexibility would increase the options for the organization. Venkatraman and colleagues have been vocal in advancing positive relationship of supply chain related issues with the acquisition of real options (Venkatraman, 1998; Venkatraman and Henderson, 1998; Kulatilaka and Venkatraman, 2001).

The “real option” literature shows that achievement of every strategic goal will bring forward the options to climb to the next level of achievement (Amram and Kulatilaka, 1998). Few real life examples can also be presented to support the fact. Honda used its excellence in motorcycle manufacturing (cost and quality wise), to enter into the car manufacturing business with the Honda Civic. Recent moves by Kodak and Dell to move into the new market are the other examples of a similar nature.

As already pointed out the studies cited here and our research differ in many significant ways. We, unlike other researchers, distinguish clearly between the "formulation" and "implementation" of strategy. We are focused at the plant level where actual manufacturing takes place. We consider the supply chain as an integral part of the competitive priority. We use a multidimensional measure of performance, instead of choosing one or the other measures in isolation. However, in spite of these differences, the discussions above provide sufficient support to hypothesize that strategy implementation is directly related to performance.

Based on the discussions above, we can present our fourth hypothesis as *H4: The implemented strategy has direct and positive impact on the plant's performance.*

Chapter Three

Research Methods (Pilot Study)

In this chapter, we operationalize the measures for manufacturing competence, information system competence, implemented manufacturing strategy and performance. Because we are using the concept of domain sampling in our measurements, we use multiple items to measure each of the dimensions. Guidance provided by theory, as well as adaptation of measurements used in past research form the basis for these item generations. These items were used in the data collection during the pilot study.

The data collected from the pilot was used to conduct the exploratory factor analysis. All of the constructs that we consider in this study (manufacturing competence, information system competence, implemented manufacturing strategy and performance) are multidimensional. During the factor analysis each dimension is expected to form into one distinct factor. This exercise also provided opportunity to purify and improve upon these factors. We measured the reliability of each of the factors. This exercise also gave indications on which factors are viable, and guided us to improve questions by changing wording, adding entirely new items or dropping items that were considered before but failed to load in any of the factors. The final model for empirical testing was fine-tuned based on the findings of the factor analysis. Similarly, with modifications of the pilot questionnaire (based on the findings of the pilot study), we developed the large-scale survey questionnaire.

3.1 Item Generation

Manufacturing competence: The essence of this construct is to define the manufacturing competence according to the resource-based view. It focuses on what abilities the concerned firms have, rather than just what hardware of software they have acquired. Grant (1991) conceptualized that manufacturing competence should be defined in terms of ability to design, produce and also to integrate various skills. Coates and McDermott (2002) conceptualized manufacturing competence as the ability to design the product, manufacture the product, develop quality related measures and enforce them, integrate different skills and also develop the software to support manufacturing and testing. Fine and Whitney (1996) identified that besides the skills related to design and production of goods and also, design and production of machines, tool and equipment and software were also the requisite capabilities related to manufacturing competence. One empirical research however confined itself to the proprietary skills and knowledge when defining the manufacturing competence (Schroeder, Bates and Junttila, 2002).

While all the studies provided background, we developed items suitable for our purpose in order to operationalize the constructs. Based on these discussions we measured the following dimensions of manufacturing competence: ability to design, ability to produce, ability to improve, skills pertaining to manufacturing machines, tool and equipment and software (manufacturing infrastructure), skills related to quality and ability to integrate skills. The items developed to measure each of these dimensions are shown in Table 3.1.

Table 3.1 Manufacturing Competence	
1. Ability to design	
1	We have the ability to develop specifications for finished goods sold by us
2	We have the ability to develop specifications for parts / subassemblies purchased by
3	We have the ability to design products as per the given specification
4	We have the ability to design the manufacturing process for our products
5	We have the ability to design the manufacturing process for our products
6	Our use of proprietary designs in products compared to our competition
2. Ability to Produce	
7	We are capable of manufacturing parts we need as per specifications
8	We are not constrained by in-house manufacturing capacity
9	We are able to deliver products in right packaging
10	Our use of proprietary manufacturing processes compared to our competition
11	Our manufacturing capacity compared to that of our competition is
3. Ability to Improve	
12	We area able to improve design of products for better manufacturability
13	We are able to continuously improve manufacturing process
14	We are able to improve design of products for better functionality
15	We are able to improve the design of the product to reduce the production cost
16	We are able to improve the manufacturing process of the product to reduce the production cost
17	Our ability to improve products and / or processes compared to that of our competition is

4. Skills Pertaining to manufacturing machine, tools, equipments and software	
18	We have thorough knowledge of one or more of following: machines, tools, equipments, software
19	We are able to design one or more of following: machines, tools, equipments, software
20	We are able to manufacture one or more of following: machines, tools, equipments, software
21	We are able to maintain one or more of following: machines, tools, equipments, software
22	We can improve upon one or more of following: machines, tools, equipments, software
23	Our knowledge and skills pertaining to machine and /or tools and/ or equipments and/ or software compared to that of our competition is
24	Our use of proprietary technology in one or more of the following Compared to that of our competition is: machines, tools, equipments, software

5. Quality related Competencies	
25	We are able to develop our own quality (conformance to specifications) testing
26	We are able to test quality (conformance to specifications) of our products
27	We are able to test quality (conformance to specifications) during our production
28	We are able to test quality (conformance to specifications) of inputs (raw materials and subassemblies)
29	Our quality related competencies compared to that of our competition is
	6. Ability to integrate skills
30	We are able to integrate expertise from different disciplines (e.g. engineering, marketing) during our design and /or manufacturing and /or improvement and /or quality control effort
31	We are able to integrate expertise of different disciplines in engineering (such as electrical, mechanical, chemical etc. and even R and D) during our design and /or manufacturing and /or improvement and /or quality control effort
32	We are able to integrate expertise of outside partners (suppliers and buyers) during our design and /or manufacturing and /or improvement and /or quality control effort
33	We are able to incorporate customers' changing demand on our design and /or manufacturing and /or improvement and /or quality control effort
34	We are able to incorporate changes in our products even before customers can articulate their need
35	Our ability to integrate skills of different fields compared to that of our competition is

Information System Competence: Manufacturing information system competence is divided into “uncertainty reduction ability” and “managers' ambiguity reduction ability,” the rationale for which is already discussed above.

“Uncertainty reduction ability” is another construct that is defined according to the resource-based view. It is again not the measure of what software and hardware the firm possesses, but what ability it has. By discussing what information systems should offer in the manufacturing context, past studies have provided some of the important background for item generation in this research. According to these studies, manufacturing information systems should be able to provide market analysis, support for design and support for manufacturing and control, support for improvement, support for quality design and enforcement, support for networking (Wu and Ellis, 2002; Lee, 2003; Kotha and Swamidass, 2000). The items developed to measure each of these dimensions are shown in Table 3.2.

Table 3.2 Uncertainty Reduction

	1. Market Analysis
1	Our manufacturing information system helps us to analyze the market
2	Our manufacturing information system helps us to forecast the business environment
3	Our manufacturing information system helps us to analyze competitors' strategy
5	Our ability to use manufacturing information system for market analysis compared to
	2. Supports for design
5	We use manufacturing information system while developing design specifications
6	We use manufacturing information system during the product design
7	We use manufacturing information system to exchange relevant information among those involved (both inside the company and with partner companies) during product development
8	We use manufacturing information system to exchange relevant information among those involved (both inside the company and with partner companies) during the
9	We use manufacturing information system for simulation of product performance before the prototype is ready
10	We use manufacturing information system for designing production processes
11	Our ability to use manufacturing information system for supporting design compared to that of our competition is

Table 3.2 Uncertainty Reduction (continued)

	3. Supports for Improvements
12	Manufacturing information system helps us in improving product design
13	Manufacturing information system helps us in improving product functionality
14	Manufacturing information system helps us in improving the production process
15	Manufacturing information system helps us in preventive maintenance
16	Manufacturing information system helps us in routine maintenance
17	Our ability to use manufacturing information system for supporting improvements compared to that of our competition is
	4. Supports for Manufacturing and Control
18	We use manufacturing information system for capacity planning
19	We use manufacturing information system for material planning
20	We use manufacturing information system for scheduling the production
21	We use manufacturing information system for facilitating the cost control
22	We use manufacturing information system for control in the factory floor
23	We use manufacturing information system to automate manufacturing process
24	We use manufacturing information system to make the manufacturing process
25	Our ability to use manufacturing information system for supporting manufacturing compared to that of our competition is
26	Our ability to use manufacturing information system for control compared to that of our competition is
	5. Supports for Quality
26	We use manufacturing information system while designing the quality control
27	We use manufacturing information system for in process quality control
28	We use manufacturing information system for quality control of raw materials/
30	We use manufacturing information system for quality control of finished goods
31	Our ability to use manufacturing information system for supporting quality compared to that of our competition is
	6. Networking
32	We use manufacturing information system for coordination within the factory floor
33	We use manufacturing information system for coordination with our suppliers
34	We use manufacturing information system for coordination with our customers
35	We use manufacturing information system to ensure delivery reliability and
36	We use manufacturing information system to ensure supply (raw materials and / or subassemblies) is received in reliable and predictable manner
37	Our ability to use manufacturing information system for networking compared to that of our competition is

"Manager's ambiguity reducing ability" is the ability to ask the right questions, coordinate activities, improve communications and foster understanding. Managers can do this by meetings, visits, face-to-face communication and planning. These types of activities help in processing the information that can not be done by collection and analysis of data alone. "Ambiguity" reduction has been discussed in the context of new product development (Brown and Eisenhardt, 1995) supply chain management (Bensaou and Venkatraman, 1995) and in many other contexts. The theoretical basis for this concept comes from an article by Daft and Lengel (1984). We used the theoretical basis provided by this study and developed items for each dimension of the construct. The items developed to measure each of these dimensions are shown in Table 3.3.

Table 3.3 Manager's Role in Ambiguity Reduction

	1. Group Meetings and Visits
1	There are meetings between personnel from our department and their counterparts in our customers' organizations
2	There are meetings between personnel from our department and their counterparts in our suppliers' organizations
3	People from our department have seen our products being used by our customers
4	There are meetings between personnel from our department and their counterparts from other departments in our firm
5	Some part of our facility is co-located with that of our suppliers' and / or customers'
	2. Manger's communication role
6	Manufacturing manager communicates frequently with his/ her counterpart in within our
7	Manufacturing manager communicates frequently with his/ her counterpart in partners' (buyers' and/ or customer') organization
8	Manufacturing manager disseminates relevant information from outside (other department with in organization or outside of organization) inside his/ her department
	3. Planning
9	We have long term plan for manufacturing
10	Manufacturing manager contributes to the development of the overall business plan
11	There is no conflict between the long term plan of manufacturing with that of other departments' in our organization

12	Manufacturing manager's role in developing business plan helps to minimize the conflict between the plan of manufacturing and other functions

Items for implemented manufacturing strategy: Manufacturing strategy is defined in terms of cost leadership, differentiation (quality, delivery speed, flexibility, new product development) and supply chain integration.

Items for cost leadership, and different dimensions of differentiation can be found in previous studies such as the ones by Kotha and Swamidass (2000), Kathuria (2000) and Narasimahan and Jayaram (1998). The items we developed for the cost leadership and the dimensions of differentiation are adapted from the ones in the above studies.

On the other hand, although the concept of supply chain has been extensively used, there is no unanimity as to what constitutes a supply chain. The conceptual article of Venkatraman and Henderson (1998), in addition to the studies by Rosenweig et al. (2003) and Frohlich and Westerbook (2001), was also utilized to generate various items in each dimension of the supply chain integration. The items developed to measure each of these dimensions of implemented manufacturing strategy are shown in Table 3.4.

Table 3.4 Implemented Manufacturing Strategy

Cost Leadership	
1	Our inventory level compared to that of our competitors is
2	Our capacity utilization compared to that of our competitors is
3	Our production cost compared to that of our competitors is
4	Productivity of our workers compared to those of our competitors is
5	Price of our products compared to that of our competitors is
6	Overall, we have the cost leadership over the competitors
Differentiation	
1. Quality	
7	Compared to that of competitors, performance of our products are
8	Compared to that of competitors, reliability of our products are
9	Compared to that of competitors, dependability of our products are
10	Compared to that of competitors, our products' conformance to specifications are
11	Compared to our competitors, our ability to compete on the basis of quality is
12	Overall, quality gives us an edge over the competitors
2. Delivery	
13	Compared to that of competitors, our delivery speeds are
14	Compared to that of competitors, our ability to meet delivery promises are
15	Compared to that of competitors, lead time of our production are
16	Overall, delivery gives us an edge over the competitors
3. Flexibility	
17	We are able to make rapid design changes
18	We are able to adjust our capacity quickly
19	We can make rapid volume changes
20	We offer a large number of product features
21	We offer a large degree of product variety
22	We can adjust product mix
23	Overall, flexibility gives us an edge over the competitors
4. New Product Development (NPD)	
24	We have developed new products (on our own, or in conjunction with partners (suppliers or
25	We have played significant role in partner's new product development effort
26	Our NPD related capabilities make NPD cycle shorter
27	Our NPD related capabilities makes ramp up time shorter
28	Overall, our ability in NPD gives us an edge over the competitors

Supply Chain Strategy	
1. Customer Interaction	
1	We can capture relevant information from our interaction with customers
2	We generally make to order rather than make to stock
3	We have ability to customize our product and services as per customers' demand
4	Customers can access and interact with us easily

2. Asset configuration	
5	We base our decision to 'make or buy' on business logic
6	We have applied systematic approach in identifying the subassemblies that can be obtained from our suppliers
7	With outsourcing, we can deploy internal capability to high value added area
8	We have applied systematic approach in identifying the subassemblies that we can provide
9	The interdependent process that are within our organization and outside of it are seamlessly integrated
10	We are able to balance our dependence on our partners with theirs on us
3. Leverage of knowledge	
11	We recognize the importance of knowledge as a source of value creation
12	Our teams and tasks units are effective in leveraging collective expertise
13	We are effective in leveraging the knowledge of partners (buyers and suppliers)
14	Our interactions with customers help us to capture their expertise

Items for performance measurement: The detail of performance measurement is discussed above. As discussed performance measurement consists of multiple dimensions, which are productivity, customer satisfaction, growth, profitability and acquisition of options. Among them productivity, customer satisfaction and financial performance (growth and performance) are extensively used in literature, but option although, discussed and conceptualized, is never operationalized.

We follow the measure used in previous research wherever possible, with suitable adjustments. Productivity has been operationalized by Narasimahan and Jayaram (1998) and that has been adopted here. Similarly, customer satisfaction item follows an article of Tu et al., (2001). Financial performance measures here are adopted from Kotha and Swamidass (2000) and Venkatraman (1989).

The items for option are developed here by taking the cue from the theoretical study of Amram and Kulatilaka (1999). The items developed to measure each of the dimensions are given in the table 3.5 below.

Table 3.5 Performance Measure	
1. Productivity	
1	Comparing today with three years ago, our production cost per unit has decreased significantly (with features and quality remaining same)
2	Comparing today with three years ago, our inventory level has decreased significantly
3	Comparing today with three years ago, level of rework required has decreased significantly
4	Comparing today with three years ago, our manufacturing labor force have become more productive
5	Manufacturing makes significant contribution in the ***profitability*** of our organization
6	Manufacturing makes significant contribution in the ***growth*** of our organization
7	Manufacturing makes significant contribution ***increasing customer satisfaction***

2. Customer Satisfaction	
8	Our customers are satisfied with the quality of products
9	Our customers are satisfied with the features that our products provide
10	Our customers are loyal to our products
11	Our customers refer new customers to purchase our products
12	Our customers feel that we offer products of high value
3. Profitability	
13	Profit margin on our sales compared to that of our competitors is
14	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is
15	Net profit position compared to that of our competitors is
16	Overall our organizations' performance compared to that of our competitors is
17	We are satisfied with our profit margin on sales
18	We are satisfied with our return on investment on manufacturing capital goods (including manufacturing information system
4. Growth	
19	Sale's revenue growth position compared to that of our competitors is
20	Sale's volume growth position compared to that of our competitors is
21	Market share gains compared to that of our competitors is
22	Overall our organizations' growth compared to that of our competitors is
23	We are satisfied with our growth on sales

Table 3.5 Performance Measure (Continued)	
1. Acquisition of Ability to acquire knowledge	
1	We can systematically gather knowledge about product and/ or market, before deciding on full investment
2	We maintain network relationships with partners with different skills/ expertise from those of ours in order to learn from them
3	Our network of relationships allow us to learn more about product or market
2. Acquisition of Ability to reshuffle and add flexibility	
4	Comparing today with three years ago, we are more able to reconfigure our customer base
5	Comparing today with three years ago, we are more able to reconfigure our supplier base
6	Comparing today with three years ago, we are more able to switch to the different product line (with the given infrastructure)
7	Based of our best judgment, we will be more able three years down the road than we are today, to reconfigure our customer base
8	Based of our best judgment, we will be more able three years down the road than we are today, to reconfigure our supplier base

9	Based of our best judgment, we will be more able three years down the road than we are today, to switch to the different product line (with the given infrastructure)
3. Acquisition of Ability to Enter/ Expand	
10	Comparing today with three years ago, we are more able to enter into new market rapidly
11	Comparing today with three years ago, we are more able to upgrade our products rapidly
12	Comparing today with three years ago, we are more able to expand our market rapidly
13	Based of our best judgment, we will be more able three years down the road than we are today, to enter into new market rapidly
14	Based of our best judgment, we will be more able three years down the road than we are today, to upgrade our products rapidly
15	Based of our best judgment, we will be more able three years down the road than we are today, to expand our market rapidly
5. Acquisition of Ability to Exit	
	Comparing today with three years ago, we are more able to withdraw from the existing market rapidly (with out incurring heavy loss)
16	Comparing today with three years ago, we are more able to survive even if one of our major market become unviable
17	Based of our best judgment, we will be more able three years down the road than we are today, to withdraw from the existing market rapidly (with out incurring heavy loss)
18	Based of our best judgment, we will be more able three years down the road than we are today to survive even if one of our major market become unviable

3.2 Pilot Study

The pilot study was conducted as a prelude to large-scale survey. Previous research provided basis for the development of constructs in this research. The pilot study provided the opportunity to pretest those constructs, purify them and test their reliability and validity. The result of this also provided the basis for changing and dropping items. That will also be a basis for improvement of the questionnaire before the large-scale survey (Nunnally, 1978; Churchill, 1979; Venkatraman, 1989; Hair et al. 2000).

Items (and factors) in manufacturing competency were developed following conceptual literature (Fine and Raff, 1996) and also one case study on manufacturing competence (Coates and McDermot, 2002). Similarly, the constructs pertaining to information systems competence (uncertainty reduction ability and management role in ambiguity reduction) followed the conceptual articles on manufacturing information system and the information processing view of the organization (Daft and Langle, 1984). Items pertaining to cost, quality, flexibility, delivery speed and new product development were developed and used in empirical studies elsewhere (Kotha and Swamidass, 2000; Narasimahan and Jayaram, 1998). Items for supply chain integration followed the conceptual articles (Venkatraman and Henderson, 1995) as well as some empirical studies.

Again, items pertaining to financial performance were developed and empirically tested in various studies (Kotha and Swamidass, 2000; Venkatraman, 1989). Items pertaining to consumer's satisfaction were taken from Tu et al. (2002). But items pertaining to acquisition of options were developed using the conceptual studies (Venkatraman and Henderson, 1995, Amaram and Kulatilaka, 2000).

The complete questionnaire for the pilot study thus developed is attached here in appendix 1.

Constructs and their measurement: In the pilot study the exploratory factor analysis is done and confirmatory factor analysis will be done after the data from the large-scale survey is collected.

The constructs (or factors as they are known in the exploratory factor analysis) rely on the concept of domain sampling, according to which items that can capture various aspects of the same underlying concept should group together into one factor. In this phase the exploratory factor analysis is carried out, using SPSS. During the factor analysis we see the items belong to the factors on which they strongly load. At the same time cross-loading with factors other than on which an item primarily loads should be minimal (Hare et al., 1998; Churchill, 1979).

All the constructs are checked for reliability and validity. Reliability measures whether the instrument is free from error and consistently brings the same result. Validity, on the other hand, measures whether it actually measures what it intends to.

Reliability is measured by Chronbach's alpha. The "square of alpha" measures the correlation between the items and the errorless true score of the underlying concept. Generally alpha value above 0.80 is considered good. In the case when a measure is not as well established, a value of 0.70 is considered sufficient (Hare et al., 1998). One important aspect in measuring reliability is that Chronbach's alpha presumes uni-dimensionality, i.e. all the items considered are taken as representing one underlying concept only. One has to test this assumption while interpreting the alpha value (Churchill, 1979). This test can be done in SPSS by seeing that all items load in one factor only.

Another important issue for each of the measure is the content validity. Content validity measures whether the factor measures what it intends to or not. To ensure the validity each items should be generated on the basis of theory (and expert opinion), and factors that are formed should be interpreted on the basis of theory as well. We used the guidance of theory and experts (in industry and academia) opinion, while generating the items.

Pilot Study Method: Various industries within manufacturing are the target population of this study. The unit of measurement is the plant level. Plant managers, who can speak for the overall plants are the respondents of the questionnaire.

Item generation was based on literature as discussed above. Each of the items was measured using a five-point Likert scale. The items thus generated were tested with professors in the College of Business Administration, fellow Ph.D. students and practitioners (plant managers, directors in manufacturing corporations). Opinions were requested on brevity, understandability and content validity. Few modifications were suggested, and these were incorporated. There was unanimity of opinions that the questions were understandable or lucid. It was reported that the time required to complete the questionnaire was between 21 to 25 minutes, which, according to experts was a long time for plant managers to devote. It was suggested that the ideal time required should be between 12 to 15 minutes, which was addressed prior to the large-scale survey.

Another important issue on which the experts' opinion was sought was whether the plant managers were the right respondents for the questionnaire. This question came up for two reasons; first the questionnaire contended the questions pertaining to financial and non-finance performance measures. Secondly, the questionnaire dealt with strategy implementation issue and the question was raised as to how involved plant managers are in strategy implementation. All the practitioners with whom the questionnaire was tested positively stated that plant managers take overall responsibility of the plant, and are informed on all aspects of performances (financial and non financial) of their plants. Similarly, they were also unanimous in asserting that the implementations of strategies (relevant to the plant) are the responsibilities of the concerned plant managers; even though they were formulated in corporate headquarters (where plant managers have only suggestive roles). So, plant managers are the right respondents on the issue of strategy implementation and also performance measures.

A convenience sample was drawn mostly from the 2003 Harris Ohio Industrial Directory and the 2003 Harris Michigan Directory. The target audiences for the questionnaire were plant managers (since plant manager is the function individuals may have different designation.) These managers were randomly contacted over the telephone and requested for the completion of the survey. About 65 managers showed interest and out of those managers twenty-five actually completed the survey and returned.

Out of those who responded and identified the industry, six reported to be in the transportation equipment industry, three belonged to fabricated metal products, two each for primary metal and machinery except electrical and each for electrical and electronics and instruments and related products. Four other identified as belonging to other industry.

Data, thus collected, was utilized for the exploratory factor analysis, purification and measurement of reliability analyses. As stated above SPSS was used for all such analysis. Items for “manufacturing competence” were analyzed together for data reduction (factor analysis), to see whether factors that were conceived on the basis of theory actually showed up (or failed to show). The same procedure was repeated for items belonging to “uncertainty reduction” and “manager’s role of ambiguity reduction.” Again this was repeated for items for “cost leadership, “ “differentiation” (quality, flexibility, delivery speed, new product development) and “supply chain strategy.” Items for “financial performance,” “customers’ satisfaction,” “productivity” and “acquisition of options” were each subjected to similar analysis. Each of the factors was subjected to reliability test and purification (Hair et. al, 1998).

To be included in a factor each item should be loaded with a factor of at least 0.6, with no or negligible cross loading. The factors thus formed are individually subjected to the purification. Items which if deleted would increase the Chronbach’s alpha were considered for deletion. Finally factors with reasonable Chronbach’s alpha were retained. However, during all these processes, the underlying theory was taken note of, because data reduction exercise should not just be data driven.

3.3 Pilot Study Result

The outcomes of factor analyses, purifications and reliability measurements are described next. As a result of factor analysis and purification, a total of nineteen factors, which were found to be consistent with our research purpose, were retained.

Manufacturing Competence: Items in the manufacturing competence were loaded in four factors, which are named as "product design capability," "process related capability," "manufacturing infrastructure" and "quality related capabilities." Some of these factors are different from the ones envisaged before the pilot study.

The first factor is "product design capability." This is not different from the one envisaged before, except for the fact that only three out of four items were loaded here. The second factor took one item each from three different factors (design capability, manufacturing capability and the ability to improve) that were envisaged. All these items have issues related to manufacturing in common, so this factor was named as "process related capability." The third factor, "manufacturing infrastructure" consists of three items out of the original five meant to be under this heading. Similarly, "quality related capability" now consists of three out of four original items. Thus two factors envisaged before the pilot study, “ability to improve” and “ability to integrate skills” were not found to be viable factors after the analysis of data from the pilot study.

As stated earlier one of the major tasks in the pilot study data analysis is to measure the reliability of the factors on the basis of the Chronbach’s alpha. This was done and all the alpha values were above the required level of 0.8 in this case. Table 3.6 gives the factors that were obtained from the pilot study, along with their individual items and Chronbach’s alpha value.

Table 3.6: Factors for Manufacturing Competence

Product Design Capability	
1	We have the ability to develop specifications for finished goods sold by us
2	We have the ability to develop specifications for parts / subassemblies purchased by us
3	We have the ability to design products as per the given specification
Alpha 0.8053	
Process Related Capability	
4	We have the ability to design the manufacturing process for our products
5	We are capable of manufacturing parts we need as per specifications
6	We area able to improve design of products for better manufacturability
Alpha = 0.8560	
Manufacturing Infrastructure	
7	We are able to design one or more of following: machines, tools, equipments, software
8	We are able to manufacture one or more of following: machines, tools, equipments, software
9	We can improve upon one or more of following: machines, tools, equipments, software
Alpha = 0.8351	
Quality Related Capability	
10	We are able to test quality (conformance to specifications) of our products
11	We are able to test quality (conformance to specifications) during our production process
12	We are able to test quality (conformance to specifications) of inputs (raw materials and subassemblies)
Alpha = 0.9009	

Competence for Uncertainty Reduction: Similarly items for “uncertainty reduction capability” loaded in two factors. It was a major change from the factors developed on the basis of conceptual studies.

The factor for planning and control took four items from original planning and control while discarding two of them, but it also took two from elsewhere. One was “use of information system for quality control,” and another was “use information system in exchange of information during the design process.”

Aside from the one discussed above, another factor also came out. The factor took two out of five items of the original factor for supporting improvement and took two more items from networking. Coordination with suppliers and coordination with customers loaded together with those two. One can surmise this factor did not load as envisaged and may not be one consistent theoretically justifiable factor. So for further consideration only one factor of planning and control needs to be considered.

Table 3.7: Factor for Uncertainty Reduction Capability

Planning and Control	
1	We use manufacturing information system to exchange relevant information among those involved (both inside the company and with partner companies) during product design
2	We use manufacturing information system for capacity planning
3	We use manufacturing information system for material planning
4	We use manufacturing information system for scheduling the production
5	We use manufacturing information system for facilitating the cost control
6	We use manufacturing information system while designing the quality control systems
Alpha = 0.9280	

Manager’s Role in Ambiguity Reduction: In ambiguity reduction, we envisaged three factors on the basis of conceptual discussion. The data analysis gave two factors, internal communication and coordination and conflict resolution. Each of these factors had reasonable alpha values and table 3.8 gives detail of these.

Two items from "manager's communication role," and two more from "planning" merged together to form a single factor. This factor was named "internal coordination and communication." A separate factor for group meeting was not realized, however one of its item merged into two items from planning (related to conflict resolution) to form a factor, which was named "conflict resolution."

The Chronbach's alpha for "internal coordination and communication" is 0.8467 well above the acceptable level. However the same for "conflict resolution" is 0.7876, marginally below 0.8. This value, although not bad, shows that there is a room for improvement. Deleting one item would boost the alpha value to 0.8336. But it makes the number of items in the factor too low.

