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Exploring forecasting and project management characteristics of supply chain management

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Abstract: Effective forecasting with the framework of Supply Chain Management (SCM) requires precise and decisive strategic leadership supportive of the roles of such tools. Traditionally, SCM was mainly a task of logistics, confined to supply chain or purchasing managers. Essential questions were sought within the empirical portions of this study: What is the perception of SCM amongst top management? How is SCM linked to corporate strategy and corporate objectives? Surveys were sent to various manufacturing companies in the Pittsburgh, PA region, resulting in 117 completed surveys, measuring business tendencies and practices in regards to SCM, forecasting, and production and supply constraints. Via Principal-Components Analysis (PCA) and factor analyses, several hypotheses were tested verifying these relationships into constructs generated by theoretical constructs from the literature review. Forecasting, a key and sometimes-overlooked component of SCM, was found to be a significant factor in the overall effectiveness of strategic planning.

Keywords: forecasting; empirical study; Supply Chain Management; SCM; strategic management; best practices.

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1 Introduction

1.1 Dynamics of team integration and performance in manufacturing

How do we measure the effectiveness of a manufacturer's supply chain strategy? This is the basic question that generated the exploration strategy using factor analysis and other variable reduction techniques to investigate the various components associated with Supply Chain Management (SCM) and its effective forecasting and team performance. An important development in understanding the dynamics of team integration and team performance characteristics is Information Processing Theory (Ross *et al.*, 1996; Simeon, 2001). This theory postulates that top management teams are required to process more diverse and more extensive information, where proper forecasting plays a pivotal role. In complex and competitive environments, firm responsiveness and survival are becoming more linked to the ability of the top management to deal with higher levels of product/service complexity (McDermott, 1999; Michalisin *et al.*, 1997; 2000; Wah, 1998a; Wah, 1998b). Consequently, the Theories of Complexity and Dependency, coupled with concepts of Agency and Information Processing Theories, would suggest that more complex and turbulent environments would demand more responsive and flexible governance structures (Fiegenbaum and Thomas, 2004; Malnight, 2001). It is therefore understandable that the literature on governance structures with New Product Development (NPD) teams generally highlights the monitoring, control, composition and incentive strategies that are linked to top management in a firm (Hout, 1999; Malnight, 2001; Simeon, 2001; Williamson, 1975).

Another complicating factor is that the existence of subcultures within manufacturing organisations may be associated with horizontal and vertical differentiation, specifically, departmental specialisation and hierarchical stratification. It has long been acknowledged, for example, that clients can themselves be complex organisations (Bryk and Raudenbush, 1989) and that this internal complexity can have implications for the management of external relations (Bresnen and Marshall, 2000). The effects of horizontal differentiation are likely to make team members feel that attempts to collaborate across the organisation with other groups are driven by their own departmental and/or divisional interests. Thus, for example, although design teams might themselves be well aligned, relations with other internal groups might be poor (Wainwright, 1995). In some cases, this might even lead to reduced functioning of the manufacturing NPD teams within the organisation.

The positive effects of vertical differentiation or hierarchical stratification within organisations are likely to be encountered when attempts are made to force new ways of working/thinking down the organisation. Frequently the literature on partnering is insistent that top management's support and enthusiasm are vital in generating and sustaining changes in a collaborative approach (Tranfield and Smith, 1998; Zaheer *et al.*, 1998; Wah, 1998a; Wah, 1998b; Smith, 2003). However, it is rather less clear on how to narrow any gap between expressed intentions at a corporate level and what actually happens on the manufacturing floor, where behaviour can be influenced by a wide range of factors (including experience of actually working directly with contractual partners, such as suppliers). The obvious way to compensate is through management's exertion of direct control of team behaviour. However