TABLE 3.8: Factors for Manager's Role in Ambiguity Reduction

Internal Communication and Coordination	
1	Manufacturing manager communicates frequently with his/ her counterpart in within our organization
2	Manufacturing manager disseminates relevant information from outside (other department with in organization or outside of organization) inside his/ her department
3	We have long term plan for manufacturing
4	Manufacturing manager contributes to the development of the overall business plan
Alpha = 0.8467	
External Conflict Resolution	
5	There are meetings between personnel from our department and their counterparts in our suppliers' organization
6	There is no conflict between the long term plan of manufacturing with that of other departments' in our organization
7	Manufacturing manager's role in developing business plan helps to minimize the conflict between the plan of manufacturing and other functions
Alpha = .7876	

Supply Chain Integration: Supply chain integration was envisaged to have three factors, customer interaction, asset configuration and leverage of knowledge. In our factor analysis two factors came out prominently. Of these two, the first factor had items that dealt with asset configuration and leverage of knowledge. It showed that decisions on asset and knowledge partitioning are closely related together (Takehsi 2002). The second factor had two items and dealt with "coordination effort between buyers and suppliers."

Table 3.9 shows the details of items and factors along with their Chronbach's alpha value. The alpha value of first item is 0.8152. The second factor has an alpha value of 0.7696. It also has only two items. The second factor can be improved before the large-scale survey.

TABLE 3.9: Factors for Supply Chain Strategy

Partitioning of Asset and Knowledge	
1	We base our decision to 'make or buy' on business logic
2	We have applied systematic approach in identifying the subassemblies that can be obtained from our suppliers
3	We are effective in leveraging the knowledge of partners (buyers and suppliers)
4	Our interactions with customers help us to capture their expertise
Alpha = 0.8152	
Buyer and Supplier Coordination	
5	The interdependent process that are within our organization and outside of it are seamlessly integrated
6	We are able to balance our dependence on our partners with theirs on us
Alpha = 0.7696	

Cost Leadership: Cost leadership gave one factor as expected. Out of five items originally envisaged, four items loaded to form one factor of cost leadership. However, the alpha value, which was 0.6167, is considered low. This shows the need to critically analyze the wording in questions looking back at

TABLE 3.10: Factor for Cost Leadership

1	Our inventory level compared to that of our competitors is
2	Our capacity utilization compared to that of our competitors is
3	Our production cost compared to that of our competitors is
4	Productivity of our workers compared to those of our competitors is
Alpha = 0.6167	

literature. Table 3.10 gives the detail of the cost leadership factor.

Differentiation: The factor analysis of items belonging to "differentiation" gave four factors: quality, deliver speed, flexibility and new product development. These were mostly as expected. However, a few items needed to be dropped, and few others moved to the different factors. Table 3.11 gives details of factors, with their items and the alpha values.

In the factor "quality," five items loaded and that was exactly as expected. The Chronbach's alpha value of this factor is 0.9497, and it is considered very good. In the factor "delivery speed," two items out of four originally considered to be the part of the factor loaded. And, it took two more items from flexibility. These two factors pertained to ability to change design and the capacity quickly. The factor thus formed has Chronbach's alpha of 0.8684. Out of the four remaining items belonging to the factor "flexibility," three loaded together. It has an alpha value of 0.8859. In the factor of "new product development," only two out of four items loaded. This gave the alpha value of 0 .9008, a very good number.

TABLE 3.11: Factors for Differentiation

Quality	
1	Compared to that of competitors, performance of our products are
2	Compared to that of competitors, reliability of our products are
3	Compared to that of competitors, dependability of our products are
4	Compared to that of competitors, our products' conformance to specifications are
5	Compared to our competitors, our ability to compete on the basis of quality is
Alpha = 0.9497	
Delivery Speed	
6	Compared to that of competitors, our delivery speeds are
7	Compared to that of competitors, our ability to meet delivery promises are
8	We are able to make rapid design changes
9	We are able to adjust our capacity quickly
Alpha = 0.8684	
Flexibility	
10	We offer a large number of product features
11	We offer a large degree of product variety
12	We can adjust product mix
Alpha = 0.8851	
New Product Development	
13	Our NPD related capabilities make NPD cycle shorter
14	Our NPD related capabilities makes ramp up time shorter
Alpha = 0.9008	

Performance Measure: In performance measure profitability, growth, "customers' satisfaction" and "productivity" came out as distinct factors as expected. Table 3.12 gives details of the factors with their items, along with their alpha values.

The first factor "profitability" consisted of seven items six as expected, and one item was originally envisaged to be the part of "productivity." The factor has an alpha value of 0.9036. Similarly, the "growth" factor was formed with five items as expected, with an alpha value of 0.8569. The "customer satisfaction" factor took four out of five items originally envisaged, and had an alpha value of 0.8856. And, "productivity" measure took six items to make a factor with an alpha value of .8884.

TABLE 3.12: Factors for Performance Measures

Profitability	
1	Profit margin on our sales compared to that of our competitors is
2	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is
3	Net profit position compared to that of our competitors is
4	Overall our organizations' performance compared to that of our competitors is
5	Comparing today with three years ago, our manufacturing labor force have become more productive
6	We are satisfied with our profit margin on sales
7	We are satisfied with our return on investment on manufacturing capital goods (including manufacturing information system)
Alpha = .9036	
Growth	
8	Sale's revenue growth position compared to that of our competitors is
9	Sale's volume growth position compared to that of our competitors is
10	Market share gains compared to that of our competitors is
11	Overall our organizations' growth compared to that of our competitors is
12	We are satisfied with our growth on sales
Alpha = 0.8569	
Customer Satisfaction	
13	Our customers are satisfied with the quality of products
14	Our customers are satisfied with the features that our products provide
15	Our customers refer new customers to purchase our products
16	Our customers feel that we offer products of high value
Alpha =0.8856	
Productivity	
17	Comparing today with three years ago, level of rework required has decreased significantly
18	Comparing today with three years ago, our manufacturing labor force have become more productive
19	Manufacturing makes significant contribution in the profitability of our organization
20	Manufacturing makes significant contribution in the growth of our organization
21	Manufacturing makes significant contribution increasing customer satisfaction
22	Productivity of our organization has increased significantly in last three years
Alpha = 0.8884	

Acquisition of Options: In acquisition of options "ability to enter and /or exit and / or expand the market" came out prominently. Options that were envisaged before were the "ability to acquire knowledge," "ability to reshuffle customer and/or supplier base," "ability to enter /expand markets," "ability to exit markets."

Items from "ability to enter or expand" and "ability to exit" merged together to form a single factor. Entering/ expansion and exiting markets are two sides of the same coin. A total of six items banded together to form a factor. The alpha value is 0.9116.

Out of all these two items pertaining to "acquisition of knowledge" and three from reshuffle of base merged together to form a factor. This merging of items in one factor shows that networking done to acquire knowledge adds to the flexibility by allowing firms to reshuffle their supplier or customer's base as well.

Of these two, the first factor, which was formed mostly along the line of expectation, is also the major concern of the manufacturing firms. This will be further considered for our research. Table 3.13 below will show the details of the factor with its items and the alpha value.

TABLE 3.13: Factor Acquisition of Options

Ability to Enter and /or Exit and / or Expand the Market	
11	Comparing today with three years ago, we are more able to enter into new market rapidly
13	Comparing today with three years ago, we are more able to expand our market rapidly
17	Comparing today with three years ago, we are more able to withdraw from the existing market rapidly (with out incurring heavy loss)
18	Comparing today with three years ago, we are more able to survive even if one of our major market become unviable
19	Based of our best judgment, we will be more able three years down the road than we are today, to withdraw from the existing market rapidly (with out incurring heavy loss)
20	Based of our best judgment, we will be more able three years down the road than we are today to survive even if one of our major market become unviable
Alpha = 0.9116	

Summary on Factor formation and Purification: After the data reduction and purification there were nineteen factors remaining. Factors that were proposed on the basis of previous empirical studies came out mostly as expected with reasonable alpha values from the analysis of the pilot study data. Factors belonging to implemented manufacturing strategy (cost leadership and differentiation) and the performance measures (profitability, growth, customer satisfaction and internal performance) fell into this category. One exception is the factor of “cost leadership,” which came out as expected, but had low alpha value. But many factors that were proposed on the basis of conceptual literature and the case studies had to be reorganized. Some of them had to be merged with other, others had to be discarded and two very important new factors emerged. Although concerns shown in case studies and conceptual literature were mostly encompassed, many factors that emerged were different from the ones that were proposed. Even then these new factors had very high alpha values and gave a sound basis for inclusion of their items in the larger scale survey. The final model for this research, after taking into consideration of the factors that actually loaded, is as shown in the figure 3.1.

This entire endeavor will lead to the questionnaire for large-scale survey. Items to be included will basically be driven by theory. Confidence (in order to be included in the questionnaire) will be high in items that were loaded in factors and contributed to high alpha value. And items in factors with low alpha value will have to be critically examined.

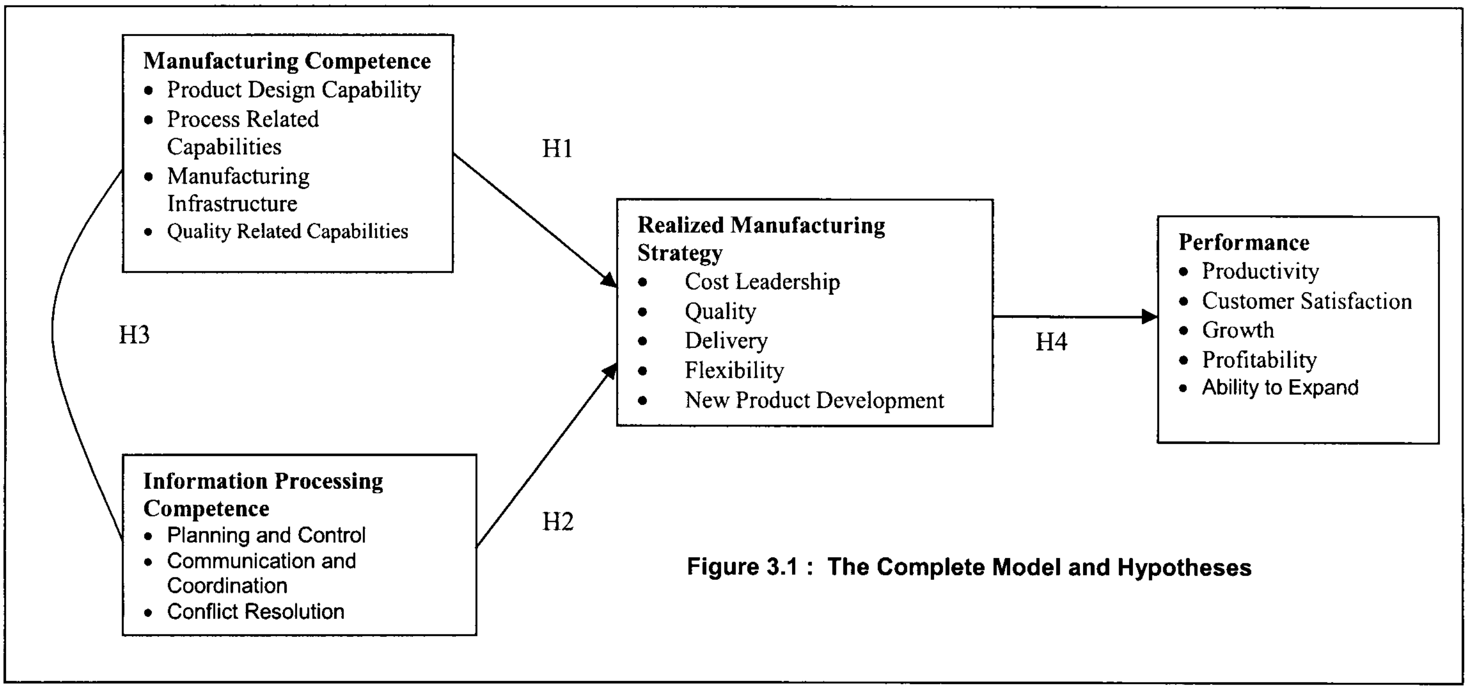


Figure 3.1 : The Complete Model and Hypotheses

3.4 Questionnaire Development for Large Scale Survey

The outcome of the pilot study, along with the theory and consideration for parsimony of constructs, gave basis for the development of the questionnaire for the large-scale survey.

Items for "manufacturing competence" will be taken from table 3.6 of this chapter. Those are the items that remained after purification and loaded well with factors pertaining to manufacturing competence. Similarly, the items for "uncertainty reduction capability" are taken from table 3.7.

In "manager's role in ambiguity reduction" (table 3.8), few changes (in wordings) were made. Changes were made in item 5 (factor 2). The first of these items will read "meetings between us and personnel from suppliers' organizations help to minimized conflict." The second of these items will read "meetings between us and personnel from buyers' organizations help to minimized conflict." These changes will bring the items closer to the overall concept (of the factor) of conflict resolution.

Changes were also made in supply chain integration (table 3.9). While the current ones ask the relationship with partner (lumping buyer and supplier together), the changes will split the question addressing buyer issue and supplier issue separately. And, when there exists on question pertaining to buyer (supplier) but similar item related to supplier (buyer) are added and vice versa.

And, there is addition of question, in line with question 2. The question read as: "We have applied systematic approach in identifying the products that can be provided by us to our customers." Similarly another question will be added in line of question 4, which reads, "Our interactions with suppliers help us to capture their expertise."

Some more questions in line with published literature in supply chain are added. The supply chain questions now are as following:

1	We are able to coordinate our process with that of our suppliers'
2	We are able to coordinate our process with that of our customers'
3	We are able to coordinate our process with different departments within our organization
4	We are able to balance our dependence on our suppliers' with theirs on us
5	We are able to balance our dependence on our buyers' with theirs on us
6	We base our decision to 'make or buy' on business logic

7 We have applied systematic approach in identifying the subassemblies that can be obtained from our suppliers
8 We have applied systematic approach in identifying the products that can supply to our customers
9 Our interactions with customers help us to capture their expertise
10 Our interactions with suppliers help us to capture their expertise

The construct of “cost leadership” (table 3.10) is of importance. The low alpha is a matter of concern. The issues identified in each of the items are similar to the ones used in literature. We slightly changed the wordings of these questions to bring them more in line with Kotha and Swamidass (2000). The questions will now read as:

1 In past three years we have focused on improving efficiency of the plant by maintaining the minimum possible level of inventory
2 In past three years we have focused on improving efficiency of the plant by keeping the capacity utilization at the maximum possible level
3 In past three years focused on keeping the production cost at the minimum possible level
4 In past three years we have focused on improving the productivity of our workers

Items from table 3.11 (differentiation strategy), table 3.12 and table 3.13 mostly remained intact, because each of the items loaded well in the factors that can be well explained by literature. However the number of items in “profitability” was reduced for the sake of parsimony. The factor without items 5, 6 and 7 would be more parsimonious and also will have high alpha value and still representing the same factor 0.9121. The detail large-scale survey questionnaire as attached as the appendix 2.

Chapter Four

Research Method (Large Scale Survey)

The pilot study as described above proved to be sufficiently intriguing and illuminating to warrant detailed research on this topic, and to test the proposed model with the empirical data collected from the wider community of manufacturers. The questionnaire for the large-scale survey was used as the instrument for data collection.

In the following paragraphs we discuss the data collection method, and then explain the data analysis procedure along with their outcomes. In the analysis we first present the first order measurement models and their tests. We then present the second order constructs and test their viability. These second order constructs are the building blocks of the complete model. Then we build the complete model. The complete model is the one that was proposed at the end of chapter three. The tests of this model allowed us to validate the hypotheses proposed in chapter three.

After the complete model is presented we have further carried some exploratory investigation. First, we modified the complete model based on the values of the modification indices. While doing so we considered whether the theory justified our action. Modifications should not just be data driven. Then we considered an alternative model. That model has the same level of fit as the complete model, but has a path indicating direct impact of manufacturing competency on the information system competency (instead of correlation in the original model).

4.1 Larger Scale Survey Method

The online database of Harris infosource (www.selectoryonline.com) was utilized to get the requisite mailing list. The list we used included in it manufacturing companies in the Midwest region (IL, IN, IA, KY, MI, MN, ND, OH, SD, WI) of the United States. It included plants or offices of manufacturers with at least hundred or more employees. From that list we took out all the facilities that acted as administrative support (or headquarters) only. Questionnaires were sent to the actual manufacturing plants. These plant managers (plant manager is considered a function, so people may have different designations) were requested to answer each question in the questionnaire from the manufacturing and the plant perspective.

A total of 5331 questionnaires were mailed, along with the self-addressed stamped envelopes. Out of those 172 such envelopes were returned in the first three weeks after the dispatch of the mailings. Out of that, 168 useful responses were received. After that individually addressed faxes were sent to the recipients of the questionnaire. In case there was a change in personnel, the current occupant of the position was requested to consider completing the questionnaire.

After these faxes, about 55 emails were received expressing interest in completing the questionnaire. Most of these emails also requested another questionnaire to be mailed to them. Out of these 39 completed and returned the questionnaire, for a total of 207 returned. This makes a total return of slightly less than 4 percent. This low return has to be considered in the context of continuous decrease in survey returns (Parente and Gattiker, 2004), along with the fact that responses from plant managers tend to be lower (Kathuria, 2000).

Demography: Each of the respondents was asked to identify their industries. Among them thirteen belonged to primary metal industries, forty-nine to fabricated metal products, nineteen were in machinery except electrical and twenty were in electrical and electronics industry. Besides, another eleven belonged to transportation equipment, and four belonged to instruments and related products. Ninety-four of them could be categorized as belonging to other industry. Those belonging to plastics, rubber and glass products were mainly represented in other industry.

Sixty-nine of the respondents belonged to the auto-industry. Among them eleven plants belonged to OEMs and twenty-five to first tier suppliers. Similarly there were responses from twenty-nine second tier suppliers, and four third tier suppliers. In addition, sixty-nine of them belonged to the single plant organization. Most of the respondents have been in business for fifteen or more years. Sales for most of the plants ranged from 10 to 500 million dollars per annum. And, about half of them employ 100 to 250 people. Similarly, most of the respondents were either top level or midlevel managers in their plants, and were at least college graduates. Fifteen in auto industry were also single plant organizations.

Demography of the respondents, who completed the questionnaire after fax requests were made, was not significantly different from those who did complete it upon the initial receipt of the questionnaire. Details of demography are shown in table 4.1.

TABLE 4.1 : Demography

		Round I Respondents	Round II Respondents	Total
	Industry Category			
1	Primary Metal Industries	10	3	13
2	Fabricated Metal Products	40	9	49
3	Machinery except electrical and electronics	16	3	19
4	Electronic and electronics	16	4	20
5	Transportation Equipments	7	4	11
6	Instrument Related Products	3	1	4
7	Other	76	17	93
	Auto Industry			
8	Auto Industry	55	14	69
9	OEM	7	3	11
10	First Tier	22	2	25
11	Second Tier	21	8	29
12	Third Tier	3	1	4
	Other Demography			
13	Sales Revenue ($ 10 to < 50 million)	70	20	90
14	Sales Revenue ($50 to < 500 Million)	65	15	80
15	Number of Employees (100 to 250)	95	20	105
16	Respondents Education (college and above)	159	38	197

Response bias: The following table (table 4.2) compares percentage, in different categories, between the potential respondents (to whom questionnaires were sent) and those who actually responded. It can be seen that percentage of "single location organizations" which responded was higher compared to their proportion in overall potential respondents. Similarly, "fabricated metal products" was over represented among the respondents compared to all the potential respondents. But "machinery" and "transportation equipments" were under represented. These discrepancies have to be taken into account when overall generalizability of the findings is considered.

TABLE 4.2 : Comparison between Respondents and Non-Respondents

#	Industry Category	Potential respondents %	Actual Respondents %
1	Primary Metal Industries	7.36	6.28
2	Fabricated Metal Products	17.13	23.67
3	Machinery except electrical	15.75	9.17
4	Electrical and Electronics Machinery	7.97	9.66
5	Transportation Equipment	10.03	5.31
6	Measuring Analyzing and Controlling Equipments	3.26	1.93
7	Other	41.76	43.98
8	Single location Organization	24.62	33.33
9	Auto Industry	32.27	33.33

4.2 Measurement Models:

This section reports on the analysis of measurement model. Such measurement models are also known as the first order confirmatory factor analysis (CFA). CFA tests the validity of factors that are empirically and theoretically derived by the researchers. In order to go through CFA, factors need to be already empirically measured through other methods (Byrne, 2001).

The factors derived from the data analyses in the pilot study are subjected to the confirmatory factor analysis with AMOS 5. The CFA uses the data collected in the large-scale survey. During the pilot study, SPSS (not AMOS) was used for the factor analysis. This outcome is considered exploratory factor analysis because SPSS by nature suggests the best possible factors within the criteria (fixed number of factors or factors with eigen value of one or more) stipulated by the researcher. Structural equation modeling procedure (for which AMOS 5 is used in our study) tests constructs (factors) that are suggested by researchers, and gives output with indicators signifying their suitability (or otherwise) as the constructs.

For the factor that needed changes in indicators (supply chain, manufacturer's role for ambiguity reduction) after the pilot study, and other factors (real option) that were not tested before (in any other studies) the exploratory factor analysis with SPSS was done before the confirmatory one with AMOS.

The suitability of CFA model is gauged in three ways. First, it is measured by significance and validity of the parameters estimated. Second, the good fit of the model have to be ensured. And third, there should be no significant evidence of the misfit (Byrne, 2001). Besides "discriminant validity" and "predictive validity" is also measured for each of the constructs. Discriminant validity is measured to ensure that each of the constructs is distinct. Predictive validity tests whether the constructs are able to predict in the general direction that supports our overall model or not (Venkatraman, 1989).

The significance and feasibility of model is measured by the strength of loadings of individual indicators to their respective factor. The strength is shown by the critical ratio of the (regression) weight of the loadings. The critical ratio is to be interpreted as "z" score. An absolute value of more than 1.96 would indicate the statistical significance at the 5% level.

Loadings also allow us to measure the reliability of the constructs. Reliability measures the extent to which each of the indicators "indicate" the common underlying concept. Although reliability is not an output of AMOS 5 or any other SEM software, it can be calculated with following formula:

$Construct\ Reliability = \dfrac{\sum (standardized\ loadings)^2}{\sum (standardized\ loadings)^2 + \sum \varepsilon_j}$. Where ε_j is the error in measurement, and it is equal to 1- (standardized loading)^2. Researchers are also urged to measure the reliability value. 0.7 is considered the acceptable cutoff value for reliability, but value less than 0.7 are accepted well. The value as low as 0.6 are accepted, when the constructs are new or they are under development (Hair et al. 1998; Byrne, 2001).

In order to measure good fit, there are many indices in the CFA that researchers can consider. The chi-square (χ^2) statistic is based on the concept of goodness-of-fit. Low chi-square value relative to the degrees of freedom signifies that covariances estimated by the model are not significantly different from the observed ones. This is the statistically based measure of goodness-of fit and requires a statistical significance of 0.05 or more. However, many models fail to achieve the required level of goodness-of-fit based on this criterion. Therefore researchers look at other criteria to assess the suitability of their models. Still, every SEM software reports the χ^2 value, and researchers utilize this to compare two models. For the same degree freedom, lower the χ^2 better is the fit (Byrne, 2000; Hair et al., 1998).

Normed chi-square is chi-square divided by degrees of freedom. Value lower than one can indicate over-fitting in the model; so, it is not appropriate. The appropriate range can be one to two or three. Others have suggested some more liberal range of one to five (Byrne, 2000; Hair et al., 1998).

Byrne (2001) emphasizes that Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) should be mainly considered when accessing the overall fit of the models (Byrne, 2001).

The Comparative Fit Index (CFI) is one of the incremental fit measures. It is an adaptation and improvement of the Normed Fit Index (NFI). NFI compares the researcher's model (default model) with the null model. (The null model assumes that all the indicators considered in the default model fit perfectly to a single construct.) The NFI is measured as: $NFI = \frac{\chi^2_{null} - \chi^2_{default}}{\chi^2_{null}}$.

CFI takes into account the sample size. Therefore, it is useful even for the smaller sample size and also in model development. It is recommended that CFI be the index of choice (Byrne, 2001). Its value ranges from 0 (no fit) to 1(perfect fit). The value of 0.9 or above is recommended, however at times 0. 8 (or above) is also acceptable (Hair et al. 1998).

The root mean square residual is the average of discrepancy between the estimated value and observed value of the covariance. The root mean square error of approximation (RMSEA), measures such discrepancy per degree of freedom. A value of less than 0.05 is considered good, and anything less than 0.08 are deemed to be within the realistic level of errors of approximation of the population. Values up to 0.1 are also sometimes accepted (Hair et al. 1998, Byrne, 2001).

We report the χ^2 value along with the statistical significance for each of the tests we carry. However, the decision of the model fit can not be made on this basis. We also report the χ^2 per degree of freedom (CMIN / DF), CFI and RMSEA. Even so, the values of these fit indices should not be the sole basis for judging the adequacy of the model. The theoretical and practical significance are weighed along with the model fit indices, when determining the adequacy of models. New models can have lower level of fit compared to those developed by improving upon the previous ones (Hair et al. 1998; Byrne, 2001).

Model misfit is indicated by a substantially large value of the modification indices provided by AMOS. Constructs and models can be improved by following the suggestions of modification indices even if the values are not that large and overall fit are acceptable. However researchers are warned not to indulge in over fitting the model to the data, just following the modification indices. Theory should be the primary basis of the model development and modification. Even then the modifications of originally suggested models makes that part of research exploratory (Byrne, 2001).

Correlations between the factors can be taken as an indication that all of them can be explained by the one underlying concept (Byrne 2001, Hair et al. 1998, Doll et al., 1994) High correlation between the constructs may also be suggesting that all of them can parsimoniously be represented by a single construct. Each construct should be distinctly different than the others. This is called discriminant validity. Discriminant validity is assured if each of the constructs is developed on the basis of concepts whose domains do not overlap with each other. This is the judgment to be made by researcher. Discriminant validity will be accepted on this theoretical judgment even if other tests give confusing signals. But tests can also be done to ensure that each of the constructs is sufficiently different from all of the others (Venkatraman, 1989).

Discriminant validity test requires that pairs of each correlating constructs be subject to two tests. The first test allows the two constructs to correlate freely. In the second test, correlation will be fixed to a high value. If the overall fit of the second model is as good as the first one, then these two constructs can parsimoniously be represented as a single construct. But, if the fit of second model is distinctly inferior compared to the first one, then each of the constructs are distinct. To see whether or not the second model is inferior we consider the difference in the values of chi-square between the first and the second model. The increase in chi-square value of the second model compared to the first one (for change in per degrees of freedom) should be statistically significant. We will carry out the discriminant validity tests for each pair of correlating constructs.

Predictive validity is measured by regressing individual dimensions of constructs (which will be predictors in our model) to the dimensions of other constructs (which will be predicted by them). For example constructs belonging to manufacturing competence and information system competence are expected to predict the implemented manufacturing strategy.

Manufacturing Competence: The pilot study suggested that there would be four constructs in manufacturing competence (which are - product design capability, process related capability, manufacturing infrastructure related capability and quality related capability).

The four constructs belonging to manufacturing competence were tested for confirmatory factor analysis together following the procedure suggested by experts (Hair et al. 1998, Byrne, 2001). The first order construct for manufacturing competence is shown in figure 4.1. The model has χ^2 value of 93.021, which is shown to be statistically insignificant (p value 0.000). The CMIN/DF is 1.938. Similarly, the CFI index for overall fit is 0.960 and RMSEA 0.067. CMIN/DF value in the range of 1 and 2, and CFI of 9.60 are the indications of a good fit. The RMSEA value of less than 0.08 shows the realistic level of approximation. Overall the fit is acceptable.

Each of the items strongly loads to their respective constructs. Similarly each of these constructs is correlated (with statistical significance) to others, indicating that all of them represent the same underlying concept of manufacturing competence. Table 4.3 shows the detail of fit for manufacturing competence.

As explained above we also measured the reliability for each of the construct. Reliability value for each of the constructs was above 0.7. Processes design capability has lowest reliability of all with the value of 0.70. Measurement for process related capability has to be improved in future studies. Reliability measurements are shown is table 4.4.

Similarly discriminant validity test was done as explained above for each pairs of correlating constructs. All of them were found to be distinctly discriminant. The detail of this is shown in table 4.5.

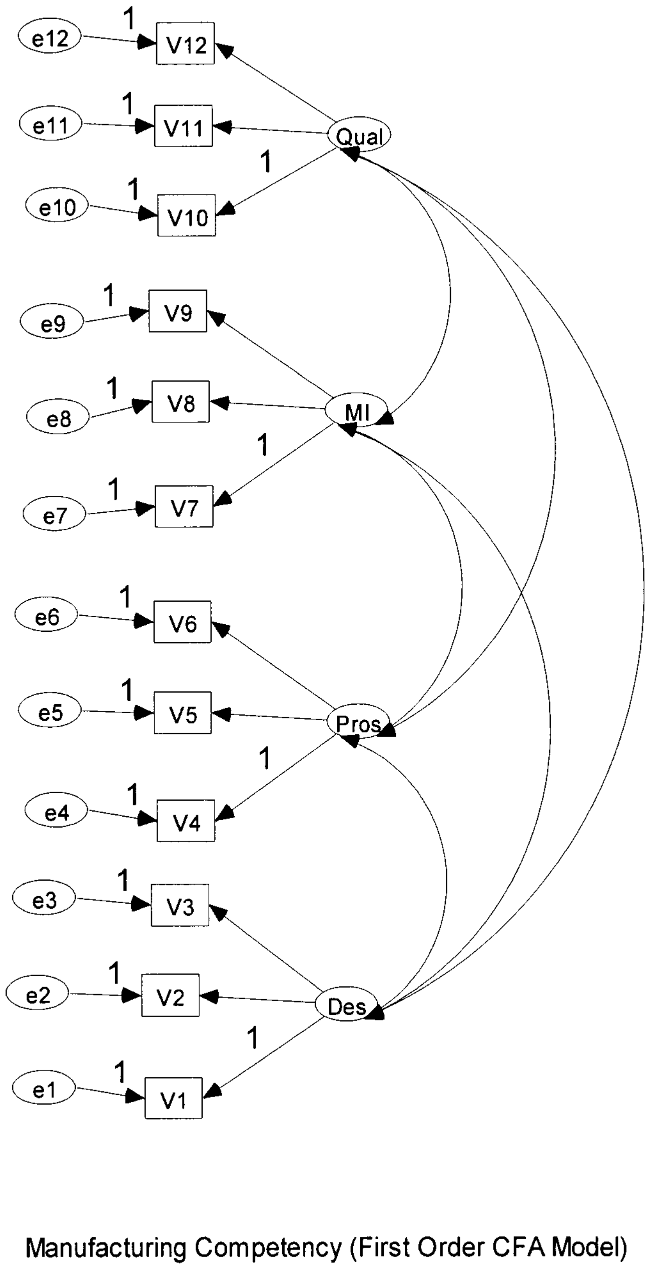


Figure 4.1: Manufacturing Competence: First Order CFA Model

TABLE 4.3 Continued: Manufacturing Competence (First Order Constructs) Covariances

			Estimate	S.E.	C.R.	P	Correlations
Product Design Capability	↔	Quality Related Capability	.139	.065	2.134	.033	0.175
Manufacturing Infrastructure	↔	Quality Related Capability	.225	.073	3.078	.002	0.254
Process Design Capability	↔	Manufacturing Infrastructure	.378	.083	4.575	***	0.445
Product Design Capability	↔	Process Design Capability	.335	.075	4.443	***	0.438
Product Design Capability	↔	Manufacturing Infrastructure	.585	.168	3.482	***	0.279
Process Design Capability	↔	Quality Related Capability	.112	.032	3.517	***	0.347

TABLE 4.3 : Manufacturing Competence (First Order Constructs) Regression Weights

				Estimate	S.E	C.R.	P	Standardized Weights
V1	We have the ability to develop specifications for finished goods sold by us	←	Product Design Capability	1.000				0.903
V2	We have the ability to develop specifications for parts/ subassemblies purchased by us	←	,,	.831	.064	12.901	***	0.782
V3	We have ability to design products as per specifications	←	,,	.891	.066	13.569	***	0.819
V4	We have the ability to design the manufacturing process for our products	←	Process Design Capability	1.000				0.721
V5	We are capable of manufacturing parts we need as per specification	←	,,	1.430	.207	6.904	***	0.659
V6	We have ability to improve design of products for better manufacturability	←	,,	1.187	.180	6.599	***	0.605
V7	We are able to design one or more of the following: machines, tools, equipments, software.	←	Manufacturing Infrastructure	1.000				0.940
V8	We are able to manufacture one or more of the following: machines, tools, equipments, software.	←	,,	.956	.063	15.173	***	0.824
V9	We are able to improve upon one or more of the following: machines, tools, equipments, software.	←	,,	.753	.051	14.629	***	0.803
V10	We are able to test quality (conformance to specifications) of our products	←	Quality Related Capability	1.000				0.797
V11	We are able to test quality (conformance to specifications) during our production process	←	,,	1.345	.134	10.032	***	0.879
V12	We are able to test quality (conformance to specifications) of inputs	←	,,	1.131	.132	8.539	***	0.617

TABLE 4.4:Manufacturing Competence Construct Reliability

	Reliability
Product Design Capability	0.87
Manufacturing Infrastructure	0.89
Process Design Capability	0.70
Quality Related Capability	0.81

Table 4.5: Manufacturing Competence Discriminant Validity

	Chi-square (df)		Chi-square Difference	p-value
	Constrained	Unconstrained		
Quality Related Capability ↔ Manufacturing Infrastructure	56.766 (9)	10.766 (8)	46.000	0.000
Product Design Capability ↔ Manufacturing Infrastructure	17.876 (9)	12.959 (8)	4.917	0.026
Quality Related Capability ↔ Process Design Capability	74.751 (9)	27.262 (8)	47.489	0.000
Quality Related Capability ↔ Product Design Capability	79.527 (9)	19.148 (8)	60.379	0.000
Process Design Capability ↔ Manufacturing Infrastructure	43.291 (9)	14.639 (8)	28.652	0.000
Process Design Capability ↔ Product Design Capability	56.317 (9)	20.508 (8)	35.809	0.000

Information System Competence: Information System Competence as discussed in chapter two consists of "uncertainty reduction" and "the manager's role in ambiguity reduction." For uncertainty reduction one factor planning and control became viable after analysis of pilot study data. After the pilot study modification were made in the language of some questions, and one completely new question was added. Because of that exploratory factor analysis is repeated here, for this portion only.

The factors belonging to the managers role in ambiguity reduction is given in table 4.5.

TABLE 4.6: Manager's Role

Information Sharing and Coordinating Capability	
V24	Manufacturing manager disseminates relevant information from outside (other department with in organization or outside of organization) inside his/ her department
V25	We have long term plan for manufacturing
V26	Manufacturing manager contributes to the development of the overall business plan
V30	Manufacturing manager's role in developing business plan helps to minimize the conflict between the plan of manufacturing and that of other functions
Conflict Resolution Capability	
V27	Meeting's between us and personnel from suppliers' organization help us to minimize conflict
V28	Meeting's between us and personnel from customers' organization help us to minimize conflict

Information system competence consists of three constructs, information sharing and coordination capability, conflict resolution capability and the planning and control. The conformance factor analysis for information system competence is done as explained above. The chi-square value is 48.033, showing no statistical significance. The CMIN/ DF value is 1.501, CFI value is 0.977 and RMSEA is 0.049; all of which indicate a good overall fit. Figure 4.2 shows the model for information system competence.

Similarly all the items loaded to their respective constructs very strongly. And these constructs within the information system constructs were highly correlated to each other showing that they belong together. The details of these constructs are shown in table 4.6.

As explained above the construct reliability for each construct was measured. Construct reliability of each of the construct was either above or at 0.7 level. The lowest reliability was that of conflict resolution, with the value of 0.7. This construct has two variables only. This construct has to be improved in future studies. Table 4.8 shows the construct reliability of each of the constructs.

Similarly, discriminant validity was tested and each of the constructs was found to be distinct. Table 4.9 shows the detail.

Table 4.7 : Information System Competence First Order Constructs Regression Weights

				Estimate	S.E.	C.R.	P	Standardized Weights
V18	We use manufacturing information system for capacity planning	←	Planning Control	1.000				0.747
V19	We use manufacturing information system for material planning	←	,,	.999	.084	11.883	***	0.859
V20	We use manufacturing information system for scheduling the production	←	,,	1.052	.089	11.757	***	0.846
V21	We use manufacturing information system for facilitating cost control	←	,,	.880	.096	9.212	***	0.664
V24	Manufacturing manager disseminates to his/ her department relevant information from outside (other departments with in organization or outside of organization)	←	Informing	0.773	.118	6.547	***	0.568
V25	We have long term plan for manufacturing	←	,,	1.095	.155	7.069	***	0.653
V26	Manufacturing manager contributes to the development of overall business plan	←	,,	1.181	.154	7.668	***	0.793
V30	Manufacturing manager's role in developing business plan helps in to minimize the conflict between the plan of manufacturing and of other functions	←	,,	1.000				0.621
V27	Meetings between us and personnel from customers' organization help us to minimize conflict	←	Conflict resolution	1.123	.218	5.141	***	0.789
V28	Meetings between us and personnel from suppliers' organization help us to minimize conflict	←	,,	1.000				

TABLE 4.7 Continued: Information System Competence First Order Constructs Covariance

			Estimate	S.E.	C.R.	P	Correlations
Plan &_Control	↔	Conflict resolution	.231	.055	4.196	***	.380
Informing	↔	Conflict resolution	.139	.035	3.975	***	.420
Plan &_Control	↔	Informing	.135	.035	3.815	***	.450

Table 4.8: Construct Reliability (Information System Competence)

Construct	Reliability
Planning Control	0.90
Informing	0.76
Conflict resolution	0.70

Table 4.9: Discriminant Validity (Information System Competence)

	Chi-square (df)		Difference	p-value
	Constrained	Unconstrained		
Plan & Control ↔ Conflict Resolution	72.966 (9)	8.561 (8)	64.405	0.000
Plan & Control ↔ Informing	107.283 (20)	34.473 (19)	72.810	0.000
Conflict Resolution ↔ Informing	86.764 (9)	7.874 (8)	78.890	0.000

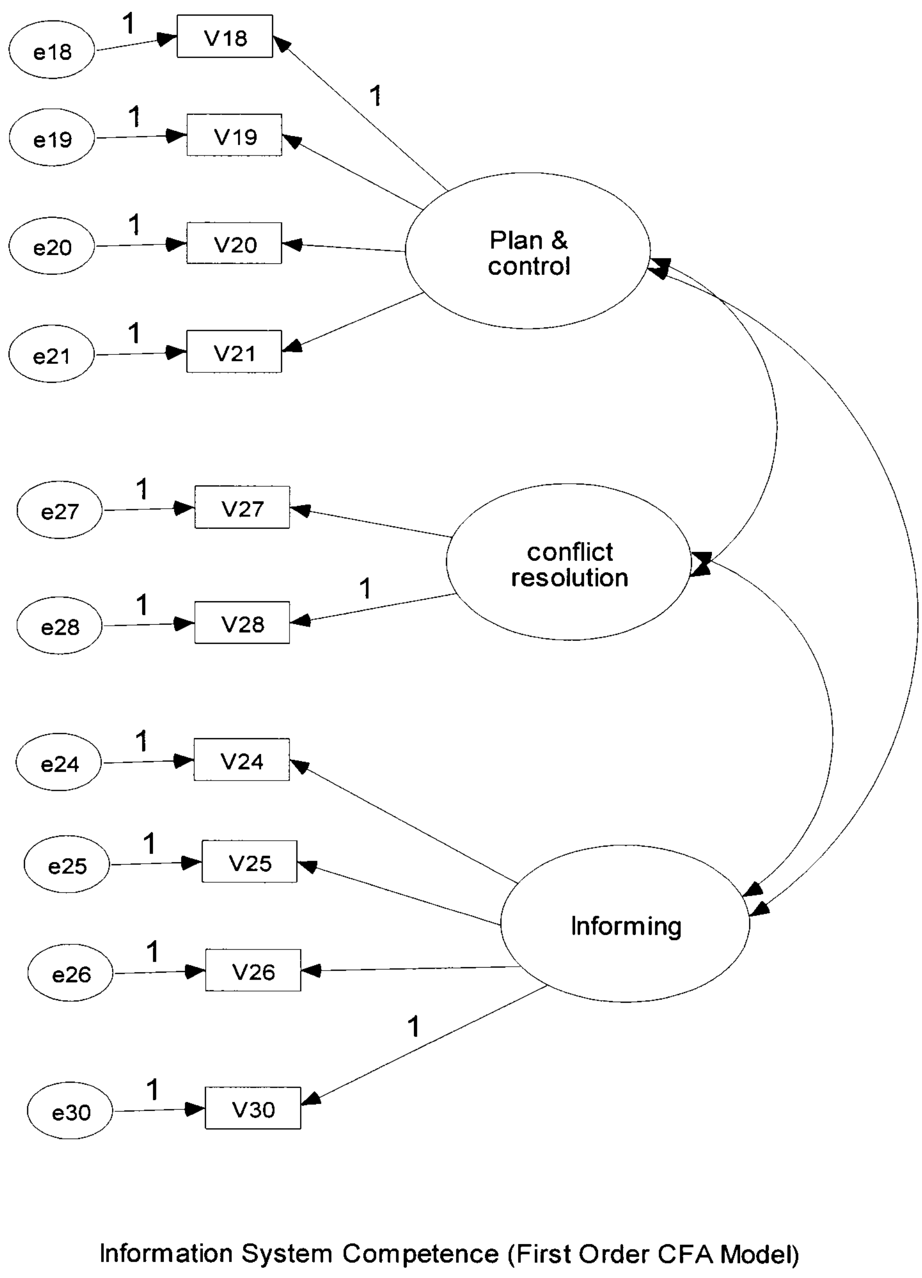


Figure 4.2: Information System Competence: First Order CFA Model

Realized Manufacturing Strategy: Realized manufacturing strategy consists of six constructs. Those are cost leadership, quality, new product development, flexibility, delivery speed and supply chain. Among them, items for cost leadership and supply chain were improved upon after the pilot study. For these two constructs, exploratory factor analysis was carried out at this stage as well. For the other four factors only confirmatory factor analysis was done.

The outcome of the factor analysis for the cost leadership is given in table 4.10.

TABLE 4.10: Cost leadership

V44	In past three years we have focused on improving efficiency of the plant by keeping the capacity utilization at the maximum possible level
V45	In past three years focused on keeping the production cost at the minimum possible level
V46	In the past three years we have focused on improving productivity of our workers

Similarly the outcome of the factor analysis for the supply chain is given in table 4.11.

Table 4.11: Supply Chain Integration

V99	We are able to coordinate our process with that of our suppliers'
V100	We are able to coordinate our process with that of our customers'
V101	We are able to coordinate our process with different departments within our organization
V102	We are able to balance our dependence on our suppliers' with theirs on us

Confirmatory factor analysis of six constructs (cost leadership, new product development, quality, flexibility, delivery speed and supply chain) belonging to the realized manufacturing strategy was done after this. The chi-square value was 309.35. However, CMIN/DF of 1.996, CFI value of 0.919 and the RMSEA of 0.068 showed the fit was acceptable. Figure 4.3 shows the input for this CFA.

Similarly, all the items loaded strongly in their respective factors. There were strong correlations between the constructs. But there were some exception also. Delivery speed was not correlated with flexibility and new product development. At the same time delivery speed, new product development and flexibility were all highly correlated to quality. Supply chain was not correlated to quality but was correlated to cost leadership, new product development, delivery speed and flexibility. Similarly cost leadership was not correlated to quality but it was correlated to all of the other factors. The interrelationships support that they all belong to realized manufacturing strategy. The detail of this is shown in table 4.12.

Similarly, the construct validity was tested. The value for each of the construct was 0.7 or above. The cost leadership had the least value of 0.7. The detail of this is shown in table 4.13. Similarly the, discriminant validity was measured for each pair of correlating constructs. It was found that each of the constructs were distinctly different than others. The detail of which is given in table 4.14.

TABLE 4.12: Realized Manufacturing Strategy First Order Constructs Regression Weights

				Estimate	S.E.	C.R.	P	Standardized Estimates
V44	In the past three years we have focused on improving cost efficiency of the plant by keeping the capacity utilization at the maximum possible level	←	,,	1.000				0.478
V45	In the past three years we have focused on keeping the production cost at the minimum possible level	←	,,	.967	.171	5.640	***	.644
V46	In the past three years we have focused on improving productivity of our workers	←	,,	1.075	..235	5.411	***	.848
V56	Compared to that of our competitors, performance of our products are	←	Quality	.961	.073	13.202	***	.844
V57	Compared to that of our competitors, reliability of our products are	←	,,	1.145	.076	14.983	***	.952
V58	Compared to that of our competitors, dependability of our products are	←	,,	1.157	.090	12.914	***	.829
V59	Compared to our competitors our ability to compete on the basis of quality is	←	,,	1.000				.770
V61	Compared to that of competitors, our ability to meet delivery promises are	←	Delivery Speed	1.000				.891
V60	Compared to that of competitors, our delivery speeds are	←	,,	1.058	.071	14.834	***	.867
V64	Overall, delivery gives us an edge over our competitors	←	,,	.901	.070	12.895	***	.768
V54	Our new product development related capabilities make our new product development cycle shorter	←	New Product Develop ment	1.000				.955
V55	Our new product development related capabilities make ramp up time shorter	←	,,	.975	.047	20.837	***	.922
V66	Overall, our ability in New Product Development gives us an edge over our competitors	←	,,	.741	.057	13.096	***	.717
V51	We offer a large number of product features	←	Flexibilit y	1.248	.160	7.799	***	.779
V52	We offer a large degree of product variety	←	,,	1.000				.718
V53	We can adjust product mix	←	,,	.772	.117	6.606	***	.552
V99	We are able to coordinate our process with that of our suppliers'	←	Supply Chain	1.000				.698
V100	We are able to coordinate our process with that of our customers'	←	,,	.868	.123	7.048	***	.606
V101	We are able to coordinate our process with different departments within our organization	←	,,	.900	.115	7.819	***	.706
V102	We are able to balance our dependence on our suppliers' with theirs on us	←	,,	.852	.115	7.378	***	.642

TABLE 4.13: Realized Manufacturing Strategy Construct Reliability

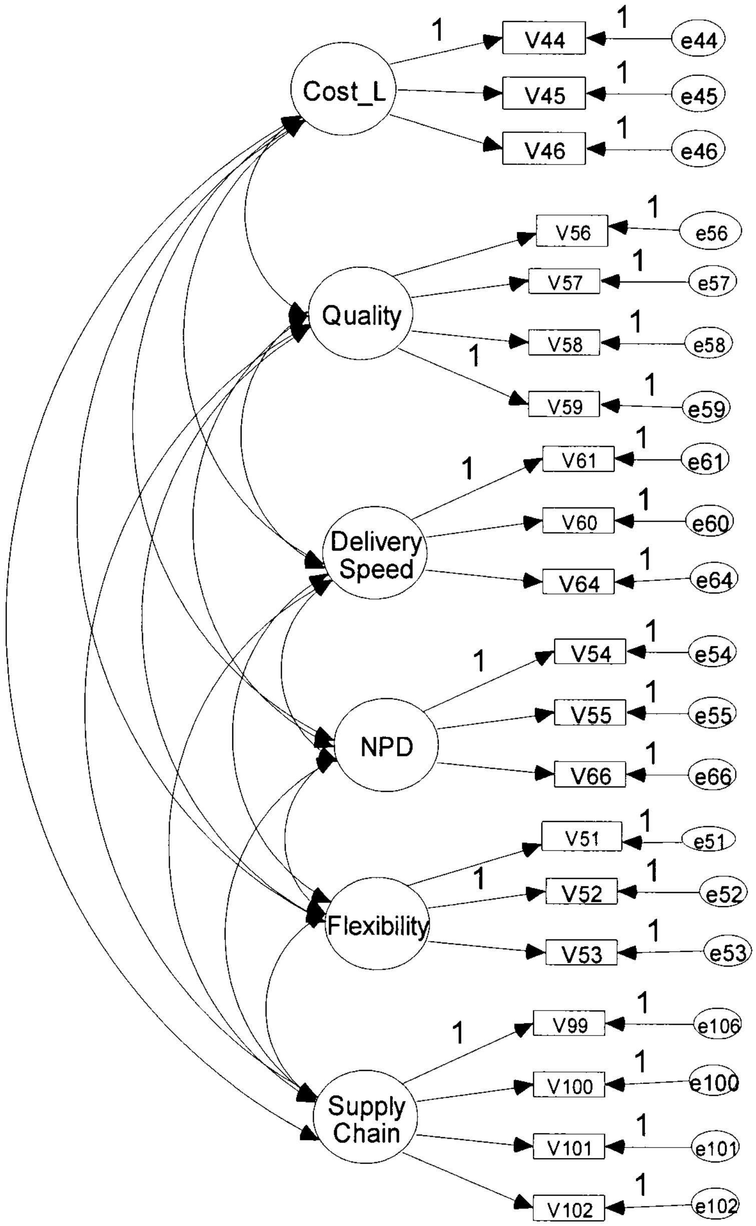
Cost Leadership	0.70
Quality	0.91
Flexibility	0.73
NPD	0.90
Delivery Speed	0.88
Supply Chain	0.76

TABLE 4.13 Continued: Realized Manufacturing Strategy First Order Constructs Covariances

			Estimate	S.E.	C.R.	P	Correlations
Cost Leadership	↔	Supply Chain	.107	.037	2.883	.004	.309
Flexibility	↔	Supply Chain	.107	.053	2.034	.042	.194
NPD	↔	Supply Chain	.298	.079	3.772	***	.337
Delivery Speed	↔	Supply Chain	.175	0.049	3.564	***	.326
Quality	↔	Supply Chain	.013	0.035	.363	.716	.030
NPD	↔	Flexibility	.461	.100	4.605	***	.435
Delivery Speed	↔	Flexibility	.005	.055	0.98	.922	.008
Quality	↔	Flexibility	.174	.047	3.703	***	.341
Cost Leadership	↔	Flexibility	.150	.047	3.188	.001	.362
Delivery Speed	↔	NPD	.091	0.79	1.156	.248	.088
Quality	↔	NPD	.198	.063	3.138	.002	.242
Quality	↔	Delivery Speed	.155	.041	3.829	***	.313
Cost Leadership	↔	Delivery Speed	.090	.037	2.420	.016	.223
Cost Leadership	↔	Quality	.036	.027	1.348	.178	.113
Cost Leadership	↔	NPD	.128	.058	2.202	.028	.193

TABLE 4.14: Realized Manufacturing Strategy Discriminant Validity

	Chi-square (df)		Chi-square Difference	p-value
	Constrained	Unconstrained		
NPD ↔ Flexibility	46.784 (9)	30.914 (8)	15.870	0.000
Supply Chain ↔ Flexibility	119.701 (14)	45.202 (13)	74.499	0.000
Delivery Speed ↔ NPD	71.780 (9)	11.812 (8)	59.968	0.000
NPD ↔ Supply Chain	77.053 (14)	40.884 (13)	36.169	0.000
Delivery Speed ↔ Supply Chain	90.432 (14)	17.799 (13)	72.653	0.000
Delivery Speed ↔ Flexibility	104.311 (9)	9.428 (8)	94.883	0.000
Quality ↔ Supply Chain	156.851 (20)	20.165 (19)	136.686	0.000
Quality ↔ Flexibility	101.263 (14)	23.733 (13)	77.530	0.000
Quality ↔ NPD	90.144 (14)	32.732 (13)	57.412	0.000
Quality ↔ Delivery Speed	127.544 (14)	32.911 (13)	94.633	0.000
Cost Leadership ↔ Supply Chain	102.344 (14)	17.715 (13)	84.629	0.000
Cost Leadership ↔ Flexibility	94.331 (9)	11.730 (8)	82.601	0.000
Cost Leadership ↔ NPD	73.125 (9)	19.415 (8)	53.710	0.000
Cost Leadership ↔ Delivery Speed	92.544 (9)	4.406 (8)	88.138	0.000
Cost Leadership ↔ Quality	148.644 (14)	18.910 (13)	129.734	0.000



Manufacturing Strategy (First Order CFA Model)

Figure 4.3: Realized Manufacturing Strategy: First Order CFA Model

Performance: Performance is measured jointly by five factors. These are growth, profitability, productivity, customer satisfaction and option to expand. All the factors except the one belonging to option are determined during our pilot study. Because the real options have never before been used as constructs in survey research, a factor analysis using SPSS was done. The detail is given in table 4.15.

Table 4.15: Real Options

Options to Expand	
V92	Comparing today with three years ago, we are more able to switch to the different product line (with the given infrastructure)
V93	Comparing today with three years ago, we are more able to enter into new market rapidly
V94	Comparing today with three years ago, we are more able to expand our market rapidly

The confirmatory factor analysis for performance was done. Factors belonging to performance consist of profitability, growth, productivity, customer satisfaction and options to expand.

The chi-square value was 223.317. The CMIN/DF was 1.787, CFI value was 0.958 and the RMSEA was 0.062. Thus the over all fit of the factors is considered good. The detail of factors of performance is shown in Table 4.15.

Again, each of the items loaded strongly to their respective factors. The construct reliability test was done for each of the constructs. Each of the construct had reliability value well above the threshold value of 0.7, with an exception of consumer satisfaction. The reliability of consumer satisfaction was only 0.65. This construct need to be improved in future research. The detail of this is shown in table 4.16.

And, there was correlation amongst the factors indicating that they represented the same overall concept of performance. At the same time these correlations warranted the tests for discrimination validity, and that was performed. It was found that each of the constructs were distinct from the others. The detail of this is shown in table 4.17.

TABLE 4.16: Performance First Order Constructs Regression Weights

				Estimate	S.E.	C.R.	P	Standardized Weight
V75	Our satisfaction with the growth of our sales	←	Growth	1.000				0.624
V74	Overall our organization's growth compared to that of our competitors is	←	Growth	1.297	.128	10.141	***	0.864
V73	Market share gains compared to that of our competitors is	←	Growth	1.389	.141	9.856	***	0.830
V72	Sale's volume growth position compared to that of our competitors is	←	Growth	1.546	.143	10.807	***	0.952
V71	Sale's revenue growth position compared to that of our competitors is	←	Growth	1.497	.140	10.681	***	0.934
V70	Overall our organization's profitability compared to that of our competitors is	←	Profitability	1.000				0.952
V69	Net profit position compared to that of our competitors is	←	Profitability	1.041	.035	29.787	***	0.964
V68	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is	←	Profitability	.909	.045	20.272	***	0.856
V85	Productivity of our organization has increased significantly in last three years	←	Productivity	1.000				0.655
V84	Manufacturing makes significant contribution in increasing customer satisfaction	←	Productivity	.997	.118	8.464	***	0.737
V83	Manufacturing makes significant contribution to the growth of our organization	←	Productivity	1.015	.140	7.263	***	0.604
V82	Manufacturing makes significant contribution to the profitability of our organization	←	Productivity	1.170	.131	8.921	***	0.829
V79	Our customers feel that we offer products of high value	←	Customer Satisfaction	1.000				0.762
V77	Our customers are satisfied with the features our products provide	←	Customer Satisfaction	.873	.182	4.800	***	0.434
V76	Our customers are satisfied with the quality of products	←	Customer Satisfaction	.787	.133	5.939	***	0.639
V94	Comparing today with three years ago, we are more able to expand our market rapidly	←	Options to Expand	1.000				0.800
V93	Comparing today with three years ago, we are more able to enter into new market rapidly	←	Options to Expand	1.184	.104	11.427	***	0.909
V92	Comparing today with three years ago, we are more able to switch to the different product line (with the given infrastructure)	←	Options to Expand	.877	.097	9.049	***	0.626

TABLE 4.16 Continued: Performance First Order Constructs Covariance

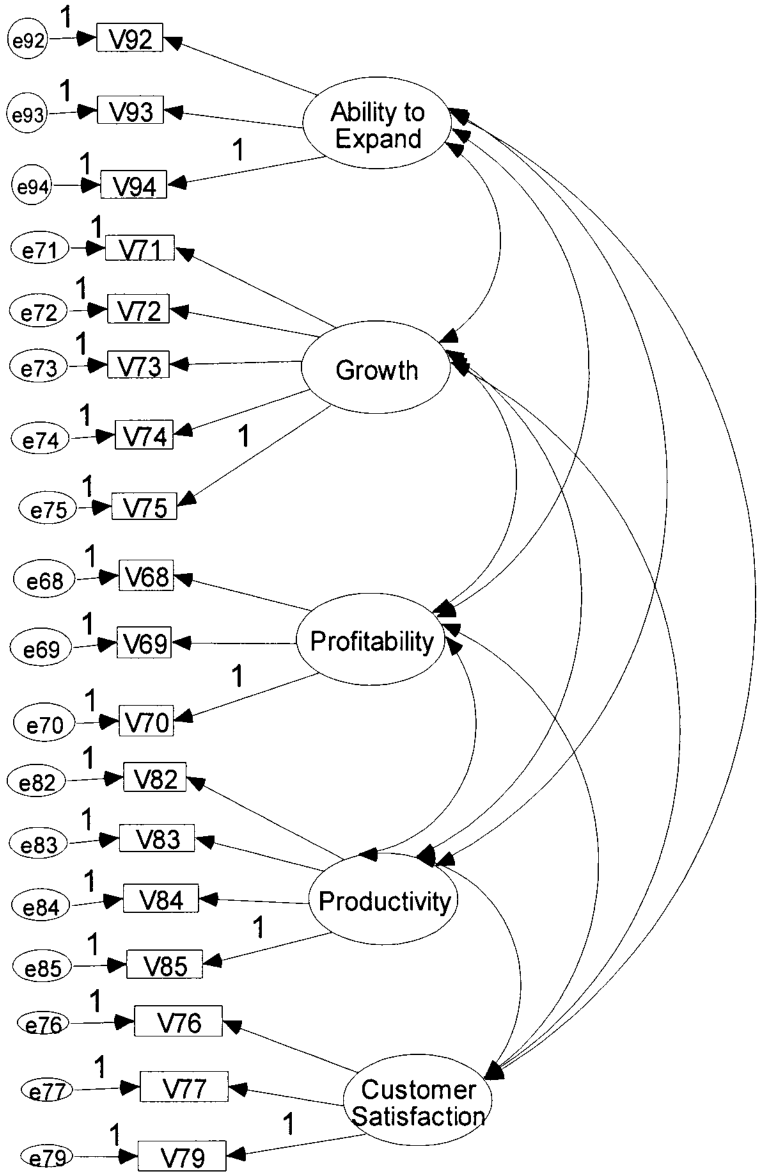
			Estimate	S.E.	C.R.	P	Correlations
Customer Satisfaction	↔	Options to Expand	.147	.048	3.098	.002	0.294
Prod	↔	Options to Expand	.098	.041	2.410	.016	0.207
Profitability	↔	Options to Expand	.377	.094	3.996	***	0.328
Growth	↔	Options to Expand	.295	.063	4.672	***	0.444
Growth	↔	Profitability	.565	.094	6.023	***	0.602
Growth	↔	Productivity	.096	.033	2.889	.004	0.248
Growth	↔	Customer Satisfaction	.100	.037	2.685	.007	0.244
Profitability	↔	Productivity	.139	.055	2.542	.011	0.207
Profitability	↔	Customer Satisfaction	.127	.061	2.074	.038	0.180
Productivity	↔	Customer Satisfaction	.148	.033	4.530	***	0.507

TABLE 4.17: Performance Construct Reliability

Construct	Reliability
Options to Expand	0.83
Profitability	0.95
Customer Satisfaction	0.65
Productivity	0.80
Growth	0.93

TABLE 4.18: Performance Discrimination Validity

	Chi-square (df)		Chi-square Difference	p-value
	Constrained	Unconstrained		
Ability to Expand ↔ Profitability	37.053 (9)	12.920 (8)	24.133	0.000
Ability to Expand ↔ Growth	101.100 (20)	59.877 (19)	41.223	0.000
Ability to Expand ↔ Productivity	114.120 (14)	17.285 (13)	96.835	0.000
Growth ↔ Profitability	52.173 (14)	38.300 (13)	13.873	0.000
Ability to Expand ↔ Customer Satisfaction	94.300 (9)	11.020 (8)	83.28	0.000
Profitability ↔ Customer Satisfaction	14.527 (13)	2.152 (8)	12.385	0.030
Productivity ↔ Customer Satisfaction	126.359 (14)	70.129 (9)	56.230	0.000
Productivity ↔ Productivity	83.253 (14)	9.770 (13)	73.483	0.000
Growth ↔ Customer Satisfaction	144.001 (20)	48.089 (19)	95.912	0.000
Growth ↔ Productivity	189.127 (27)	83.480 (26)	105.647	0.000



Performance (First Order CFA Model)

Figure 3.5: Performance: First Order CFA Model

Predictive Validity: In order to access predictive validity first, we regressed the constructs belonging to "manufacturing competence" with constructs belonging to "implemented manufacturing strategy." We also did the same with constructs belonging to "information system competence" and "implemented manufacturing strategy." Constructs belonging to "manufacturing competence" and "information system competence," are independent and those belonging to "implemented manufacturing competence" are dependent. Similarly, we tested the correlations between constructs belonging to "manufacturing competence" and "information system competence." The outcome of which is shown in table 4.19a, 4.19b and 4.19 c respectively. The regression coefficients support the overall direction of our model.

Then we regressed the constructs belonging to "implemented manufacturing strategy" with those of "performance." The detail is shown in table 4.20. The coefficients here support the overall direction as well.

TABLE 4.19: Relations between Competencies (individual constructs) and Performance (individual constructs)

A: Relations between Manufacturing Competencies (individual constructs) and Performance (individual constructs)				
			Standardized Regression Coefficient	P
Cost Leadership	**<---**	**Design and enforce Quality**	**.312**	**.001**
Quality	**<---**	**Design and enforce Quality**	**.191**	**.018**
NPD	<---	Design and enforce Quality	.028	.864
Flex	<---	Design and enforce Quality	.002	.983
Supply Chain	<---	Design and enforce Quality	.086	.371
Cost Leadership	<---	Manufacturing Infrastructure	.016	.551
quality	<---	Manufacturing Infrastructure	.002	.942
NPD	<---	Manufacturing Infrastructure	.066	.257
Flex	**<---**	**Manufacturing Infrastructure**	**.072**	**.080**

TABLE 4.19: Relations between Competencies (individual constructs) and Performance (individual constructs)

Supply Chain	<---	Manufacturing Infrastructure	-.012	.715
Cost Leadership	**<---**	**Process related capability**	**.258**	**.016**
Quality	**<---**	**Process related capability**	**.264**	**.012**
NPD	**<---**	**Process related capability**	**.708**	**.001**
Flexibility	**<---**	**Process related capability**	**.242**	**.103**
Supply _Chain	**<---**	**Process related capability**	**.361**	**.006**
Cost Leadership	<---	Product design capability	-.034	.273
Quality	<---	Product design capability	.030	.346
Delivery	<---	Product design capability	-.003	.936
NPD	<---	Product design capability	.122	.065
Flexibility	**<---**	**Product design capability**	**.189**	***
Supply Chain	<---	Product design capability	-.020	.611
Delivery	**<---**	**Product design capability**	**.564**	***
Delivery	<---	**Manufacturing Infrastructure**	.052	.151
Delivery	<---	Quality	-.025	.807
B: Relations between Information System Competencies (individual constructs) and Performance (individual constructs)				
			Estimate	P
Cost Leadership	<---	Planning & Control	.074	.231
Quality	<---	Planning & Control	-.061	.363
Delivery Speed	<---	Planning & Control	-.035	.689
NPD	**<---**	**Planning & Control**	**.692**	***
Flexibility	**<---**	**Planning & Control**	**.231**	**.031**
Supply Chain	**<---**	**Planning & Control**	**.253**	**.002**
Cost Leadership	<---	Conflict Resolution	.118	.134
Quality	<---	Conflict Resolution	.138	.107
Delivery Speed	**<---**	**Conflict Resolution**	**.288**	**.014**
NPD	<---	Conflict Resolution	.141	.375
Flexibility	<---	Conflict Resolution	.157	.235
Supply Chain	**<---**	**Conflict Resolution**	**.258**	**.012**
Cost Leadership	**<---**	**Informing**	**.337**	***
Quality	**<---**	**Informing**	**.267**	**.003**
Delivery Speed	<---	Informing	.141	.214
NPD	**<---**	**Informing**	**.442**	**.009**
Supply Chain	<---	Informing	.114	.241
C: Relations between Manufacturing Competencies (individual constructs) and Information System Competencies (individual constructs)				
			Estimate	P
Product design capability	**<-->**	**Process related capability**	**.333**	***
Process related capability	**<-->**	**Manufacturing Infrastructure**	**.373**	***
Manufacturing Infrastructure	**<-->**	**Design and enforce Quality**	**.226**	**.002**
Product design capability	**<-->**	**Manufacturing Infrastructure**	**.587**	***

TABLE 4.19: Relations between Competencies (individual constructs) and Performance (individual constructs)

Product design capability	<-->	Design and enforce Quality	.141	.030
Product design capability	<-->	Planning & Control	.150	.054
Product design capability	<-->	Conflict Resolution	.238	.004
Product design capability	<-->	Informing	.089	.175
Planning & Control	<-->	Conflict Resolution	.188	***
Informing	<-->	Conflict Resolution	.163	***
Planning & Control	<-->	Informing	.152	***
Process related capability	<-->	Design and enforce Quality	.110	***
Process related capability	<-->	Planning & Control	.078	.028
Process related capability	<-->	Conflict Resolution	.115	.002
Process related capability	<-->	Informing	.121	***
Manufacturing Infrastructure	<-->	Planning & Control	.230	.008
Manufacturing Infrastructure	<-->	Conflict Resolution	.246	.006
Manufacturing Infrastructure	<-->	Informing	.201	.007
Design and enforce Quality	<-->	Planning & Control	.124	***
Design and enforce Quality	<-->	Conflict Resolution	.134	***
Design and enforce Quality	<-->	Informing	.101	.001

TABLE 4.20: Relations between manufacturing strategy (individual constructs) and performance (individual constructs)

			Standardized Regression Coefficient	P
Ability to Expand	←	Cost Leadership	.070	.362
Growth	←	**Cost Leadership**	**.214**	**.011**
Profitability	←	**Cost Leadership**	**.146**	**.068**
Productivity	←	**Cost Leadership**	**.510**	***
Customer Satisfaction	←	**Cost Leadership**	**.321**	**.001**
Ability to Expand	←	Quality	-.035	.624
Profitability	←	Quality	.077	.283
Productivity	←	Quality	.062	.384
Customer Satisfaction	←	**Quality**	**.453**	***
Ability to Expand	←	Delivery Speed	-.054	.457
Growth	←	Delivery Speed	.036	.610
Growth	←	**Quality**	**.151**	**.033**
Profitability	←	Delivery Speed	.112	.127
Productivity	←	**Delivery Speed**	**.216**	**.004**
Ability to Expand	←	**New Product Development**	**.278**	***
Growth	←	**New Product Development**	**.225**	**.002**
Ability to Expand	←	**Flexibility**	**.247**	**.003**
Growth	←	Flexibility	.032	.675
Profitability	←	Flexibility	.083	.298
Productivity	←	Flexibility	.049	.539
Customer Satisfaction	←	**Flexibility**	**.193**	**.033**
Ability to Expand	←	**Supply Chain**	**.212**	**.010**
Growth	←	Supply Chain	.102	.189
Profitability	←	Supply Chain	.048	.542
Productivity	←	Supply Chain	.124	.123
Customer Satisfaction	←	**Supply Chain**	**.228**	**.013**
Customer Satisfaction	←	**Delivery Speed**	**.201**	**.015**
Profitability	←	New Product Development	.075	.292
Productivity	←	New Product Development	.104	.145
Customer Satisfaction	←	New Product Development	-.054	.494

Summary for the first order confirmatory factor analysis: First order confirmatory factor analysis was conducted for eighteen factors. Overall fit measures for all the tests were found to be above the acceptable level. Discriminant validity of each of the factors was established. And, reliability of all the constructs was measured. Construct reliability for each of the factors was equal to or above the threshold value of 0.7; only customer satisfaction construct had the lower reliability.

4.3 Second Order Constructs:

The second order constructs are the super constructs that have other constructs as their dimensions. In our case there will be four second order constructs which are manufacturing competence, information system competence, realized manufacturing strategy and performance.

After all, the second order construct is a parsimonious way of presenting number of correlating constructs. Whether or not second order construct is required depends on the researcher's judgment and the underlying theory (Byrne, 2001, Hair et al., 1998; Doll et al., 1994).

Besides their judgment, authors also confirm the adequacy of second order construct by assessing the level of variation of the first order construct captured by the second order construct. This is called "target coefficient" and measured as $\frac{\chi^2_{second\ order\ construct}}{\chi^2_{first\ order\ construct}}$. The value of ratio can theoretically be up to one.

Higher this ratio is higher will be the variation of the correlating first order constructs captured by the second order construct. Target coefficient for the second order coefficient with only three dimensions is always one. Doll et al. (1994) used this method to measure the adequacy of their second order construct. The value of their target coefficient was 0.74; and it was deemed adequate. We measured the target coefficient for each of the second order construct we develop.

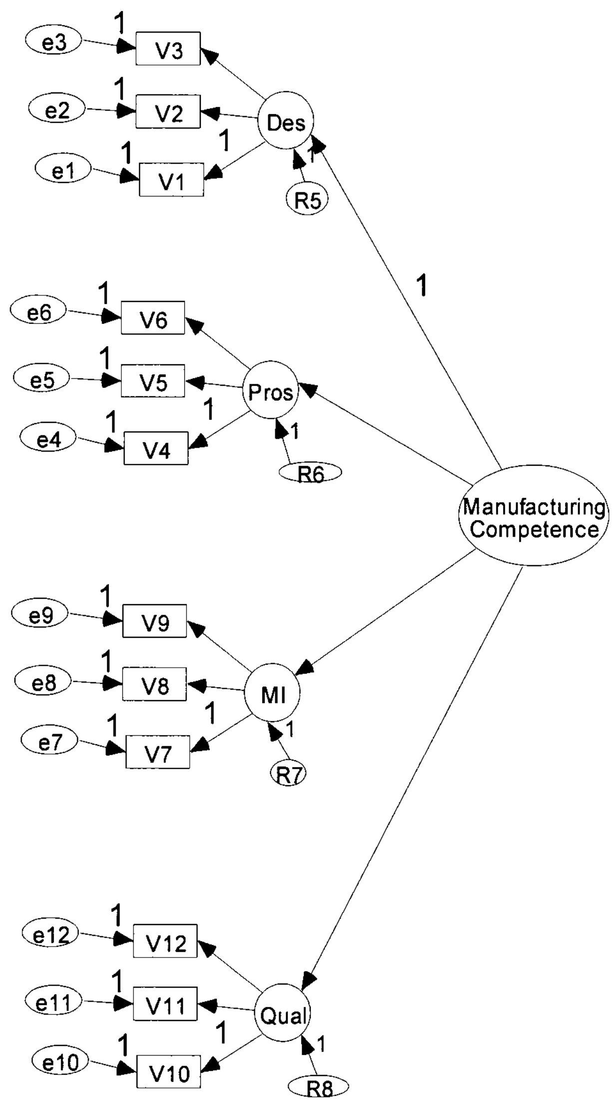
Manufacturing competence: This second order construct consist of four constructs as its dimensions, which are product design capability, process related capability, manufacturing infrastructure related capability and quality related capability. This is shown in figure 4.5.

All of the four capabilities should be strongly loaded to the second order constructs of manufacturing competence and there should a good fit overall in order to accept that such second order constructs exists. The loading of individual construct to the second order construct was found to be very strong. Similarly the overall fit was found to be acceptable. The chi-square value of the overall model is 93.629. Similarly, NFI value is 1.873, CFI of 0.961 and RMSEA is 0.065. These three values show the good fit of overall model.

Similarly, since chi-square value of the first order construct was 93.021, the target ratio is 0.9935, well above the required minimum. So the second order construct is adequate.

Table 4.21: Manufacturing Competence Second Order Construct

			Estimate	S.E	C.R.	P	Standardized Estimate
Design Capability	←	Manufacturing Competence	1.000				0.510
Process related Capability	←	Manufacturing Competence	0.663	.166	4.004	***	0.835
Manufacturing Infrastructure	←	Manufacturing Competence	1.188	.280	4.245	***	0.544
Quality Related Capability	←	Manufacturing Competence	0.342	.098	3.492	***	0.411



Manufacturing Competence (Second Order CFA Model)

Figure 4.5: Manufacturing Competence: Second Order Construct

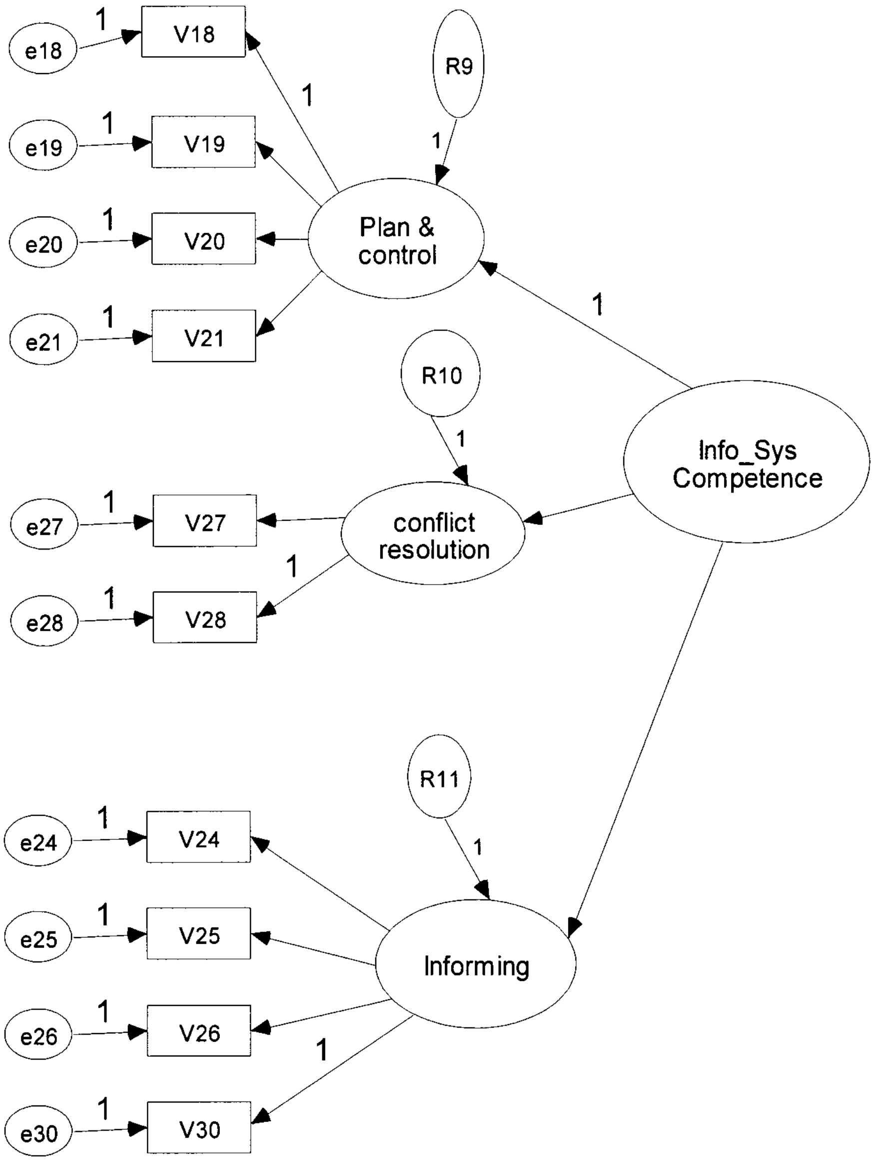
Information System Competence: The second order construct of Information System Competence consists of three constructs, planning and control, informing and coordinating and conflict resolution.

The chi-square value for the second order construct is 48.033. The overall fit of the second order model can also be assessed by the CIMN/ DF of 1.501, CFI of 0.977 and RMSEA of 0.049. All these three measure indicate the model has a good fit. The Second Order construct of the information system competence is shown in Figure 4.6. The chi-square value here is equal to that of first order model.

The loading of the individual constructs to the second order construct of information system competence is shown in table 4.22.

TABLE 4.22: Information System Competence Second Order Construct

			Estimate	S.E.	C.R.	P	Standardized Estimate
Informing	←	Information System Competence	0.779	.210	3.704	***	0.693
Planning and Control	←	Information System Competence	1.000				0.596
Conflict Resolution	←	Information System Competence	0.917	.263	3.483	***	0.705



Information System Competence (Second Order CFA Model)

Figure 4.6: Information System Competence: Second Order Construct

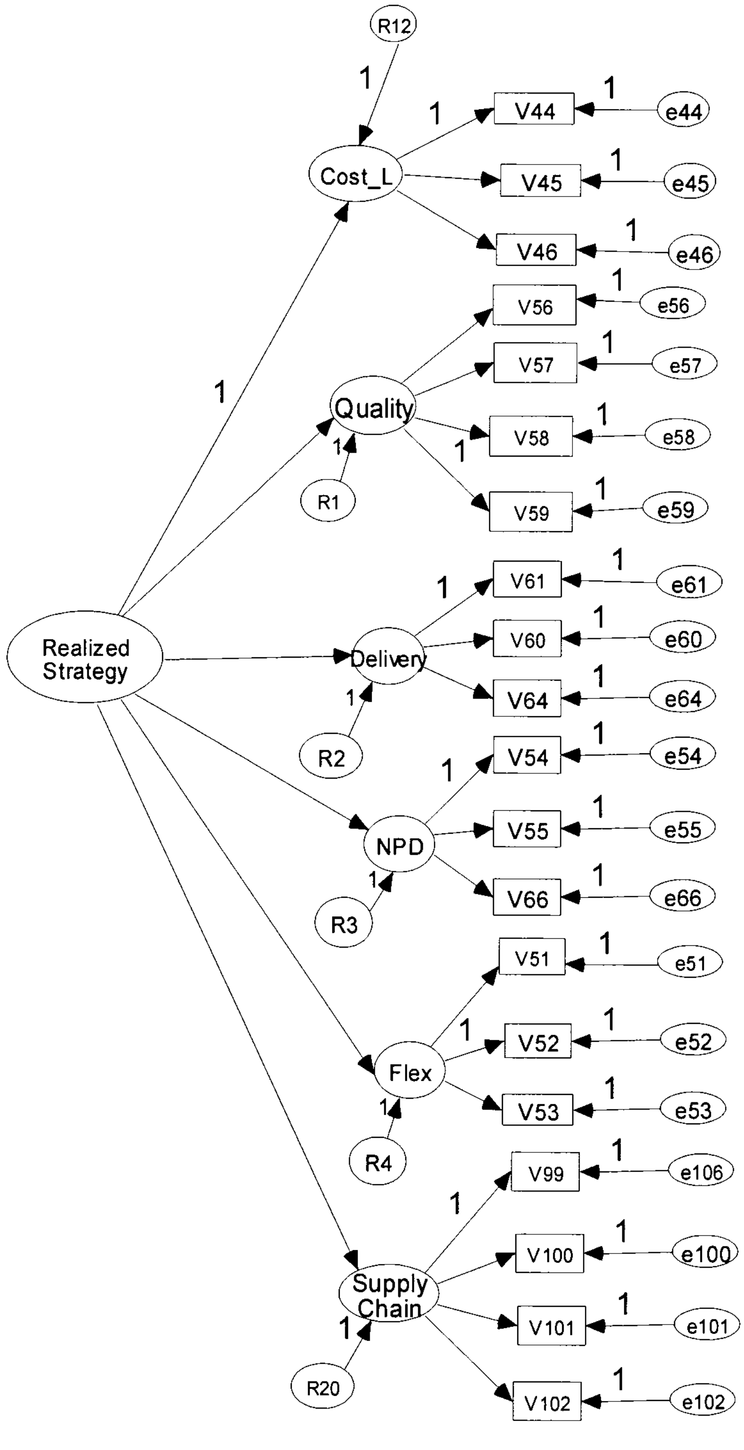
Realized Manufacturing Strategy: Realized manufacturing strategy is a second order construct with: cost leadership, quality, delivery speed, flexibility, new product development and supply chain as its dimensions.

The input for the second order constructs are shown in figure 4.7. The chi-square value of the model is 356.317. The overall fit is gauged also by CIMN/ DF 2.173, CFI of 0.901 and RMSEA of 0.074. CIMN/DF is slightly above the strictest range 1 to 2, but within the range of 1 to 3. Overall the model is acceptable. The loading of the individual constructs to overall construct of realized manufacturing strategy, as shown in Table 4.23 are statistically significant.

Since the chi-square value of the first order construct was 309.35, the target ratio is 0.868, which is deemed to be adequate. This further confirms the adequacy of second order construct.

TABLE 4.23: Realized Manufacturing Strategy Second Order Construct

			Estimate	S.E.	C.R.	P	Standardized Estimate
Quality	←	Realized Strategy	1.062	.362	2.934	.003	.411
Delivery Speed	←	Realized Strategy	.961	.391	2.458	.014	.293
Cost Leadership	←	Realized Strategy	1.000				.465
New Product Development	←	Realized Strategy	3.212	.968	3.318	***	.599
Flexibility	←	Realized Strategy	2.214	.690	3.210	.001	.660
Supply Chain	←	Realized Strategy	1.280	.439	2.916	.004	.464



Realized Manufacturing Strategy (Second Order CFA Model)

Figure 4.7: Realized Manufacturing Strategy: Second Order Construct

Performance: As discussed above, performance is the second order construct consisting of profitability, growth, productivity, customer satisfaction and option to expand.

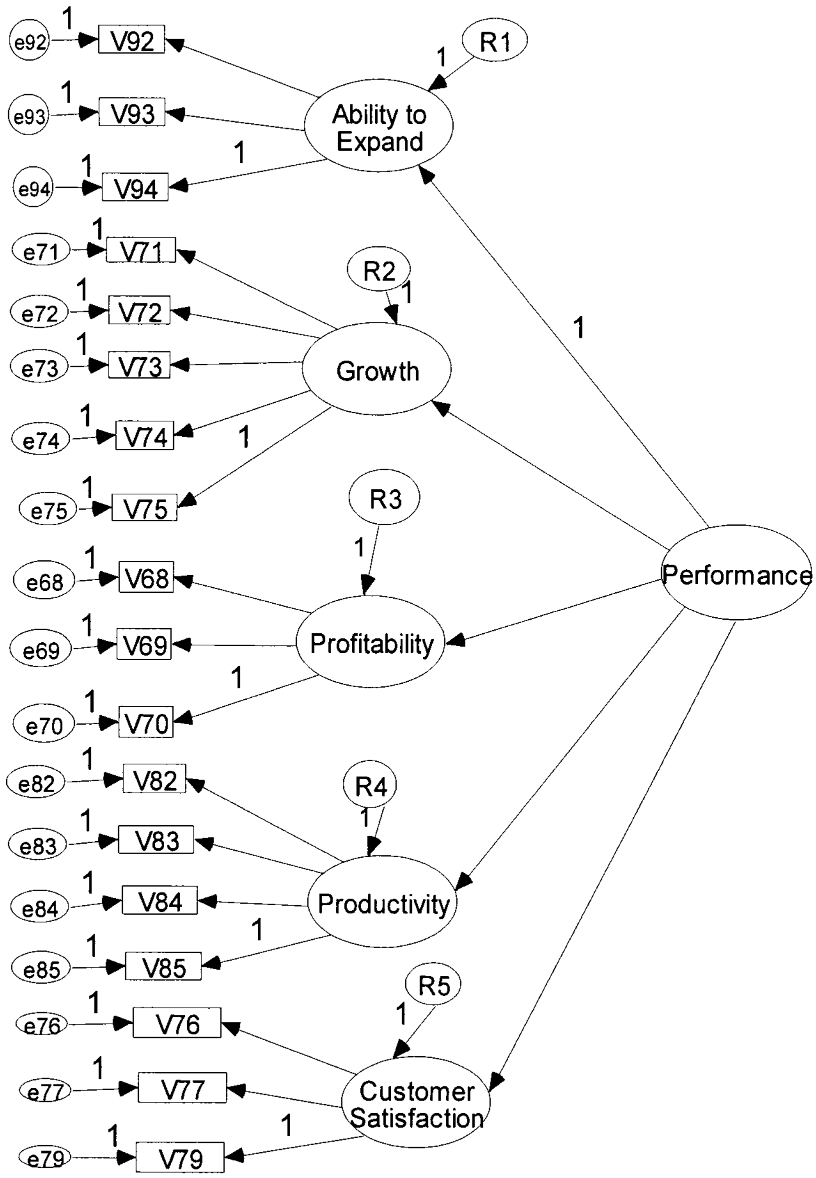
The chi-square value of the construct is 251.06. The overall fit of the second order construct is found adequate. It has the CMIN/DF of 1.931, CFI value of 0.948 and RMSEA of 0.067. Figure 4.8 shows the second order model.

The strong values for loading of the individual constructs with the performance are also the testament of the validity of the second order construct of performance. Table 4.24 shows the detail of loadings.

Since the chi-square value of the first order model was 223.317, the target ratio is 0.8895. This also confirms the adequacy of the second order construct.

TABLE 4.24: Performance Second Order Construct

			Estimate	S.E.	C.R.	P	Standardized Estimates
Growth	←	Performance	1.320	.275	4.805	***	.524
Profitability	←	Performance	1.863	.344	5.422	***	.846
Productivity	←	Performance	.368	.113	3.260	.001	.690
Customer Satisfaction	←	Performance	.436	.133	3.272	.001	.336
Option to Expand	<--	Performance	1.000				.344



Performance (Second Order CFA Model)

Figure 4.8: Performance: Second Order Construct

Summary for the second order construct: As per the fit statistics, overall fit for all the second order constructs were found to be adequate. These second order constructs form the building blocks for the complete model which are discussed in the next section.

As stated, Doll et al. (1994) used target coefficient to confirm the adequacy of their second order construct. The value of their target coefficient was 0.74; and it was deemed adequate. In our case lowest value of the coefficient was for the second order construct of the implemented manufacturing strategy. Even this ratio is well over 0.85. Therefore it can be easily concluded that, all our second order constructs have adequate fit and high target coefficient. Next step is construction and analysis of the complete model.

4.4 The Complete Model:

The purpose of going through all the steps described above is to make sure that each construct of what would be the complete model are valid measures of the concepts they are supposed to embody. After that a complete model is tested. The complete model is the one proposed at the end of section 3.3.

In this model we have four second order constructs (manufacturing competence, information system competence, realized manufacturing strategy and performance), which were developed and tested as explained above. Manufacturing competence has four dimensions, which are product design capability, process design capability, manufacturing infrastructure and the capability to develop and enforce quality. Each of these dimensions is constructs on their own right, with multiple indicators. Values of each of these indicators result from the responses to the questionnaire.

Similarly, information system competence has three dimensions. These dimensions are planning and control, informing and conflict resolution. Realized manufacturing strategy has six dimensions: cost leadership, quality, flexibility, delivery speed, new product development and supply chain integration. And finally, performance has five dimensions, which are customer satisfaction, productivity, profitability, growth, ability to expand.

According to this model the manufacturing and information system competencies both have direct and positive impact on the realized manufacturing strategy, and the realized manufacturing strategy have direct impact on the performance. Besides, manufacturing and information system competencies are correlated to each other. The complete model is shown in figure 4.9.

The Amos analysis of this model tests viability of these measurement models and the hypothesized relationships between the constructs (path) simultaneously. The chi-square value of this complete model is 2777.329. Similarly CMIN/ DF is 1.645, CFI is 0.841 and RMSEA is 0.056. CMIN/DF is within the range of 1 and 2. Similarly RMSEA value is 0.056 which is below 0.08. RMSEA of below 0.08 is considered reasonable error of approximation in population. However CFI value of below 0.9 and above 0.8 shows that this model can be marginally accepted. Judging by considering all the three indices overall fit of the model can be considered acceptable. The judgment on the model should be made taking theoretical and practical significance into consideration, besides the fit indices.

The detail of the outcome is shown in table 4.25. It shows that manufacturing competence has only indirect impact on the realized manufacturing strategy but the information system competence has a very strong positive impact ($p = 0.002$). Besides, the information system competence and the manufacturing competence are strongly and positively correlated to each other ($p < 0.001$). Because of this correlation, manufacturing competence exhibits considerable influence in the realized strategy. The realized strategy has strong and positive impact on the performance ($p < 0.001$). The direct relationship between the manufacturing competence and the implemented strategy was not found to be statistically significant ($p = 0.303$). These outcomes will form the basis for hypothesis testing, conclusion and discussions in the next chapter.

TABLE 4.25: The Complete Model

			Estimate	S.E.	C.R.	P	Standardized Estimate
Realized Strategy	←	Manufacturing Competence	.071	.069	1.031	.303	0.176
Realized Strategy	←	Information System Competence	.462	.171	2.701	.007	0.646
Performance	←	Realized Strategy	1.139	.297	3.827	***	0.902
Manufacturing Competence	↔	Information System Competence	.187	.052	3.597	***	0.674

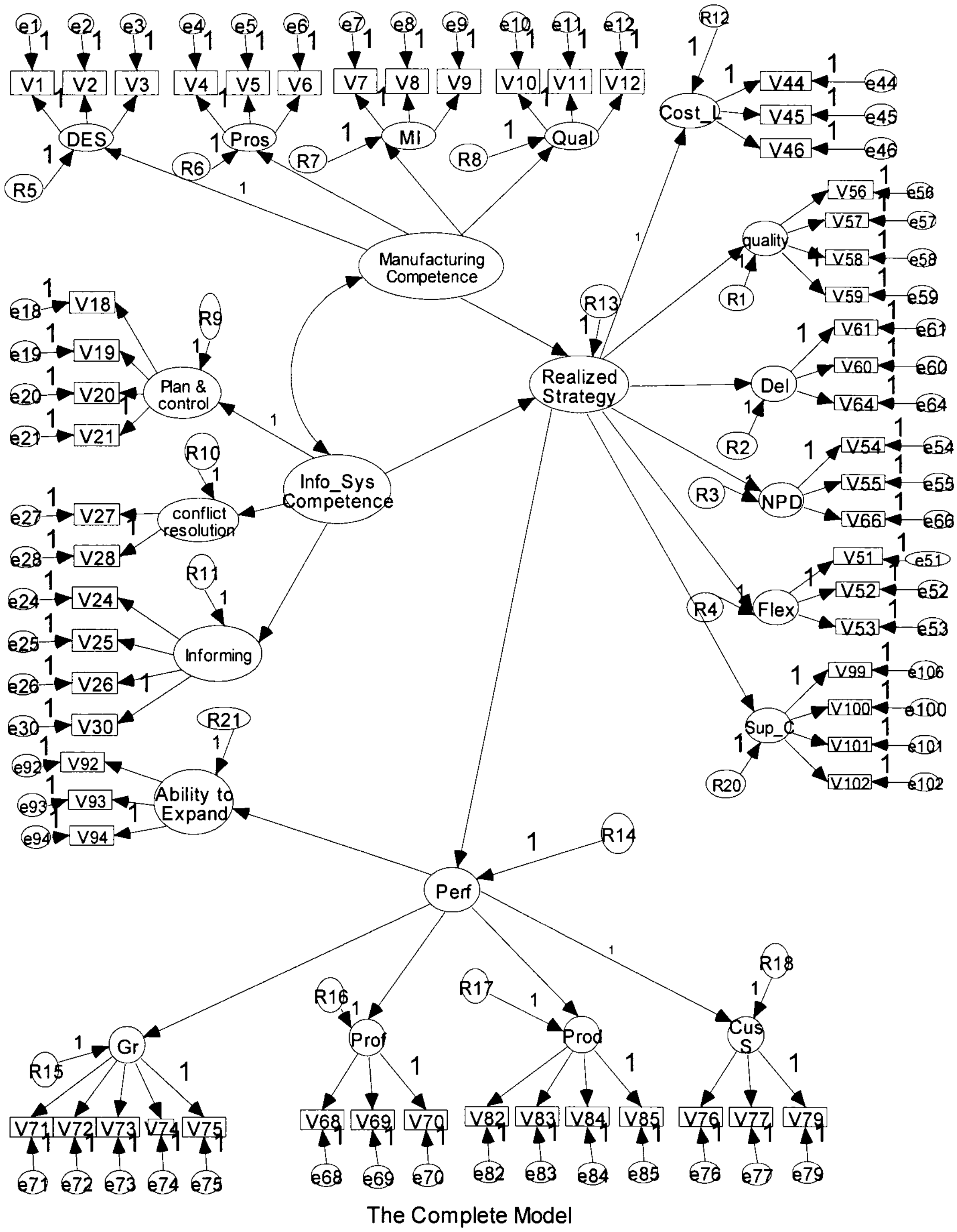


Figure 4.9 The Complete Model

4.5 Modification of the model

This part looks at the possibility of modifying the model. The modification indices will give the hint on where to modify. Modification indices (MI) with values of 10 or more were considered for modification. Ten was chosen following the suggestion of Byrne (2000). Any modification will have to be theoretically justified. In order to modify the complete model, we will start modifying from the first order and second order constructs.

The first and second order constructs of manufacturing competence and the information system competence were not modified. Their fit indices showed good fit, and there was no significant MI's in the AMOS output.

The first order construct of realized manufacturing strategy suggested important modification. Looking at the index, the decision can be made to drop supply chain integration from the manufacturing competence. Manufacturing competence was made up of cost, quality, flexibility, delivery speed, new product development and supply chain integration. The first five measures will have direct impact on customers' evaluation of products. Supply chain integration however is the manager's tool to achieve desired attributes in their products. Besides, it can be seen that plant managers' concern regarding supply chain are encompassed by the dimensions of flexibility and delivery speed. Dropping supply chain is theoretically justified. Besides, one indicator for new product development, which stated, "overall new product development gives us edge over the competitors", was dropped as well. It did not have direct and strong bearing on the NPD construct and it showed the cross relationship with several other indicators.

First Order Construct for Realized Manufacturing Strategy: Modified first order construct of realized manufacturing strategy (figure 4.10) showed marked improvement from the original construct. The chi-square value is now 150.174 instead of original 309.352. CMIN/DF is now 1.877 instead of 2.173. This value being within the range of 1 and 2 is considered an improvement. CFI has improved from 0.906 to 0.957. RMSEA showed little deterioration (0.075 from 0.065), but remained at the same range (0.05 to 0.08). The loadings of indicators in the remaining constructs, and correlations between them remained almost same (as expected). Table 4.26 shows the detail.

TABLE 4.26 : Standardized Loadings for Modified First Order Construct The Realized Manufacturing Strategy

V44	In the past three years we have focused on improving cost efficiency of the plant by keeping the capacity utilization at the maximum possible level	Cost Leadership	0.481
V45	In the past three years we have focused on keeping the production cost at the minimum possible level	,,	0.646
V46	In the past three years we have focused on improving productivity of our workers	,,	0.844
V56	Compared to that of our competitors, performance of our products are	Quality	0.844
V57	Compared to that of our competitors, reliability of our products are	,,	0.952
V58	Compared to that of our competitors, dependability of our products are	,,	0.829
V59	Compared to our competitors our ability to compete on the basis of quality is	,,	0.770
V61	Compared to that of competitors, our ability to meet delivery promises are	Delivery Speed	0.885
V60	Compared to that of competitors, our delivery speeds are	,,	0.876
V64	Overall, delivery gives us an edge over our competitors	,,	0.763
V54	Our new product development related capabilities make our new product development cycle shorter	NPD	0.939
V55	Our new product development related capabilities make ramp up time shorter	,,	0.940
V51	We offer a large number of product features	Flexibility	0.779
V52	We offer a large degree of product variety	,,	0.724
V53	We can adjust product mix	,,	0.544

TABLE 4.26 Continued: The Correlations between the Constructs
The Realized Manufacturing Strategy

New Product Development	↔	Flexibility	0.412
Delivery Speed	↔	Flexibility	0.009
Quality	↔	Flexibility	0.340
Cost Leadership	↔	Flexibility	0.362
Delivery Speed	↔	New Product Development	0.100
Quality	↔	New Product Development	0.236
Cost Leadership	↔	Delivery Speed	0.224
Cost Leadership	↔	Quality	0.114
Cost Leadership	↔	New Product Development	0.210

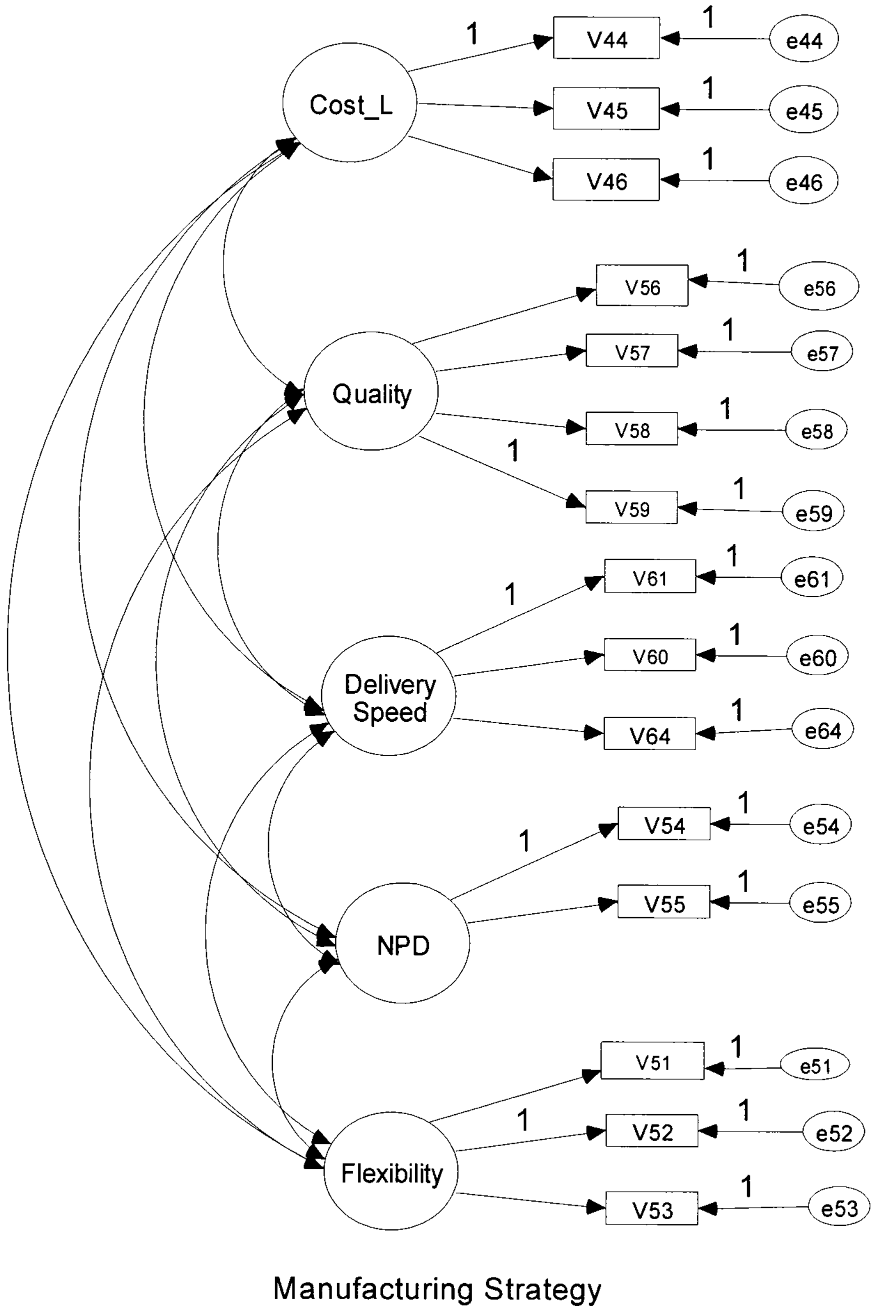


Figure 4.10: Realized Manufacturing Strategy First Order Factors (Modified)

Second Order Construct for Realized Manufacturing Strategy:

Modified second order construct followed the first order construct (figure 4.11). The chi-square value is now 173.944 compared to 356.317 before. The new value of CMIN/DF is 2.046, CFI is 0.945 and RMSEA is 0.071. All of them are improvements compared to the original values. And as expected, the loading of individual constructs to the overall second order construct remain almost same (Table 4.27).

TABLE 4.27: Second Order Construct Standardized Regression Weights of individual dimension to The Realized Manufacturing Strategy

Quality	0.467
Delivery	0.240
Cost Leadership	0.444
New Product Development	0.537
Flexibility	0.716

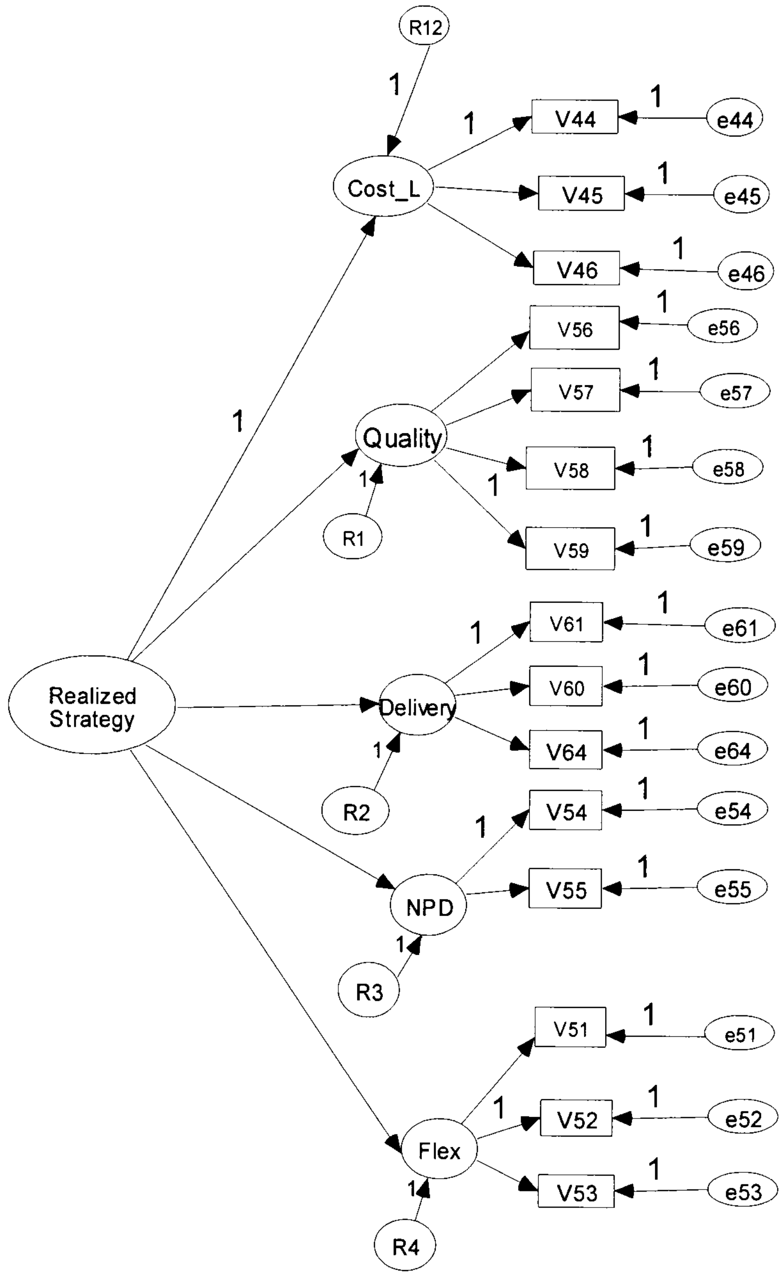


Figure 4.11: Realized Manufacturing Strategy Second Order Construct (Modified)

First Order Construct for Performance: Performance was improved upon in stages. The indicators V71 (sale revenue growth position compared to our competitors) and V75 (our satisfaction with the growth) were dropped from the construct of growth. V71 was close to profitability, and V75 was close to productivity.

After that customer satisfaction was dropped. Dropping customer satisfaction was considered for two reasons. Customer satisfaction construct itself was not very strong (reliability of 0.65). In second order construct the customer satisfaction showed strong affinity with productivity. Both of them in the same construct would be confusing. Plant managers do not deal with the end consumers. They are not as concerned with the notion of customer satisfaction as someone who has to deal with them. So, the justification of this construct in this context may not be as strong. The modified model is shown in figure 4.12.

Overall modification improved the chi-square value from 223.317 to 85.690. Similarly for the modified model, the CMIN/DF value is 1.452, CFI is 0.984 and RMSEA is 0.047. All of them are substantial improvement over the original model. The loadings of individual items to their respective constructs were not very different though. Details are is in table 4.28.

TABLE 4.28 : Standardized Loadings for Modified First Order Construct Performance

V74	Overall our organization's growth compared to that of our competitors is	←	Growth	0.871
V73	Market share gains compared to that of our competitors is	←	Growth	0.850
V72	Sale's volume growth position compared to that of our competitors is	←	Growth	0.938
V70	Overall our organization's profitability compared to that of our competitors is	←	Profitability	0.950
V69	Net profit position compared to that of our competitors is	←	Profitability	0.966
V68	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is	←	Profitability	0.856
V85	Productivity of our organization has increased significantly in last three years	←	Productivity	0.644
V84	Manufacturing makes significant contribution in increasing customer satisfaction	←	Productivity	0.733
V83	Manufacturing makes significant contribution to the growth of our organization	←	Productivity	0.620
V82	Manufacturing makes significant contribution to the profitability of our organization	←	Productivity	0.831
V94	Comparing today with three years ago, we are more able to expand our market rapidly	←	Options to Expand	0.796
V93	Comparing today with three years ago, we are more able to enter into new market rapidly	←	Options to Expand	0.914
V92	Comparing today with three years ago, we are more able to switch to the different product line (with the given infrastructure)	←	Options to Expand	0.625

Table 4.28 Continued: The Correlations between the Constructs Performance

Profitability	↔	Productivity	.206
Productivity	↔	Ability to Expand	.206
Profitability	↔	Ability to Expand	.325
Growth	↔	Productivity	.258
Growth	↔	Ability to Expand	.457
Growth	↔	Ability to Expand	.567

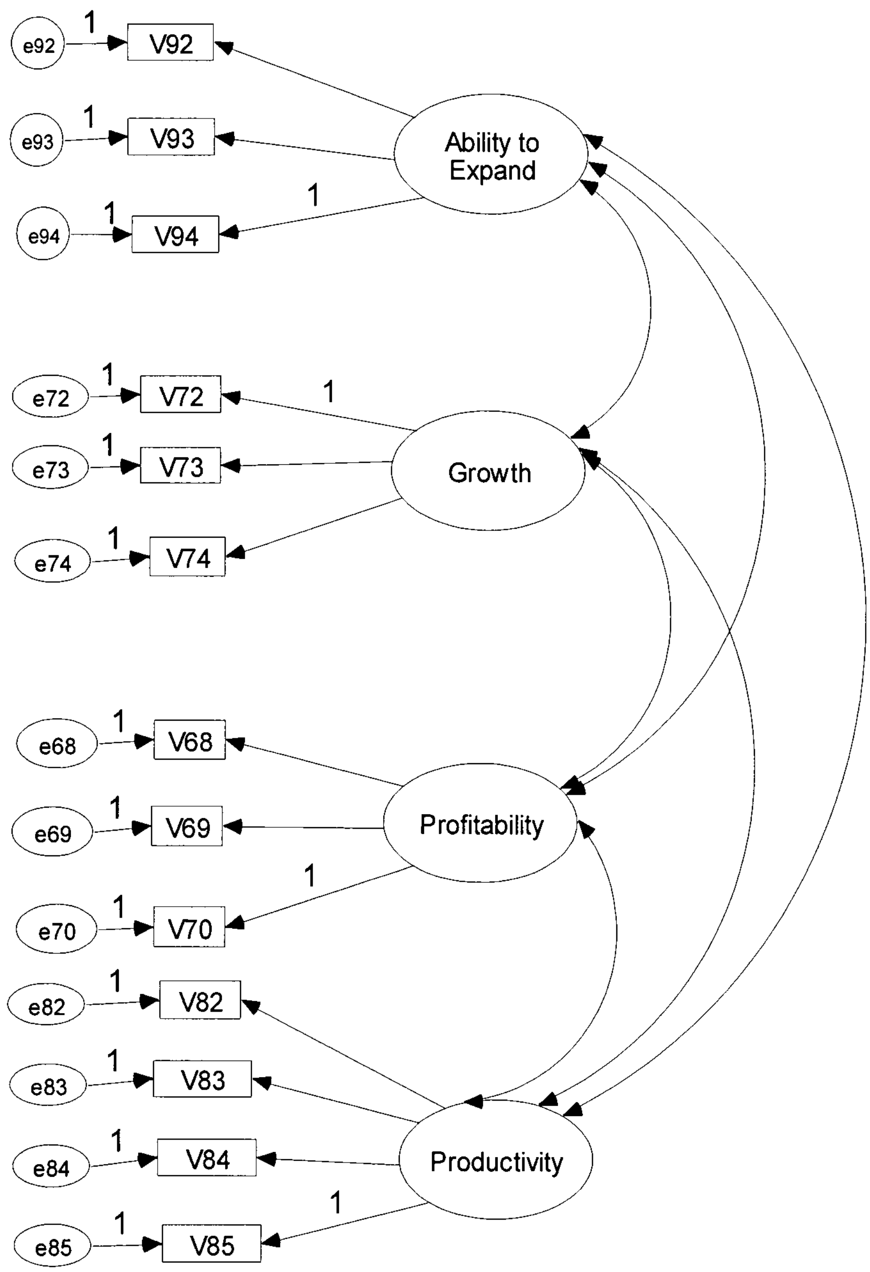


Figure 4.12: Performance First Order Construct (Modified)

Second Order Construct for Performance: Based on the modified first order construct, a second order construct for the performance was developed (figure 4.13). The chi-square value of this model was 86.289 against the value of 251.06 for original model. The modified performance model has CMIN/DF of 1.415, CFI or 0.985 and RMSEA of 0.045. All of them showed excellent fit and improvement compared to original model. The loading of individual dimensions to the overall construct of performance was not very different from that of original model (table 4.29).

Since the chi-square value of the original first order construct was 85.690, the target coefficient is 0.993. It is a great improvement over the original coefficient of 0.86.

Table 4.29: Second Order Construct Standardized Regression Weights of individual dimensions to Performance

Ability to Expand	←	Performance	0.524
Growth	←	Performance	0.871
Profitability	←	Performance	0.648
Productivity	←	Performance	

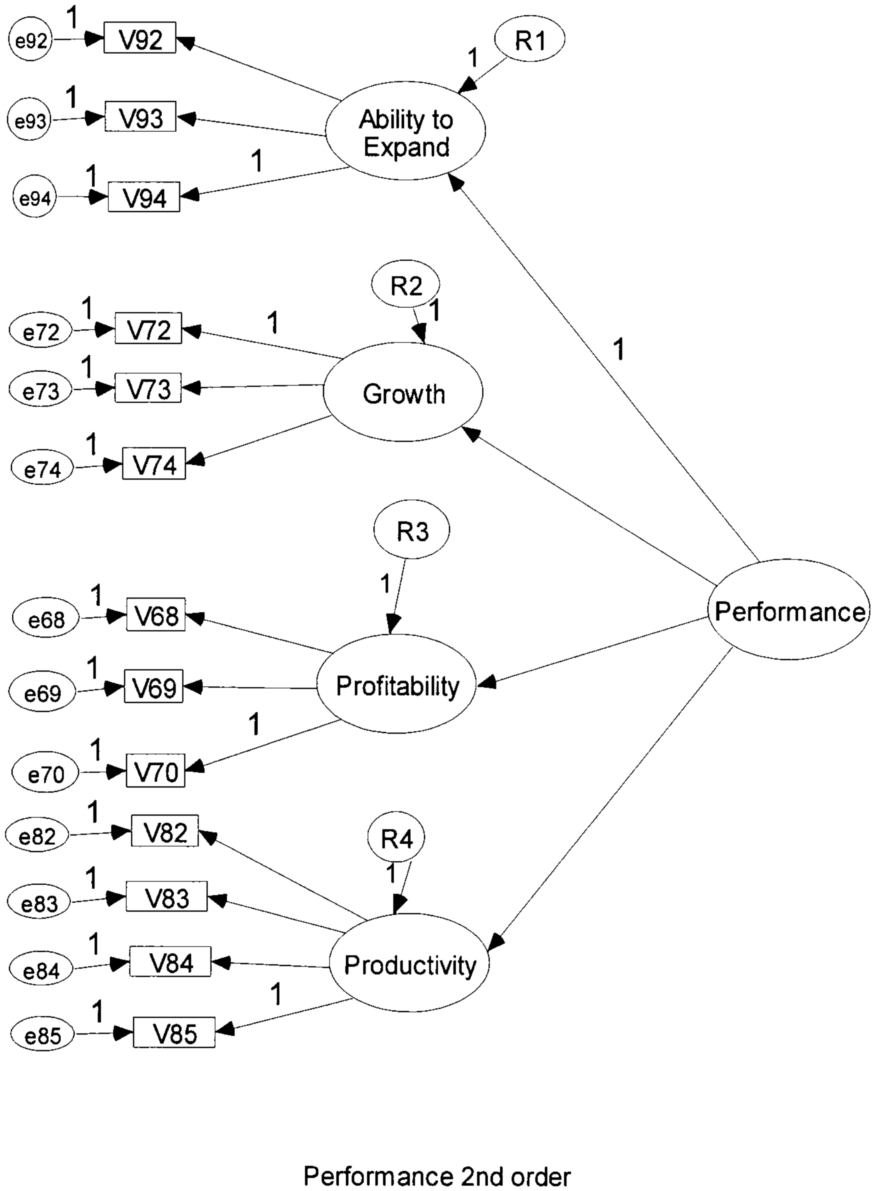


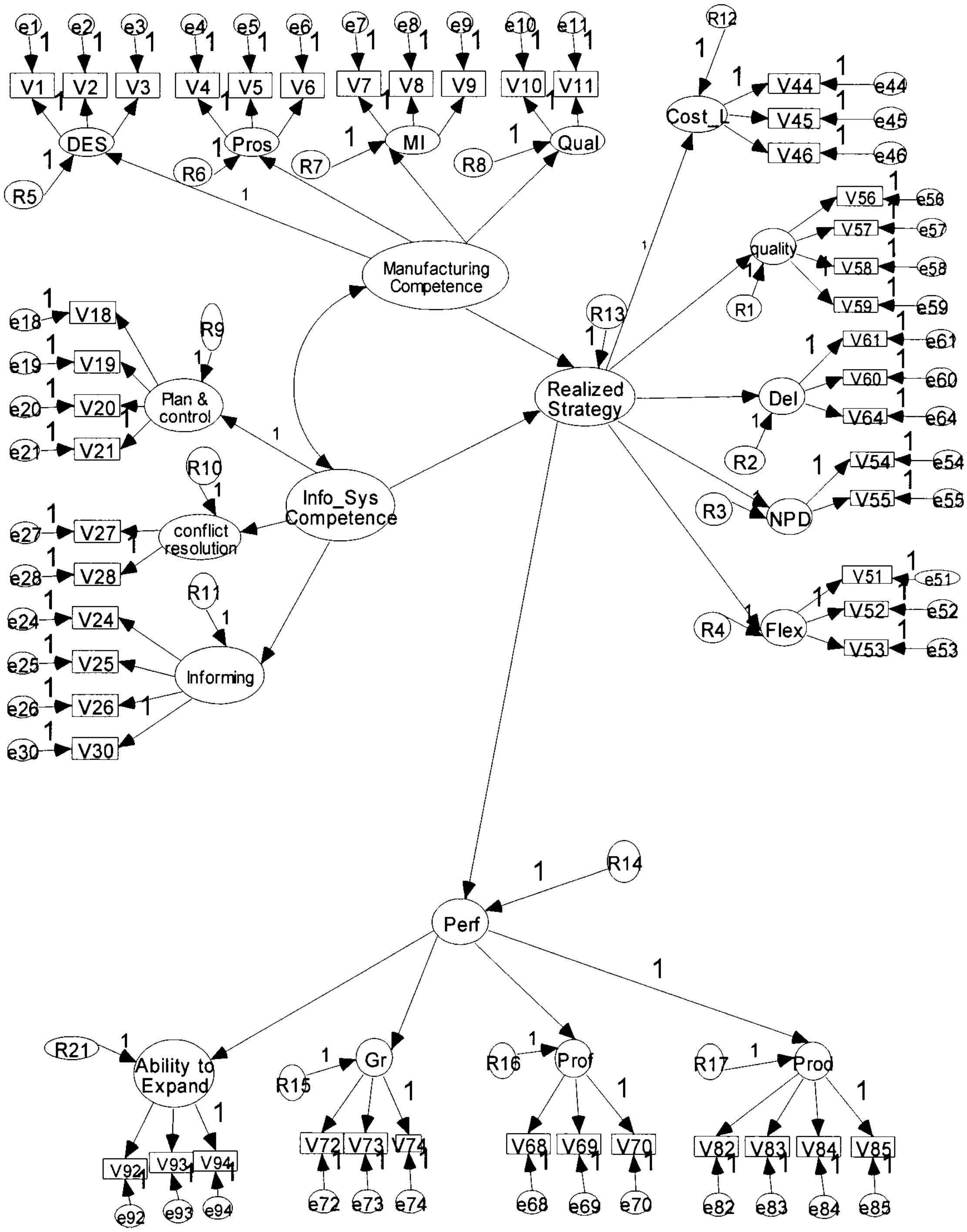
Figure 4.13: Performance Second Order Construct (Modified)

The modified complete model: The modified second order constructs (realized manufacturing strategy and performance) and two other construct (manufacturing competence and information system competence, which were not modified) were used to form the modified complete model. Besides after the model was completed. The indicator v12 (we are able to test quality (conformance to specification) of our inputs) was removed. It was not the most important indicator for the construct of ability to design and enforce quality, and it showed some cross loadings to other items. After this purging the modified completed model was finalized (Figure 4.14).

With this model there is distinct improvement in the overall fit. The Chi-square value of this model is 1660.477, much lower than 2777.329 of the original model. Similarly, CMIN/DF has reduced from 1.645 to 1.500. CFI has gone up from 0.847 to 0.901. And, RMSEA has reduced to 0.049 from 0.056. All the changes show the improvement in the fit of the model. However the relationships among the manufacturing competence, information system competence, realized manufacturing strategy and performance have not changed significantly. Details are shown in table 4.30.

TABLE 4.30: The Modified Complete Model Standardized Coefficients

Realized Strategy	←	Manufacturing Competence	0.176
Realized Strategy	←	Information System Competence	0.674
Performance	←	Realized Manufacturing Competence	0.677
Manufacturing Competence	↔	Information System Competence	0.655



The Complete Model

Figure 4.14: The Complete Model (Modified)

Summary on the modification model: The modification of the model achieved a model that was parsimonious and had better fit compared to the original one. All the fit indices consider here points that this model is acceptable. At the same time, the improvements of the model did not alter any of the conclusions reached on the basis of original model. This shows the robustness of the conclusion.

4.6 The Alternate Models

The alternate models change the original models. However, the purpose of the change is not to improve fit or parsimony of the model. In this model we allow the manufacturing competence to directly impact the information system competence (instead of correlating as in the original model). This add further insight, on the extent of the manufacturing competence's impact on realized manufacturing strategy (and hence the performance).

There are two alternative models. The first one (the alternate model 1 figure 4.15) is achieved by changing the correlations between manufacturing competence and information system competence, with the direct path showing the impact of manufacturing competence on the information system competence, in the original model. The second one (the alternate model 2 figure 4.16) is achieved by making those changes in the modified model.

The fit indices of the alternate model 1, are similar to the original model. But, this model clearly shows the direct and indirect effect of the manufacturing competence on the realized strategy and hence the performance. It shows that both manufacturing and information system competence have equal impact on the realized manufacturing strategy and the performance. This is the additional insight over the original one, with both theoretical and practical significance. Table 4.31 shows the detail of the direct and indirect effects.

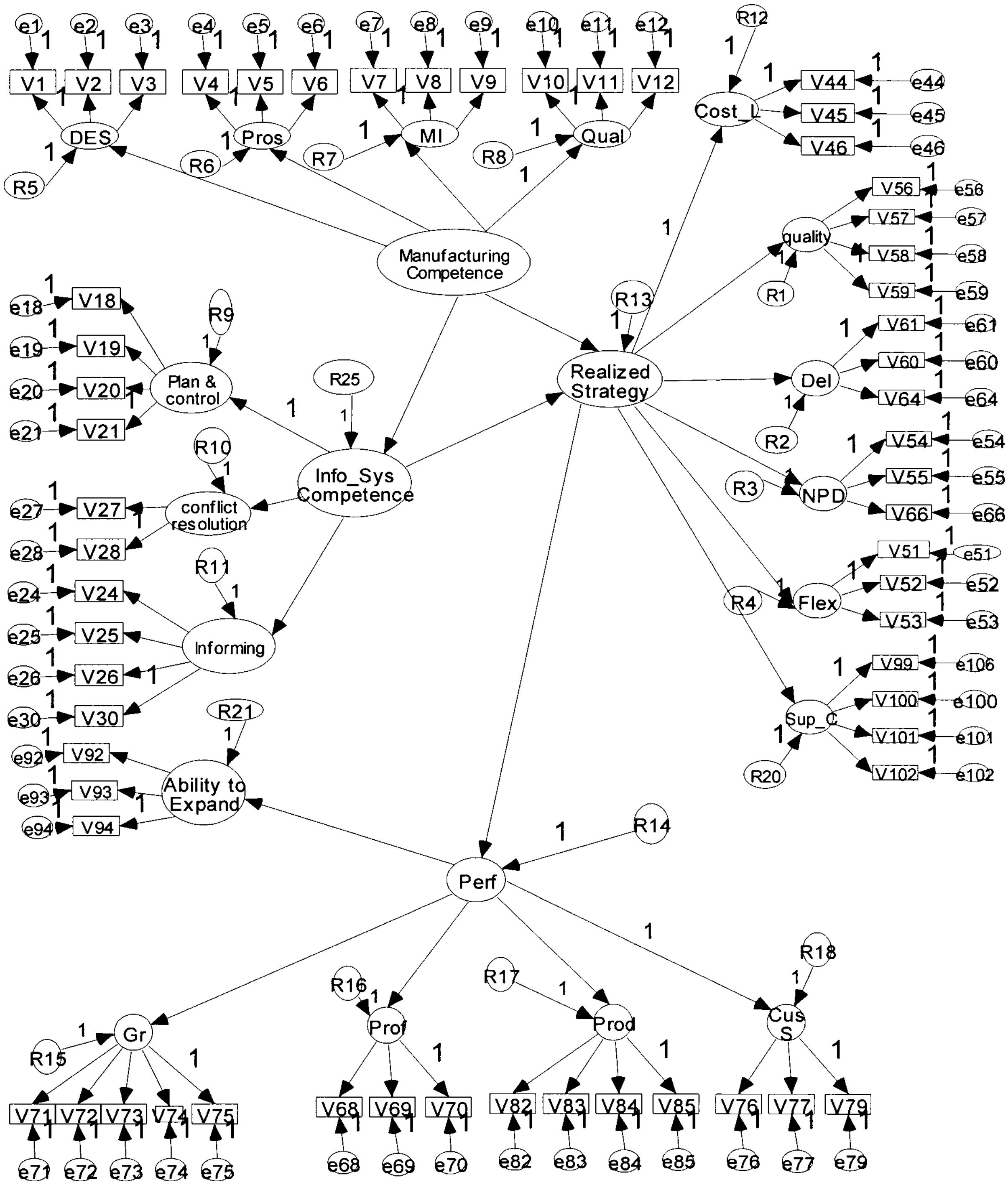
TABLE 4.31: Total Effect: The alternative model 1

	Manufacturing Competence	Information System Competence	Realized Strategy
Information System Competence	0.673	0.000	0.000
Realized Strategy	0.613	0.653	0.000
Performance	0.542	0.578	0.885

The alternative model 2 has the same fit as the modified complete model; however, it also shows the direct and indirect effect of manufacturing competence on the realized manufacturing strategy and performance. The detail is in table 4.32.

Table 4.32: Total Effect : The alternative model 2

	Manufacturing Competence	Information System Competence	Realized Strategy
Information System Competence	0.382	0.000	0.000
Realized Strategy	0.252	0.421	0.000
Performance	0.136	0.227	0.538



The Complete Model Alternative

Figure 4.15: The Alternative Model I

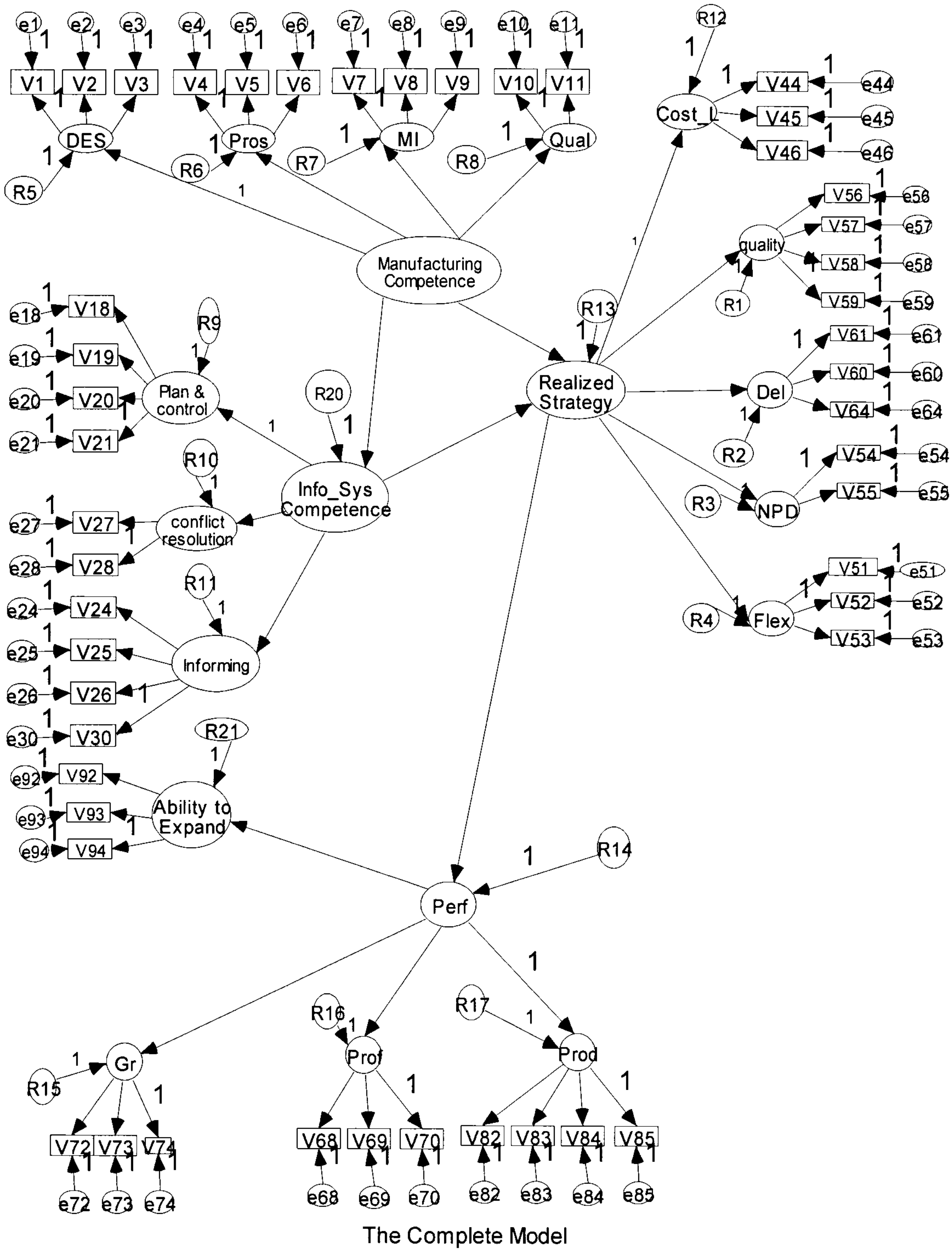


Figure 4.16: The Alternative Model II

4.7 Summary on Data Analysis

We developed the complete model and analyzed it in this chapter. This model was proposed at the end of chapter 3, and all the hypotheses were proposed based on this model. We our analyses will allow us to test hypotheses, which will be done in the next chapter. Besides we also tested modified and alternative model. Modified model gave us a parsimonious model that fitted the data better than the original one. The alternate models provided with additional insights on the effect of the manufacturing competence on information system competence, realized strategy and the performance. Further analysis of relations between the realized strategy and performance is carried out in the previous section. The outcome of hypotheses tests as well as the additional insights (gained from exploratory studies and analyses) will be the basis of discussions and conclusion in the next chapter.

Chapter Five

Analysis, Conclusion and Future Research

In this chapter we draw conclusions of this research. We use the complete model developed in the previous chapter to test the hypotheses proposed in chapter two. While drawing conclusions we also take note of the basis on which the model was developed, and the insights gained from the analyses of the alternate model along with the result of the hypotheses tests. First, we explain the complete model. The model was presented in the end of chapter three and its AMOS input for this was developed in chapter four. These models are reproduced here in figure 5.1 and figure 5.2 for references.

The complete model is built with the second order constructs (manufacturing competence, information system competence, realized manufacturing strategy and performance) developed in chapter three. While analyzing the model and interpreting its outcome, the fact that this research focuses at the plant level competencies and in the realized strategy (which is realized by the actions at the plant level) should be taken note of. Strategies are realized at the plant level, even though they are formulated at the headquarters by the top management.

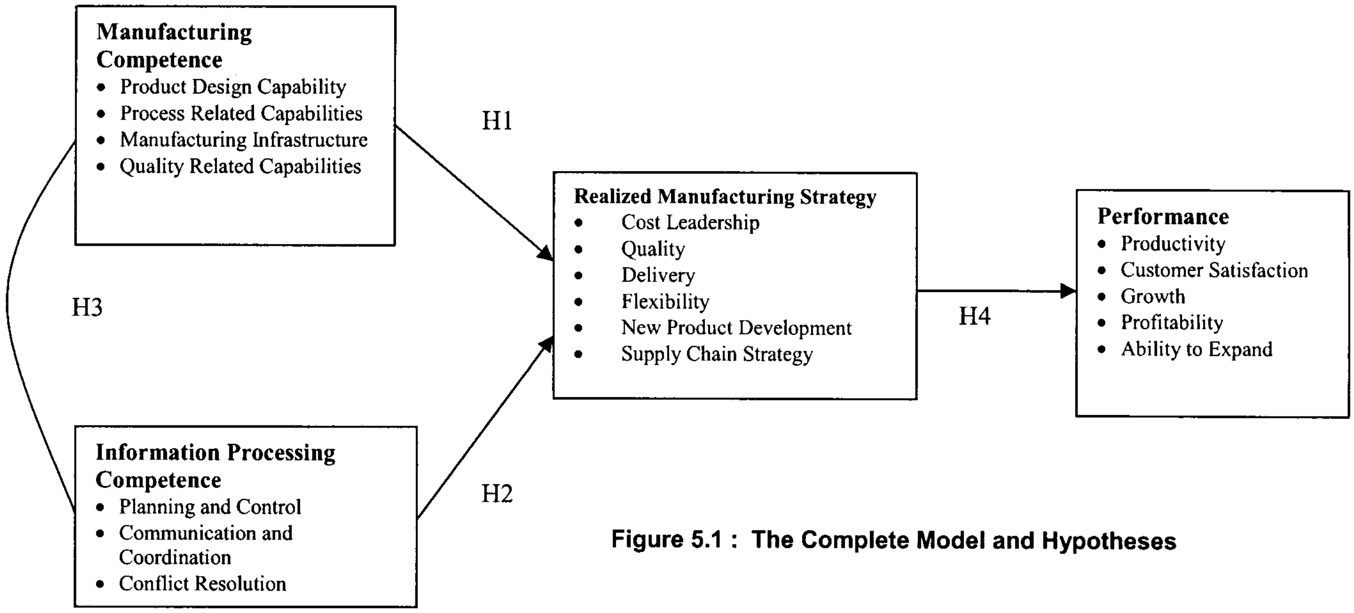
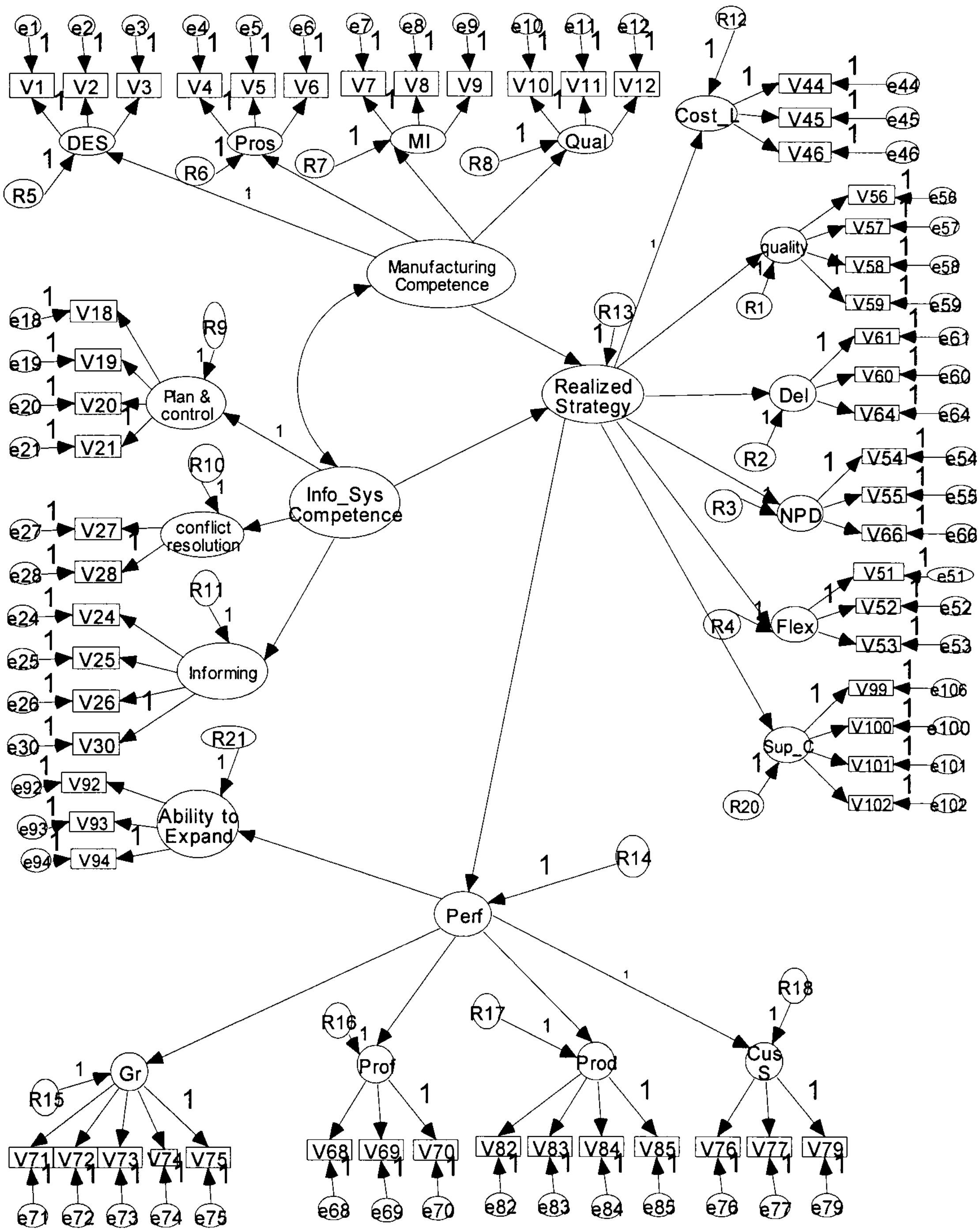
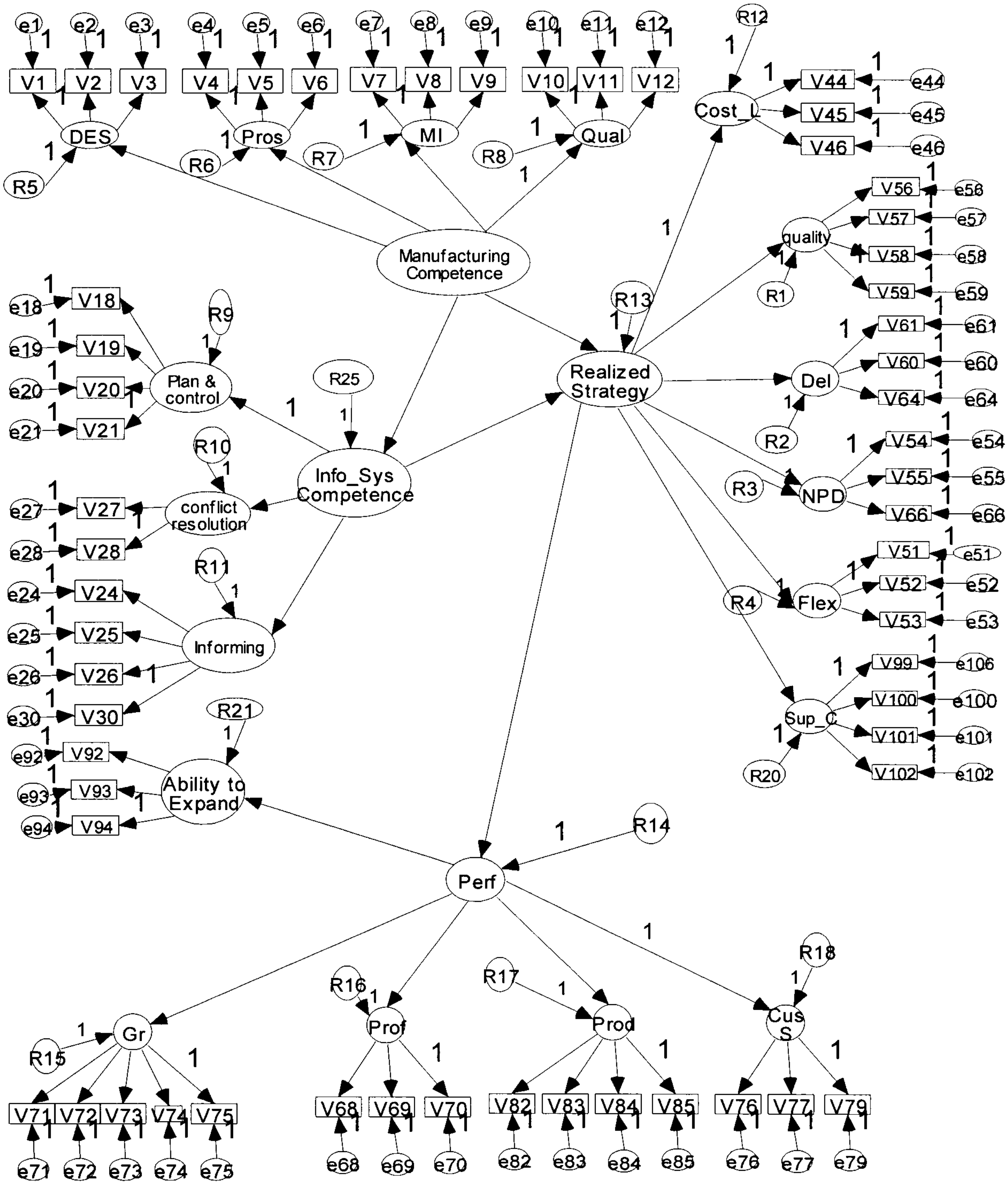


Figure 5.1 : The Complete Model and Hypotheses



The Complete Model

Figure 5.2: The Complete Model



The Complete Model Alternative

Figure 5.3: The Alternative Model

In our theory part (chapter two) we discussed that competencies (both manufacturing and information system) are deployed in the plant in order to implement the strategy. And implementation of strategy leads to performance. Manufacturing competence consists of product design capability, process design capability, manufacturing infrastructure related capability and capability to design and enforce quality. Information system competence, on the other hand, consists of manufacturing plants' ability to control, coordinate and share information. Similarly, implemented strategy consists of cost leadership, quality, delivery speed, flexibility, new product development and supply chain integration. And, performance consists of customer satisfaction, profitability, growth, productivity and ability to expand.

Information system competence includes the abilities that are required in day to day operations of the plant. Research has shown that simply having an enterprise wide information system does not help a plant. When the information system is introduced along with the operations system, these two together can have impact on the performance (Rabinovich et al. 2003).

Manufacturing strategy literature presents these abilities (although they discuss this in terms of the underlying technology, the limitation of which is elaborated in chapter two) as the vehicles for implementation of manufacturing strategy (Berry and Hill, 1992; Hill, 1989). Products from the plants are the outcomes of such operations. Numbers, variety, functionality and sophistication of the products are the reflection of the excellence the plant has achieved in its operations. Once the process reaches a certain level and stabilizes, modifications can be incorporated and the next level of excellence can be achieved (Chanaron and Lung, 1999).

Manufacturing information system literature also emphasizes the need for the system to have the ability to channel the manufacturing capability in the plant towards achieving the desired outcome (Wu and Ellis, 2000; Xu and Kaye, 1997). Besides that, literature also emphasizes that such a system should be able to scan the environment and understand competitors' strategies (Wu and Ellis, 2000; Xu and Kaye, 1997). These abilities however are required for the formulation of a strategy (which is not the domain of the plant managers), and do not figure in the dimensions of the information system competence discussed here. Our concept of information system competence incorporates the information technology and the operations process discussed above.

5.1 Analysis of the complete model

The complete model is the model that we proposed in chapter two. As stated the second order constructs developed in chapter three are the building blocks of this model. We also developed hypotheses to be tested in chapter two. The analysis of this model allowed us to tests those hypotheses. In next few paragraphs we discuss the outcome from test of these hypotheses. As discussed already, while drawing conclusions, the context of this research and practical significance of issues are considered in addition to the outcome of hypotheses testing.

Figure 5.2 shows the model (The model is the AMOS input for the model shown in figure 5.1). It tests the relationship of both manufacturing competence and information system competence with the realized manufacturing strategy. It also tests the correlation between the manufacturing and information system competence. And, it also tests the relation of realized manufacturing strategy and performance.

The detail of the output from the test of this model is shown in Table 4.23 (chapter four). According to this there is strong correlation between the manufacturing and information system competencies (correlation value of 0.674, p value < 0.001). Information system competence has strong and positive impact on the realized strategy (standardized regression value of 0.646 and p value = 0.007). And, realized strategy has a strong influence on the performance (standardized regression value of 0.902 and p value= 0.000).

The correlations between the manufacturing and information system competencies: The outcome shows that manufacturing competence and the information system competence are strongly and positively correlated (correlation value 0.67) with each other. This correlation supports the H3 proposed in chapter three. Since both manufacturing and information system competencies are deployed in the plant as a result of the strategy formulation (chapter two), the correlation is expected. The high positive correlation also supports our suggestion that these two competencies should progress by supporting each other. Weakness in one competence weakens the effectiveness of both competencies.

Realized Strategy and Performance: The tests shows that realized strategy has a strong influence on the performance. The standardized regression coefficient is 0.9. It supports the H4 proposed in chapter three. As expected the ability to realize the (goals set in) strategy has a direct and strong impact on the performance.

Interrelationships between manufacturing competence, information system competence and the realized strategy: It is seen that the information system competence has a direct impact on the realized manufacturing strategy. The standardized regression coefficient is 0.65 and is statistically significant. This supports the H2 proposed in chapter three. The acceptance of this hypothesis confirms the suggestion that "information system competence" is the facilitator of the operations in the plant, enabling the plant to realize the goals set in strategy. In addition to that, its strong correlation with manufacturing competence (as shown above) suggests, that while facilitating the operations of the plant it (information system competence) also has to be the vehicle for channeling the manufacturing competence. The extent to which the goals of the strategy are realized depends on the information system competence's ability to channel the manufacturing competence as well.

Indirect and Direct impact of Manufacturing Competence and Realized strategy: This study also tests the hypothesis (H1 proposed in chapter two) that manufacturing has direct and positive impact on the realized manufacturing strategy. The standardized regression coefficient of this path is 0.17, and it was not statistically significant, showing that the hypothesis is rejected. However, the rejection of this hypothesis alone should not be interpreted as the evidence of insignificant influence of manufacturing competence in realizing strategy. Discussions in previous paragraphs indicate that manufacturing competence has a significant influence in the implemented manufacturing strategy. Information system competence's role to channel manufacturing competence for realizing strategy is shown above. Further exploration was done to gauge the influence of manufacturing competence on the implemented manufacturing strategy.

An alternative model was developed and tested for this purpose. The alternative model is given in figure 5.3. This model is almost the same as our original model (figure 5.2). This model also shows the impact of manufacturing competence and information system competence on the realized strategy. There is also a direct relationship between the realized strategy and the performance. But unlike the original model, it suggests the direct impact of the manufacturing competence on the information system competence (not just correlation).

The outcome of the analysis of this model is almost same as the outcome of the original one. The overall fit of the model (CFI of 0.841 and RMSEA of 0.056) is almost same as in original model. Similarly, the standardized regression coefficients (between manufacturing competence and realized strategy, between the information system competence and the realized strategy and between the realized strategy and the performance) are similar to that of the original model, and all are statistically significant as expected. However, this model also shows the strong impact of manufacturing competence on the information system competence. The standardized regression coefficient is 0.67 and is statistically significant. This shows that the development of information system competence (which includes in it the operations, coordination, communication, control and planning) is dependent strongly on the level of manufacturing competence available at the plant level. This supports all of our discussions on the interrelationships between information system competence and manufacturing competence.

Beyond that, the analysis of this model also shows the direct and indirect impact of manufacturing and information system competencies in the realized strategy and the performance. As shown in table 5.1 (this is the same table as table 4.27, reproduced here for convenience) the impact of manufacturing competence and information system competence on the realized strategy and also in performance is almost equal. The only difference between these two is while the information system competence effect is direct, the manufacturing competence's effect is mostly indirect (through its impact on the information system competence).

Table 5.1 Total Effect: The alternative model 1

	Manufacturing Competence	Information System Competence	Realized Strategy
Information System Competence	0.673	0.000	0.000
Realized Strategy	0.613	0.653	0.000
Performance	0.542	0.578	0.885

5.2 Practical and Theoretical Implications of our Findings:

Because this is one of the few studies in the area of strategy implementation at the manufacturing plant level, its findings will have both practical and theoretical significance.

Past studies point out that the stronger the plant manager's contribution in the formulation of strategy, the better the performance would be (Swamidass, 1988). Research also indicates that agreement between the plant and headquarter on the level of competence available at the floor level, increases the chance of formulated strategy being implemented (Dobni, 2003). Yet others have discussed the complex interaction, in production plant, between technology, people and organization (Frohlich, 1998; Chanaron and Lung, 1999; Conner, 1991).

Our findings support, add clarity and extend the above suggestions. It spells out clearly that competencies that are of concern are manufacturing competence and information system competence. By showing the underlying dimensions and items of each dimension for each competence, our study provides clear explanations of each of them. Besides, we also show that these two competencies should support each other.

The plant managers can use our measurement to gauge the level of both competencies (manufacturing and information system) inside the plant. They should also use the information system competence (which includes operating system, control, procedures and routines) to facilitate the manufacturing competence's contribution in achieving goals. In addition, plant managers should be able to clearly communicate the level of competencies available at their plant to their headquarters. When headquarter formulate strategy they should consider the level of competencies available at the plant level and set goals that are achievable. They (headquarter) can also agree on the enhancement of the competencies and set resources accordingly, when ambitious goals are set.

Researchers, since many years, have emphasized the need for conducting empirical research (Adam and Swamidass, 1989; Minor et al. 1994; Swamidass, 1991), and adapting the resource-based view (Grant, 1991; Gagoon, 1999; Dangayach and Deshmukh, 2001) in the area of manufacturing strategy research. This study contributes to the fulfillment of both of these gaps.

This research takes a strong initial step in developing the constructs of manufacturing competence and information system competence (in manufacturing context), using the resource-based view. In manufacturing, researchers had urged that competence should be used to gauge the excellence in manufacturing (Grant, 1991). And there was a case study, which in addition to supporting the above mentioned view also suggests various dimensions of manufacturing competence (Coats and McDermott, 2002). Our study brings this research endeavor to completion by developing and validating such measures with a large scale empirical study.

This will be only one of the very few empirical studies that focus on the interrelationships between the manufacturing and the information system competencies and their impact on the strategy. Thus this study investigates one of the most important issues in manufacturing research which was mostly overlooked by empirical researchers (Kotha and Swamidass, 2000).

While there is widespread agreement that strategy implantation at the manufacturing plant is the important issue, this work has actually studied the implemented strategy and conducted a survey at the plant level where implementations are done. This is one very important additional contribution of this research.

We have also developed and used the multidimensional measure of performance. There was a very strong relationship between realized strategy and performance (standardized regression coefficient, 0.9). This indicates that our measure encompasses in it almost all the concerns related to performance those plant managers have.

In a nutshell, this study makes an important contribution to “theory building” in the area of manufacturing strategy as urged by researchers. The theory this study put forth has a strong practical significance.

5.3 Generalizability of the findings of this Study

We collected data from many sub sectors within the manufacturing. The data represents primary metal industries, fabricated metal products, machinery except electrical, electrical and electronics machinery, transportation equipments, measuring analyzing and controlling equipments and others. It also has organizations with a single plant. It is well represented by the auto-industry. To that extent the findings of this research are generalizable to the entire manufacturing industry.

5.4 Limitations of this Study

The data collected for this research comes from the ten states of the Midwest region of the United States. The regional nature of this research may be indicative of the limitations in generalizing its findings.

Similarly, the data collection was biased even compared to the population on which the questionnaires were sent. Detail of this bias is discussed in chapter three. That should be also taken note in generalizing the findings of this research.

This is an initial effort in operationalizing many of the constructs. Future research will have to improve the reliabilities of “customer satisfaction,” “supply chain integration, ““manufacturing process related capability” and “informing.” The reliability of customer satisfaction is 0.65 (marginally acceptable) and other constructs mentioned above is 0.7, showing that there are rooms for improvement.

5.5 Suggestions for Future Studies

Like any research this was an attempt to find explanations on some of the burning issues researchers and practitioners have in mind. This research provides useful insights, and it was successful in this respect. However, findings of every research are tentative explanations, which need to be verified and improved by future research. Therefore findings of our research also are to be subjected to verification with data set different than this one. More insights may be gleaned from future investigations.

One area of future research will be to see how much impact the agreement between the plant managers and headquarter, on the levels of manufacturing and information system competencies will have on the realization of the formulated strategy. Although the findings of this study indicate the probability of strong positive relationship, future research will be explicitly formulated to measure the impact of such understanding on the implementation of strategy. The role of plant managers in converting resources at hand in to the competencies which would help him (her) to realize the strategy can also be a subject of a future study.

These studies will also have to endeavor to improve upon the individual constructs used in this one. Customer satisfaction is one such construct, which need to be improved (its reliability is marginally acceptable). Other constructs whose reliability were acceptable can be improved as well. Supply chain, cost leadership and process design capability are the candidates for further improvements and development. Improving the reliability of instruments will have a practical implication. In addition to that, the process of improvements, which requires both the fine-tuning of theory and communicating with practitioners, will provide insights with both theoretical and practical significance.

Some hints of future empirical research can be found from our theory discussions in chapter two, where we developed the conceptual model. Only part of the conceptual model was subjected to the empirical test here. Future investigations can focus on the other parts of the model yet to be empirically tested.

One area of empirical investigation will be the relation between the formulated strategy (which are done at the headquarters) and the acquisition of resources (human resources, physical capital) at the plant level. The relevant research question can be how plant managers combine resources to achieve the requisite level of manufacturing competence. And another question can be how they modify the information system competence in order to channel the manufacturing competence in achieving the goals of plant.

Similarly, a future study can also focus on the feed back lines. How the success (or failure) in realizing strategy (at the plant level) effect the strategy formulation (at the headquarters), can be one area of investigation. Similarly, one can study how various performance affect the formulation of the strategy. The extent to which goals are realized compared to what was intended, and the plant's performance can be the areas on which headquarter and plant manager need to agree on during the formulation of strategies. Future study should explicitly ask these questions.

Future research will also have to be conducted to see the interrelationship between various dimensions of the realized strategy. It is generally agreed that cost, quality, delivery speed, flexibility and new product development constitute manufacturing strategy. However, there is less agreement as to how these individual dimensions of strategy are related to each other. Porter(1980) argues that there is a tradeoff, suggesting that achievement of one aspect of manufacturing strategy (for example cost leadership) comes at the cost of ability of achieve another dimension (for example high quality). But, Deming (1993, 1994) suggests that cost and quality can be achieved simultaneously. Focus on quality will lead to reduction on rework, less warranty cost, less waste and hence less overall cost. DeMeyer et al. (1989) have suggested that each goal is achieved sequentially. However, there is no definite answer as to how each dimensions of strategy are related to the others. Future study will have to clarify the interrelationship between these dimensions.

Similarly the interrelationships with in the constructs of performance have to be studied and these measures improved upon. There are past studies which focus on the interrelationships between ”customer satisfaction”, “productivity” and “profitability “ (Hitt and Brynjolfsson, 1996; Anderson, Fornell and Rust, 1997). We have added “real options” to this list. Real option allows organizations to develop strategies suitable for the situations different from the current ones. The research question can be, how much of customer satisfaction, productivity and profitability enhance the real option of organizations. Similarly, it can also be how much of sacrifice the organization has to make (and are ready to make) in current the performance (in terms of customer satisfaction, productivity and profitability) in order to acquire such real options.

In addition, interrelationships between the constructs within the manufacturing competence constructs will have to be done. For example, capability related to manufacturing infrastructure can have direct impact on organization’s product design capability and processes design capability. Future study can focus on these interrelationships.

5.6 Summary of the results

Three out of four hypotheses were not rejected and one hypothesis was rejected. The hypotheses that were rejected and not rejected are as following.

H1:	Manufacturing competence has direct and positive impact on the implementation of manufacturing strategy	Rejected
H2:	Information system competence has direct and positive impact on the implementation of manufacturing strategy	Not Rejected
H3:	There is a positive correlation between manufacturing and information system competencies.	Not Rejected
H4:	The implemented strategy has direct and positive impact on the plant's performance.	Not Rejected

Even so, with the alternate model we also demonstrated that manufacturing competence's impact on the implemented manufacturing strategy is almost as much as that of information system competence, although its impact is mostly indirect while the information system competence's impact is direct.

This study identified and empirically verified the competencies that plant mangers need, in order to implement the strategy. It also identified almost all the performance concern of the plant managers. Therefore, this is a significant study with both practical and theoretical implications. This study can also be the stepping stone for many future studies to be carried out in this arena. Like any research this has its limitations, which has to be taken into account in every conclusion that can be drawn.

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APPENDIX 1

Questionnaire for Pilot Survey

Thank you for taking time to answer the questionnaire. Following points will assist you in completing this:

- Ideally the Operations Manager, Plant Manager, or a member of the management team familiar with all aspects manufacturing management in the organization should complete this questionnaire.
- For each of the questions we seek answer from manufacturing perspective.
- We/ our organization should be understood as the division/ department/ plant/ profit center as applicable. It should not be taken as meaning the corporation as a whole.
- Competition in questions means competition on the average.
- If question starts with "Comparing with three years ago…", and your company is less than three years old, please read the question as "Comparing with when we began…"
- Customers in questions mean immediate customer of your organization, not necessarily the end-consumers.
- **Manufacturing information system** in the questionnaire means information technology (hardware, software, computers, communication technology, robots or similar technology) **available to the manufacturing function**. If there are such systems available in organization but manufacturing function does not use them, then those are not considered manufacturing information system
- Before answering each question, please read the relevant scoring scales as these do change throughout the questionnaire.
- Unless otherwise specifically requested, for each question please circle the number which accurately reflects your organization's **PRESENT** position.
- It is critical to the success of this study that you answer the questions as they relate to the **CURRENT** practices of your organization- **NOT** as you wish them to be. This study aims to take a snap shot of manufacturing practices and competitive capabilities as they exist **CURRENTLY**.
- Data you provide will remain strictly confidential.

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1=Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

I. Manufacturing competence

1. Ability to design

1	We have the ability to develop specifications for finished goods sold by us	1 2 3 4 5 n/a
2	We have the ability to develop specifications for parts / subassemblies purchased by us	1 2 3 4 5 n/a
3	We have the ability to design products as per the given specification	1 2 3 4 5 n/a
4	We have the ability to design the manufacturing process for our products	1 2 3 4 5 n/a

2. Manufacturing capacity

5	We are capable of manufacturing parts we need as per specifications	1 2 3 4 5 n/a
6	We are not constrained by in-house manufacturing capacity	1 2 3 4 5 n/a
7	We are able to deliver products in right packaging	1 2 3 4 5 n/a

3. Ability to Improve

8	We area able to improve design of products for better manufacturability	1 2 3 4 5 n/a
9	We are able to continuously improve manufacturing process	1 2 3 4 5 n/a
10	We are able to improve design of products for better functionality	1 2 3 4 5 n/a
11	We are able to improve the design of the product to reduce the production cost	1 2 3 4 5 n/a
12	We are able to improve the manufacturing process of the product to reduce the production cost	1 2 3 4 5 n/a

4. Knowledge and skills pertaining to machines and/ or tools and/ or equipments and/ or software

13	We have thorough knowledge of one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
14	We are able to design one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
15	We are able to manufacture one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
16	We are able to maintain one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
17	We can improve upon one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

5. Quality related Competencies

18	We are able to develop our own quality (conformance to specifications) testing procedure	1 2 3 4 5 n/a
19	We are able to test quality (conformance to specifications) of our products	1 2 3 4 5 n/a
20	We are able to test quality (conformance to specifications) during our production process	1 2 3 4 5 n/a
21	We are able to test quality (conformance to specifications) of inputs (raw materials and subassemblies)	1 2 3 4 5 n/a

6. Ability to Integrate Skills

22	We are able to integrate expertise from different disciplines (e.g. engineering, marketing) during our design and /or manufacturing and /or improvement and /or quality control effort	1 2 3 4 5 n/a
23	We are able to integrate expertise of different disciplines in engineering (such as electrical, mechanical, chemical etc. and even R and D) during our design and /or manufacturing and /or improvement and /or quality control effort	1 2 3 4 5 n/a
24	We are able to integrate expertise of outside partners (suppliers and buyers) during our design and /or manufacturing and /or improvement and /or quality control effort	1 2 3 4 5 n/a
25	We are able to incorporate customers' changing demand on our design and /or manufacturing and /or improvement and /or quality control effort	1 2 3 4 5 n/a
26	We are able to incorporate changes in our products even before customers can articulate their need	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

1	Our ***ability to design*** compared to that of our competition is	1 2 3 4 5 n/a
2	Our use of proprietary designs in products compared to our competition	1 2 3 4 5 n/a
3	Our use of proprietary manufacturing processes compared to our competition	1 2 3 4 5 n/a
4	Our ***manufacturing capacity*** compared to that of our competition is	1 2 3 4 5 n/a
5	Our ***ability to improve products*** and / or processes compared to that of our competition is	1 2 3 4 5 n/a
6	Our ***knowledge and skills pertaining to machine and /or tools and/ or equipments and/ or software*** compared to that of our competition is	1 2 3 4 5 n/a
7	Our use of proprietary technology in one or more of the following Compared to that of our competition is: machines, tools, equipments, software	1 2 3 4 5 n/a
8	Our ***quality related competencies*** compared to that of our competition is	1 2 3 4 5 n/a
9	Our ***ability to integrate skills*** of different fields compared to that of our competition is	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

II. Information processing for uncertainty reduction

1. Market Analysis

1	Our manufacturing information system helps us to analyze the market	1 2 3 4 5 n/a
2	Our manufacturing information system helps us to forecast the business environment	1 2 3 4 5 n/a
3	Our manufacturing information system helps us to analyze competitors' strategy	1 2 3 4 5 n/a

2. Supports for design

4	We use manufacturing information system while developing design specifications	1 2 3 4 5 n/a
5	We use manufacturing information system during the product design	1 2 3 4 5 n/a
6	We use manufacturing information system to exchange relevant information among those involved (both inside the company and with partner companies) during product development	1 2 3 4 5 n/a
7	We use manufacturing information system to exchange relevant information among those involved (both inside the company and with partner companies) during the product design	1 2 3 4 5 n/a
8	We use manufacturing information system for simulation of product performance before the prototype is ready	1 2 3 4 5 n/a
9	We use manufacturing information system for designing production processes	1 2 3 4 5 n/a

3. Supports for Improvements

10	Manufacturing information system helps us in improving product design	1 2 3 4 5 n/a
11	Manufacturing information system helps us in improving product functionality	1 2 3 4 5 n/a
12	Manufacturing information system helps us in improving the production process	1 2 3 4 5 n/a
13	Manufacturing information system helps us in preventive maintenance	1 2 3 4 5 n/a
14	Manufacturing information system helps us in routine maintenance	1 2 3 4 5 n/a

4. Supports for Manufacturing and Control

15	We use manufacturing information system for capacity planning	1 2 3 4 5 n/a
16	We use manufacturing information system for material planning	1 2 3 4 5 n/a
17	We use manufacturing information system for scheduling the production	1 2 3 4 5 n/a
18	We use manufacturing information system for facilitating the cost control	1 2 3 4 5 n/a
19	We use manufacturing information system for control in the factory floor	1 2 3 4 5 n/a
20	We use manufacturing information system to automate manufacturing process	1 2 3 4 5 n/a
21	We use manufacturing information system to make the manufacturing process more flexible	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

5. Supports for Quality

25	We use manufacturing information system while designing the quality control systems	1 2 3 4 5 n/a
26	We use manufacturing information system for in process quality control	1 2 3 4 5 n/a
27	We use manufacturing information system for quality control of raw materials/ subassemblies	1 2 3 4 5 n/a
28	We use manufacturing information system for quality control of finished goods	1 2 3 4 5 n/a

6. Networking

29	We use manufacturing information system for coordination within the factory floor	1 2 3 4 5 n/a
30	We use manufacturing information system for coordination with our suppliers	1 2 3 4 5 n/a
31	We use manufacturing information system for coordination with our customers	1 2 3 4 5 n/a
32	We use manufacturing information system to ensure delivery reliability and predictability	1 2 3 4 5 n/a
32	We use manufacturing information system to ensure supply (raw materials and / or subassemblies) is received in reliable and predictable manner	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your company's **PRESENT** position, where:*

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

1	Our ability to use manufacturing information system for ***market analysis*** compared to that of our competition is	1 2 3 4 5 n/a
2	Our ability to use manufacturing information system for ***supporting design*** compared to that of our competition is	1 2 3 4 5 n/a
3	Our ability to use manufacturing information system for ***supporting improvements*** compared to that of our competition is	1 2 3 4 5 n/a
4	Our ability to use manufacturing information system for ***supporting manufacturing*** compared to that of our competition is	1 2 3 4 5 n/a
5	Our ability to use manufacturing information system for ***control*** compared to that of our competition is	1 2 3 4 5 n/a
6	Our ability to use manufacturing information system for ***supporting quality*** compared to that of our competition is	1 2 3 4 5 n/a
7	Our ability to use manufacturing information system for ***networking*** compared to that of our competition is	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	**2=Disagree**	**3=Neither Agree nor Disagree**	**4=Agree**	**5=Strongly Agree**	**n/a= not applicable**

III. Information processing for equivocality (ambiguity) reduction

1. Group Meetings and Visits

1	There are meetings between personnel from our department and their counterparts in our customers' organizations	1 2 3 4 5 n/a
2	There are meetings between personnel from our department and their counterparts in our suppliers' organizations	1 2 3 4 5 n/a
3	People from our department have seen our products being used by our customers	1 2 3 4 5 n/a
4	There are meetings between personnel from our department and their counterparts from other departments in our firm	1 2 3 4 5 n/a
5	Some part of our facility is co-located with that of our suppliers' and customers'	1 2 3 4 5 n/a

2. Manger's communication role

6	Manufacturing manager communicates frequently with his/ her counterpart in within our organization	1 2 3 4 5 n/a
7	Manufacturing manager communicates frequently with his/ her counterpart in partners' (buyers' and/ or customer') organization	1 2 3 4 5 n/a
8	Manufacturing manager disseminates relevant information from outside (other department with in organization or outside of organization) inside his/ her department	1 2 3 4 5 n/a

3. Planning

9	We have long term plan for manufacturing	1 2 3 4 5 n/a
10	Manufacturing manager contributes to the development of the overall business plan	1 2 3 4 5 n/a
11	There is no conflict between the long term plan of manufacturing with that of other departments' in our organization	1 2 3 4 5 n/a
12	Manufacturing manager's role in developing business plan helps to minimize the conflict between the plan of manufacturing and other functions	1 2 3 4 5 n/a

IV. Supply Chain Strategy

1. Customer Interaction

1	We can capture relevant information from our interaction with customers	1 2 3 4 5 n/a
2	We generally make to order rather than make to stock	1 2 3 4 5 n/a
3	We have ability to customize our product and services as per customers' demand	1 2 3 4 5 n/a
4	Customers can access and interact with us easily	1 2 3 4 5 n/a

For the following items please circle the number which accurately reflects your organization's ***PRESENT*** *position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

2. Asset configuration

5	We base our decision to 'make or buy' on business logic	1 2 3 4 5 n/a
6	We have applied systematic approach in identifying the subassemblies that can be obtained from our suppliers	1 2 3 4 5 n/a
7	With outsourcing, we can deploy internal capability to high value added area	1 2 3 4 5 n/a
8	We have applied systematic approach in identifying the subassemblies that we can provide to our customers	1 2 3 4 5 n/a
9	The interdependent process that are within our organization and outside of it are seamlessly integrated	1 2 3 4 5 n/a
10	We are able to balance our dependence on our partners with theirs on us	1 2 3 4 5 n/a

3. Leverage of knowledge

11	We recognize the importance of knowledge as a source of value creation	1 2 3 4 5 n/a
12	Our teams and tasks units are effective in leveraging collective expertise	1 2 3 4 5 n/a
13	We are effective in leveraging the knowledge of partners (buyers and suppliers)	1 2 3 4 5 n/a
14	Our interactions with customers help us to capture their expertise	1 2 3 4 5 n/a

V. Acquisition of Options

1. Acquisition of Ability to acquire knowledge

1	We can systematically gather knowledge about product and/ or market, before deciding on full investment	1 2 3 4 5 n/a
2	We maintain network relationships with partners with different skills/ expertise from those of ours in order to learn from them	1 2 3 4 5 n/a
3	Our network of relationships allow us to learn more about product or market	1 2 3 4 5 n/a

2. Acquisition of Ability to reshuffle and add flexibility

4	Comparing today with three years ago, we are more able to reconfigure our customer base	1 2 3 4 5 n/a
5	Comparing today with three years ago, we are more able to reconfigure our supplier base	1 2 3 4 5 n/a
6	Comparing today with three years ago, we are more able to switch to the different product line (with the given infrastructure)	1 2 3 4 5 n/a
7	Based of our best judgment, we will be more able three years down the road than we are today, to reconfigure our customer base	1 2 3 4 5 n/a
8	Based of our best judgment, we will be more able three years down the road than we are today, to reconfigure our supplier base	1 2 3 4 5 n/a
9	Based of our best judgment, we will be more able three years down the road than we are today, to switch to the different product line (with the given infrastructure)	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

3. Acquisition of Ability to Enter/ Expand

11	Comparing today with three years ago, we are more able to enter into new market rapidly	1 2 3 4 5 n/a
12	Comparing today with three years ago, we are more able to upgrade our products rapidly	1 2 3 4 5 n/a
13	Comparing today with three years ago, we are more able to expand our market rapidly	1 2 3 4 5 n/a
14	Based of our best judgment, we will be more able three years down the road than we are today, to enter into new market rapidly	1 2 3 4 5 n/a
15	Based of our best judgment, we will be more able three years down the road than we are today, to upgrade our products rapidly	1 2 3 4 5 n/a
16	Based of our best judgment, we will be more able three years down the road than we are today, to expand our market rapidly	1 2 3 4 5 n/a

5. Acquisition of Ability to Exit

17	Comparing today with three years ago, we are more able to withdraw from the existing market rapidly (with out incurring heavy loss)	1 2 3 4 5 n/a
18	Comparing today with three years ago, we are more able to survive even if one of our major market become unviable	1 2 3 4 5 n/a
19	Based of our best judgment, we will be more able three years down the road than we are today, to withdraw from the existing market rapidly (with out incurring heavy loss)	1 2 3 4 5 n/a
20	Based of our best judgment, we will be more able three years down the road than we are today to survive even if one of our major market become unviable	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

VI. Cost leadership

1	Our inventory level compared to that of our competitors is	1 2 3 4 5 n/a
2	Our capacity utilization compared to that of our competitors is	1 2 3 4 5 n/a
3	Our production cost compared to that of our competitors is	1 2 3 4 5 n/a
4	Productivity of our workers compared to those of our competitors is	1 2 3 4 5 n/a
5	Price of our products compared to that of our competitors is	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Very good	2=Good	3=Neither Good nor Bad	4=Bad	5=Very Bad	n/a= not applicable

VII. Differentiation

1. Quality

1	Compared to that of competitors, performance of our products are	1 2 3 4 5 n/a
2	Compared to that of competitors, reliability of our products are	1 2 3 4 5 n/a
3	Compared to that of competitors, dependability of our products are	1 2 3 4 5 n/a
4	Compared to that of competitors, our products' conformance to specifications are	1 2 3 4 5 n/a
5	Compared to our competitors, our ability to compete on the basis of quality is	1 2 3 4 5 n/a

2. Delivery

6	Compared to that of competitors, our delivery speeds are	1 2 3 4 5 n/a
7	Compared to that of competitors, our ability to meet delivery promises are	1 2 3 4 5 n/a
8	Compared to that of competitors, lead time of our production are	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

3. Flexibility

9	We are able to make rapid design changes	1 2 3 4 5 n/a
10	We are able to adjust our capacity quickly	1 2 3 4 5 n/a
11	We can make rapid volume changes	1 2 3 4 5 n/a
12	We offer a large number of product features	1 2 3 4 5 n/a
13	We offer a large degree of product variety	1 2 3 4 5 n/a
14	We can adjust product mix	1 2 3 4 5 n/a

4. New Product Development (NPD)

15	We have developed new products (on our own, or in conjunction with partners (suppliers or buyers))	1 2 3 4 5 n/a
16	We have played significant role in partner's new product development effort	1 2 3 4 5 n/a
17	Our NPD related capabilities make NPD cycle shorter	1 2 3 4 5 n/a
18	Our NPD related capabilities makes ramp up time shorter	1 2 3 4 5 n/a

1	Overall, we have the ***cost leadership*** over the competitors	1 2 3 4 5 n/a
2	Overall, ***quality*** gives us an edge over the competitors	1 2 3 4 5 n/a
2	Overall, ***delivery*** gives us an edge over the competitors	1 2 3 4 5 n/a
3	Overall, ***flexibility*** gives us an edge over the competitors	1 2 3 4 5 n/a
4	Overall, ***our ability in NPD*** gives us an edge over the competitors	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

VII. Financial Performance

1. Profitability

1	Profit margin on our sales compared to that of our competitors is	1 2 3 4 5 n/a
2	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is	1 2 3 4 5 n/a
3	Net profit position compared to that of our competitors is	1 2 3 4 5 n/a
4	Overall our organizations' performance compared to that of our competitors is	1 2 3 4 5 n/a

2. Growth

5	Sale's revenue growth position compared to that of our competitors is	1 2 3 4 5 n/a
6	Sale's volume growth position compared to that of our competitors is	1 2 3 4 5 n/a
7	Market share gains compared to that of our competitors is	1 2 3 4 5 n/a
8	Overall our organizations' growth compared to that of our competitors is	1 2 3 4 5 n/a

*For the following items please circle the number which accurately reflects your organization's **PRESENT** position, where:*

1= Strongly Disagree	2=Disagree	3=Neither Agree nor Disagree	4=Agree	5=Strongly Agree	n/a= not applicable

VIII. Customer Satisfaction

1	Our customers are satisfied with the quality of products	1 2 3 4 5 n/a
2	Our customers are satisfied with the features that our products provide	1 2 3 4 5 n/a
3	Our customers are loyal to our products	1 2 3 4 5 n/a
4	Our customers refer new customers to purchase our products	1 2 3 4 5 n/a
5	Our customers feel that we offer products of high value	1 2 3 4 5 n/a

IX. Productivity

1	Comparing today with three years ago, our production cost per unit has decreased significantly (with features and quality remaining same)	1 2 3 4 5 n/a
2	Comparing today with three years ago, our inventory level has decreased significantly	1 2 3 4 5 n/a
3	Comparing today with three years ago, level of rework required has decreased significantly	1 2 3 4 5 n/a
4	Comparing today with three years ago, our manufacturing labor force have become more productive	1 2 3 4 5 n/a

1	Manufacturing makes significant contribution in the ***profitability*** of our organization	1 2 3 4 5 n/a
2	Manufacturing makes significant contribution in the ***growth*** of our organization	1 2 3 4 5 n/a
3	Manufacturing makes significant contribution ***increasing customer satisfaction***	1 2 3 4 5 n/a
4	***Productivity*** of our organization has increased significantly in last three years	1 2 3 4 5 n/a
5	We are satisfied with our profit margin on sales	1 2 3 4 5 n/a
6	We are satisfied with our return on investment on manufacturing capital goods (including manufacturing information system)	1 2 3 4 5 n/a
7	We are satisfied with our growth on sales	1 2 3 4 5 n/a

BUSINESS PROFILE

X. Deployment of Manufacturing and Information technology

*For the following items please circle the letter which accurately how frequently you use the technology at **PRESENT** where:*

1= Very Rarely	2=Rarely	3=Moderately	4=Frequently	5=Very Frequently	n/a= not applicable (do not have)

1	CAD and/ or CAE. Use of computers for drawing and designing parts or products and for analysis and testing designed parts or products	1 2 3 4 5 n/a
2	Automated drafting technologies. Use of computers for drafting engineering drawings	1 2 3 4 5 n/a
3	CAD/ CAM. Use of CAD output for controlling machines used in manufacture of the parts or products	1 2 3 4 5 n/a
4	Pick and place robots. A simple robots which transfers items from place to place	1 2 3 4 5 n/a
5	Use of sophisticated Robots that can handle tasks such as welding or painting on an assembly line	1 2 3 4 5 n/a
6	Flexible manufacturing cells (FMC). Two or more machines with automated material handling capabilities controlled by computers or programmable controllers, capable of single path acceptance or raw materials and multiple path delivery of a finished product	1 2 3 4 5 n/a
7	FMS. Two or more machines with automated material handling capabilities controlled by computers or programmable controllers, capable of multiple path acceptance or raw materials and multiple path delivery or a finished product	1 2 3 4 5 n/a
8	NC/ computer numerically controlled (CNC) machine (s). A single machine either NC or CNC with or without automated material handling capabilities. NC machines are controlled by numerical commands punched on paper or plastic mylar type, while CNC machines are controlled electronically through a computer residing in the machine	1 2 3 4 5 n/a
9	Programmable controllers. A solid state industrial control device that has programmable memory for storage or instruction, which performs functions equivalent to a relay panel or wired solid state logic control system	1 2 3 4 5 n/a
10	Use of computer for scheduling	1 2 3 4 5 n/a
11	Use of manufacturing automation protocol	1 2 3 4 5 n/a
12	Computer-aided inspection performed on incoming or in process materials. This denotes the use of computers for inspecting incoming materials	1 2 3 4 5 n/a
13	Computers used for control on the factory floor. These include computers that may be dedicated to control, but which are capable of being reprogrammed for other functions. It excludes computers imbedded within machines, or computers used solely for data acquisition	1 2 3 4 5 n/a
14	MRP I and MRP II systems. Use of computers and computer modules for controlling the entire manufacturing system for order entry through scheduling, inventory control, finance, accounting, account payables, and so on	1 2 3 4 5 n/a
15	ERP systems, manufacturing information system that provides integrated information system for planning and control for manufacturing	1 2 3 4 5 n/a
16	LAN for technical data. Use of LAN technology is employed to exchange technical data within design and engineering departments.	1 2 3 4 5 n/a
17	LAN for factory use. LAN for factory use denotes the network employed to exchange information between different points on the factory floor	1 2 3 4 5 n/a
18	Inter-company computer networks linking plant to subcontractors, suppliers, and / or customers. This denotes the computerized networks used to exchange information with the firm's external constituents	1 2 3 4 5 n/a
19	EDI network linking plant to subcontractors, suppliers and / or customers	1 2 3 4 5 n/a

To what extent is your organization's environment characterized by the following conditions:

1= Not at all	2= to Some Extent	3= to Moderate Extent	4= to Great Extent	5= to Very Great Extent	n/a= not applicable

1	The requirements of the end users of our products is predictable	1	2	3	4	5	n/a
2	Behavior of suppliers of our raw materials or parts is predictable	1	2	3	4	5	n/a
3	Behavior of competitors for our customers is predictable	1	2	3	4	5	n/a
4	Governments policy and regulations towards our industry is predictable	1	2	3	4	5	n/a
5	Public's political views and perception towards us is predictable	1	2	3	4	5	n/a
6	Our relationships with various trade unions is predictable	1	2	3	4	5	n/a
7	Overall the condition of our market is predictable	1	2	3	4	5	n/a
8	Overall the environment we work in is predictable	1	2	3	4	5	n/a

Please rank the following factors (from **1 - most important** - through to **6 - least important**) in relation to your organization 's business strategy for the **next three years** by placing a **different** number in each box (Use each number only once)

Cost		Quality		Dependability		Flexibility		New product development		Supply Chain Strategy	

Please rank the following factors (from **1 - most important** - through to **8 - least important**) in relation to your organization 's performance preferences measure for the **next three years** by placing a **different** number in each box (Use each number only once)

Profitability	
Growth	
Customer Satisfaction	
Manufacturing Productivity	
Acquisition of Ability (Options) to acquire knowledge	
Acquisition of Ability (Options) to reshuffle and add flexibility	
Acquisition of Ability (Options) to Enter markets or to Expand	
Acquisition of Ability (Options) to Exit	

If you know your SIC code please provide:
otherwise indicate the industry subdivision in which you operate, from the list below.
(Please circle ONE number only)

Primary metal industries 1
Fabricated metal products 2
Machinery, except electrical 3
Electric and electronic equipment 4
Transportation equipment 5
Instruments and related products 6
Other 7

Questions below pertains to division/ department/ plant that you work for, not the whole corporation

CATEGORY	1	2	3	4	5
We have been in business for	< 2 years	2 to 5 years	6 to 10 years	10 to 15 years	> than 15 years
The range of our annual sales is	< than 10 million	11 to 50 million	51 to 500 million	501 to 1000 million	> than 1 billion
Number of our employees is	<100	101 to 250	251 to 500	501 to 1000	> than 1001
Level of education of our work force is	Very low	Low	Average	High	Very high
% of College graduates (including engineers) in our employees is	<5%	5-10%	10-15%	15-20%	25% or more
% of workers with graduate degrees in engineering	None	Up to 5%	5-10%	10-15%	15% or more
% of high school graduates in our employees (including college grads) is	<20%	20-40%	40-60%	60-80%	80% or more
% of engineering technicians (excluding those with engineering degrees) in the workforce	<10%	10-20%	20-30%	30-40%	50% or more
% of employees with job related training (including high school and college grads)	<20%	20-40%	40-60%	60-80%	80% or more
Average experience of our employees is	<2 years	2 to 5 years	6 to 10 years	10-15 years	> 15 years
Your title	Top level Management	Middle Management	Supervisor	Staff	Other
Your level of education	High School	College	Master	Ph.D.	Other
Your seniority at this company	Less than 1 year	1 - 2 years	2 - 5 years	5 - 10 years	10 + years
Our company is	Unionized	Not unionized	Partially unionized		
Company ownership	Wholly U.S. owned	Joint Venture	Wholly non U.S. owned		
Answers to this questionnaire are at the following business level	Plant	Division	Company	Corporate	

Filling of details below is optional

Business Name: ____

Address: ____

Your name: ____________________Tel:________________Fax_________________

Email: ____

Would you like to receive a benchmark report? Yes___ No___

Would you like to receive an executive report? Yes___ No___

Thank you for completing this questionnaire and please note that the data you have provided will remain strictly confidential

Annex II

Large-Scale Survey Questionnaire

The University of Toledo
College of Business Administration
Manufacturing Management Program

THE UNIVERSITY OF TOLEDO

Dear Manufacturing Executive:

I am a doctoral student in the Manufacturing Management Program at the University of Toledo, Toledo, Ohio. This research study is part of my doctoral work. We request you to fill this questionnaire. The insights gained through this research are expected to contribute to the advancement of knowledge about the relationship between competencies (manufacturing and information processing), implemented manufacturing strategy and performance.

Please be assured that individual company data will be held in total confidence, and only aggregate data will be used in our analysis and findings. If you would like to receive a copy of findings, please attach your business card. We deeply appreciate your help in completing my doctoral dissertation.

Thank you

D. Subedi
Doctoral Student
College of Business Administration
The University of Toledo

Survey for a Doctoral Dissertation

Effect of Manufacturing and Information Processing Competence on Manufacturing Strategy Implementation and Performance

Kindly note following:

1. This survey is designed to capture the perception manufacturing executives have, and it is to be answered from his/ her point of view.
2. **We/ our organization** implies **division/ department/ plant/ profit center as applicable**. Not the entire corporation.
3. Competition refers to competition on the average.
4. Customers refer to your immediate customers, not ultimate end-users.
5. **Manufacturing information system** in the questionnaire means information technology (hardware, software, computers, communication technology, robots or similar technology and data) **available to the manufacturing function**.
6. Please note the scoring scales, as they may change from section to section.
7. For each question please circle the number that accurately reflects your organization's present position - not as you wish them to be.

1=Strongly Disagree	2=Disagree	3=Neither agree nor disagree	4=Agree	5 = Strongly Agree	n/a = Not Applicable

1. Manufacturing Competence

Product Design Capability		
1	We have the ability to develop specifications for finished goods sold by us	1 2 3 4 5 n/a
2	We have the ability to develop specifications for parts / subassemblies purchased by us	1 2 3 4 5 n/a
3	We have the ability to design products as per specifications	1 2 3 4 5 n/a
Process Design Capability		
4	We have the ability to design the manufacturing process for our products	1 2 3 4 5 n/a
5	We are capable of manufacturing parts we need as per specifications	1 2 3 4 5 n/a
6	We are able to improve design of products for better manufacturability	1 2 3 4 5 n/a
Manufacturing Infrastructure related Capability		
7	We are able to design one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
8	We are able to manufacture one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
9	We can improve upon one or more of following: machines, tools, equipments, software	1 2 3 4 5 n/a
Quality Related Capability		
10	We are able to test quality (conformance to specifications) of our products	1 2 3 4 5 n/a
11	We are able to test quality (conformance to specifications) during our production process	1 2 3 4 5 n/a
12	We are able to test quality (conformance to specifications) of inputs (raw materials and subassemblies)	1 2 3 4 5 n/a

2. Data Processing Competence

Support for Product design and Improvement		
1	Manufacturing information system helps us in improving product design	1 2 3 4 5 n/a
2	Manufacturing information system helps us in improving product functionality	1 2 3 4 5 n/a
3	We use manufacturing information system for coordination with our suppliers	1 2 3 4 5 n/a
4	We use manufacturing information system for coordination with our customers	1 2 3 4 5 n/a
Support for production process and control		
5	We use manufacturing information system to exchange relevant information among those involved (both inside and outside the company) during the product design	1 2 3 4 5 n/a
6	We use manufacturing information system for capacity planning	1 2 3 4 5 n/a
7	We use manufacturing information system for material planning	1 2 3 4 5 n/a
8	We use manufacturing information system for scheduling the production	1 2 3 4 5 n/a
9	We use manufacturing information system for facilitating cost control	1 2 3 4 5 n/a
10	We use manufacturing information system while designing the quality control systems	1 2 3 4 5 n/a

1=Strongly Disagree	2=Disagree	3= Neither agree nor disagree	4=Agree	5 = Strongly Agree	n/a = Not Applicable

3. Managers' role in ambiguity reduction

Coordination

11	Manufacturing manager communicates frequently with his/ her counterpart within our organization	1 2 3 4 5 n/a
12	Manufacturing manager disseminates to his/ her department relevant information from outside (other department with in organization or outside of organization)	1 2 3 4 5 n/a
13	We have long term plan for manufacturing	1 2 3 4 5 n/a
14	Manufacturing manager contributes to the development of the overall business plan	1 2 3 4 5 n/a

Conflict Resolution

15	Meetings between us and personnel from suppliers' organizations help to minimized conflict	1 2 3 4 5 n/a
16	Meetings between us and personnel from customers' organizations help to minimized conflict	1 2 3 4 5 n/a
17	There is no conflict between the long term plan of manufacturing with that of other departments' in our organization	1 2 3 4 5 n/a
18	Manufacturing manager's role in developing business plan helps to minimize the conflict between the plan of manufacturing and of other functions	1 2 3 4 5 n/a

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

Comparative Manufacturing Capability

1	Our use of proprietary manufacturing processes compared to our competition is	1 2 3 4 5 n/a
2	Our manufacturing capacity compared to that of our competition is	1 2 3 4 5 n/a
3	Our proprietary technology in one or more of the following: machine, tools, equipments and software compared to that of our competition is	1 2 3 4 5 n/a
4	Our quality related competencies compared to that of our competition is	1 2 3 4 5 n/a
5	Our ability to integrate skills of different fields compared to that of our competition is	1 2 3 4 5 n/a

Comparative Manufacturing Information Systems Capability

6	Our ability to use manufacturing information system for ***market analysis*** compared to that of our competition is	1 2 3 4 5 n/a
7	Our ability to use manufacturing information system for ***supporting design*** compared to that of our competition is	1 2 3 4 5 n/a
8	Our ability to use manufacturing information system for ***supporting improvements*** compared to that of our competition is	1 2 3 4 5 n/a
9	Our ability to use manufacturing information system for ***supporting manufacturing*** compared to that of our competition is	1 2 3 4 5 n/a
10	Our ability to use manufacturing information system for ***control*** compared to that of our competition is	1 2 3 4 5 n/a
11	Our ability to use manufacturing information system for ***supporting quality*** compared to that of our competition is	1 2 3 4 5 n/a
12	Our ability to use manufacturing information system for ***networking*** compared to that of our competition is	1 2 3 4 5 n/a

1=Strongly Disagree	2=Disagree	3= Neither agree nor disagree	4=Agree	5 = Strongly Agree	n/a = Not Applicable

4. Cost leadership

1	In past three years we have focused on improving efficiency of the plant by maintaining the minimum possible level of inventory	1 2 3 4 5 n/a
2	In past three years we have focused on improving efficiency of the plant by keeping the capacity utilization at the maximum possible level	1 2 3 4 5 n/a
3	In past three years we have focused on keeping the production cost at the minimum possible level	1 2 3 4 5 n/a
4	In past three years we have focused on improving the productivity of our workers	1 2 3 4 5 n/a

5. Differentiation

1	We are able to make rapid design changes	1 2 3 4 5 n/a
2	We are able to adjust our capacity quickly	1 2 3 4 5 n/a
3	We offer a large number of product features	1 2 3 4 5 n/a
4	We offer a large degree of product variety	1 2 3 4 5 n/a
5	We can adjust product mix	1 2 3 4 5 n/a
6	Our **NEW PRODUCT DEVELOPMENT** related capabilities make NEW PRODUCT DEVELOPMENT cycle shorter	1 2 3 4 5 n/a
7	Our **NEW PRODUCT DEVELOPMENT** related capabilities makes ramp up time shorter	1 2 3 4 5 n/a

1= Very bad	2=bad	3=Almost Same	4=Good	5=Very Good	n/a= not applicable

8	Compared to that of competitors, performance of our products are	1 2 3 4 5 n/a
9	Compared to that of competitors, reliability of our products are	1 2 3 4 5 n/a
10	Compared to that of competitors, dependability of our products are	1 2 3 4 5 n/a
11	Compared to our competitors, our ability to compete on the basis of quality is	1 2 3 4 5 n/a
12	Compared to that of competitors, our delivery speeds are	1 2 3 4 5 n/a
13	Compared to that of competitors, our ability to meet delivery promises are	1 2 3 4 5 n/a

1=Strongly Disagree	2=Disagree	3= Neither agree nor disagree	4=Agree	5 = Strongly Agree	n/a = Not Applicable

14	Overall, we have ***cost leadership*** over our competitors	1 2 3 4 5 n/a
15	Overall, ***quality*** gives us an edge over our competitors	1 2 3 4 5 n/a
16	Overall, ***delivery*** gives us an edge over our competitors	1 2 3 4 5 n/a
17	Overall, ***flexibility*** gives us an edge over our competitors	1 2 3 4 5 n/a
18	Overall, ***our ability in NEW PRODUCT DEVELOPMENT*** gives us an edge over our competitors	1 2 3 4 5 n/a

1=Very Low	2= Low	3= About the Same	4= High	5= Very High	n/a= not applicable

6. Financial Performance

Profitability

1	Profit margin on our sales compared to that of our competitors is	1 2 3 4 5 n/a
2	Return on investment in manufacturing capital goods (including manufacturing information system) compared to that of our competitors is	1 2 3 4 5 n/a
3	Net profit position compared to that of our competitors is	1 2 3 4 5 n/a
4	Overall our organizations' profitability compared to that of our competitors is	1 2 3 4 5 n/a

Growth

5	Sale's revenue growth position compared to that of our competitors is	1 2 3 4 5 n/a
6	Sale's volume growth position compared to that of our competitors is	1 2 3 4 5 n/a
7	Market share gains compared to that of our competitors is	1 2 3 4 5 n/a
8	Overall our organizations' growth compared to that of our competitors is	1 2 3 4 5 n/a
9	Our satisfaction with the growth of our sales	1 2 3 4 5 n/a

1= Strongly Disagree	2=Disagree	3= Neither agree nor disagree	4=Agree	5=Strongly Agree	n/a= not applicable

7. Customer Satisfaction

1	Our customers are satisfied with the quality of products	1 2 3 4 5 n/a
2	Our customers are satisfied with the features that our products provide	1 2 3 4 5 n/a
3	Our customers refer new customers to purchase our products	1 2 3 4 5 n/a
4	Our customers feel that we offer products of high value	1 2 3 4 5 n/a

8. Productivity

5	Comparing today with three years ago, level of rework required has decreased significantly	1 2 3 4 5 n/a
6	Comparing today with three years ago, our manufacturing labor force have become more productive	1 2 3 4 5 n/a
7	Manufacturing makes significant contribution to the ***profitability*** of our organization	1 2 3 4 5 n/a
8	Manufacturing makes significant contribution to the ***growth*** of our organization	1 2 3 4 5 n/a
9	Manufacturing makes significant contribution ***increasing customer satisfaction***	1 2 3 4 5 n/a
10	***Productivity*** of our organization has increased significantly in last three years	1 2 3 4 5 n/a
11	We are satisfied with our profit margin on sales	1 2 3 4 5 n/a
12	We are satisfied with our return on investment on manufacturing capital goods (including manufacturing information system)	1 2 3 4 5 n/a

9. Acquisition of Options

1	We maintain relationships with partners with different skills/ expertise from those of ours in order to learn from them	1 2 3 4 5 n/a
2	Our network of relationships allow us to learn more about product or market	1 2 3 4 5 n/a
3	Comparing with three years ago, we are more able to reconfigure our customer base	1 2 3 4 5 n/a
4	Comparing with three years ago, we are more able to reconfigure our supplier base	1 2 3 4 5 n/a
5	Comparing with three years ago, we are more able to switch to the different product line (with the given infrastructure)	1 2 3 4 5 n/a
6	Comparing with three years ago, we are more able to enter into new market rapidly	1 2 3 4 5 n/a
7	Comparing with three years ago, we are more able to expand our market rapidly	1 2 3 4 5 n/a
8	Comparing with three years ago, we are more able to withdraw from the existing market rapidly (with out incurring heavy loss)	1 2 3 4 5 n/a
9	Comparing with three years ago, we are more able to survive even if one of our major market become unviable	1 2 3 4 5 n/a
10	Based of our best judgment, we will be more able three years down the road than we are today, to withdraw from the existing market rapidly (with out incurring heavy loss)	1 2 3 4 5 n/a
11	Based of our best judgment, we will be more able three years down the road than we are today to survive even if one of our major market become unviable	1 2 3 4 5 n/a

Is your organization a single location organization	Yes	No

1= Not at all	2= Small Extent	3= Moderate Extent	4= Great Extent	5= Very Great Extent	n/a= not applicable

10. Supply Chain Management

1	We are able to coordinate our process with that of our suppliers'	1 2 3 4 5 n/a
2	We are able to coordinate our process with that of our customers'	1 2 3 4 5 n/a
3	We are able to coordinate our process with different departments within our organization	1 2 3 4 5 n/a
4	We are able to balance our dependence on our suppliers' with theirs on us	1 2 3 4 5 n/a
5	We are able to balance our dependence on our buyers' with theirs on us	1 2 3 4 5 n/a
6	We base our decision to 'make or buy' on business logic	1 2 3 4 5 n/a
7	We have applied systematic approach in identifying the subassemblies that can be obtained from our suppliers	1 2 3 4 5 n/a
8	We have applied systematic approach in identifying the products that can supply to our customers	1 2 3 4 5 n/a
9	Our interactions with customers help us to capture their expertise	1 2 3 4 5 n/a
10	Our interactions with suppliers help us to capture their expertise	1 2 3 4 5 n/a

11. Business Environment

1	The requirements of our customers are predictable	1 2 3 4 5 n/a
2	Behavior of suppliers of our raw materials or parts are predictable	1 2 3 4 5 n/a
3	Behavior of competitors for our customers are predictable	1 2 3 4 5 n/a
4	Overall the condition of our market is predictable	1 2 3 4 5 n/a
5	Overall the environment we work in is predictable	1 2 3 4 5 n/a
6	We are able to gauge the competitive capabilities of our competitors	1 2 3 4 5 n/a

a) Your organization 's **performance preferences** measure for the **next three years**
Please rank the following factors (from 1 - most important - through to 4 - least important)

Profitability	Growth	Customer Satisfaction	Manufacturing Productivity

b) Your organization 's **business strategy** for the **next three years**
Please rank the following factors (**from 1 - most important - through to 6** - least important)

Cost	Quality	Delivery Speed	Flexibility	New Product Development	Supply Chain Strategy

SIC code of your business (if you know)___________

Please circle the industry subdivision in which you operate, from the list below.

1. Primary metal industries	**2.** Fabricated metal products	**3.** Machinery, except electrical	**4.** Electric & electronic equipment	**5.** Transportation equipment	**6.** Instruments & related products

7. **Other**, please specify the industry

Do you belong to auto industry? Y___ N____
If yes which of the following would describe your plant's position

OEM	Tier I Supplier	Tier II Supplier	Tier III Supplier	Other, Please Specify

Deployment of Manufacturing and Information technology

*For the following items please circle the letter which accurately how frequently you use the technology at **PRESENT** where:*

1 = very rarely 2 = rarely 3 = modestly 4 = frequently 5 = Very frequently n/a = not applicable

1	CAD and/ or CAE. Use of computers for drawing and designing parts or products and for analysis and testing designed parts or products	1	2	3	4	5	n/a
2	Automated drafting technologies. Use of computers for drafting engineering drawings	1	2	3	4	5	n/a
3	CAD/ CAM. Use of CAD output for controlling machines used in manufacture of the parts or products	1	2	3	4	5	n/a
4	Pick and place robots. A simple robots which transfers items from place to place	1	2	3	4	5	n/a
5	Use of sophisticated Robots that can handle tasks such as welding or painting on an assembly line	1	2	3	4	5	n/a
6	Flexible manufacturing cells (FMC). Two or more machines with automated material handling capabilities controlled by computers or programmable controllers, capable of single path acceptance or raw materials and multiple path delivery of a finished product	1	2	3	4	5	n/a
7	FMS. Two or more machines with automated material handling capabilities controlled by computers or programmable controllers, capable of multiple path acceptance or raw materials and multiple path delivery or a finished product	1	2	3	4	5	n/a
8	NC/ computer numerically controlled (CNC) machine (s). A single machine either NC or CNC with or without automated material handling capabilities.	1	2	3	4	5	n/a
9	Programmable controllers. A solid state industrial control device that has programmable memory for storage or instruction, which performs functions equivalent to a relay panel or wired solid state logic control system	1	2	3	4	5	n/a
10	Use of computer for production scheduling	1	2	3	4	5	n/a
11	Use of manufacturing automation protocol (MAP)	1	2	3	4	5	n/a
12	Computer-aided inspection performed on incoming or in process materials. This denotes the use of computers for inspecting incoming materials	1	2	3	4	5	n/a
13	Computers used for control on the factory floor. These include computers that may be dedicated to control, but which are capable of being reprogrammed for other functions. It excludes computers imbedded within machines, or computers used solely for data acquisition	1	2	3	4	5	n/a
14	MRP I and MRP II systems. Use of computers and computer modules for controlling the entire manufacturing system for order entry through scheduling, inventory control, finance, accounting, account payables, and so on	1	2	3	4	5	n/a
15	ERP systems, manufacturing information system that provides integrated information system for planning and control for manufacturing	1	2	3	4	5	n/a
16	LAN for technical data. Use of LAN technology is employed to exchange technical data within design and engineering departments.	1	2	3	4	5	n/a
17	LAN for factory use. LAN for factory use denotes the network employed to exchange information between different points on the factory floor	1	2	3	4	5	n/a
18	Inter-company computer networks linking plant to subcontractors, suppliers, and / or customers. This denotes the computerized networks used to exchange information with the firm's external constituents	1	2	3	4	5	n/a
19	EDI network linking plant to subcontractors, suppliers and / or customers	1	2	3	4	5	n/a

Business Profile					
• **Please answer all these questions from the perspective of your plant except for the last two questions where the corporate level is explicitly specified** • For each category put a cross mark on the box that represents the correct answer for your organization					
CATEGORY	**1**	**2**	**3**	**4**	**5**
We have been in business for (in years)	< 2	2 to < 5	5 to < 10	10 to < 15	15 or more
The range of our annual sales is (in million)	< 10	10 to< 50	50 to < 500	500 to < 1000	1001 or more
Number of our employees is	<100	100 to< 250	250 to < 500	500 to < 1000	1000 or more
Level of education of our work force is	Very low	Low	Average	High	Very high
% of College graduates (including engineers) in our employees is	< 5%	5 to < 10%	10 to< 15%	15 to < 20%	25% or more
% of workers with graduate degrees in engineering	None	Up to 5%	5 to< 10%	10 to < 15%	15% or more
% of high school graduates in our employees (including college grads) is	<20%	20 to < 40%	40 to< 60%	60 to < 80%	80% or more
% of engineering technicians (excluding those with engineering degrees) in the workforce	<10%	10 to < 20%	20 to< 30%	30 to < 40%	50% or more
% of employees with job related training (including high school and college grads)	<20%	20 to < 40%	40 to< 60%	60 to < 80%	80% or more
Information system budget as the % of total budget in your plant	<5%	5 to < 10%	10 to< 15%	15 to < 20%	25% or more
Average experience of our employees is (in years)	<2	2 to < 5	6 to< 10	10 to< 15	≥ 15 years
Your title	Top level Management	Middle Management	Supervisor	Staff	Other
Your level of education	High School	College	Master	Ph.D.	Other
Your seniority at this company (in years)	Less than 1	1 to < 2	2 to < 5	5 to < 10	10 +
Range of Sales in whole organization (in millions) **(Total Corporate level)**	< 50	50 to < 500	500 to < 1000	1000 to < 2500	> 2500
Number of employees **(Total Corporate level)**	< 250	251 to 500	501 to 1000	1001 to 2500	> 2500

Thank you for completing this questionnaire. This kind act of yours will go a long way in helping me in completing my dissertation.

D. Subedi

Please return this using the enclosed self-addressed envelope provided to:

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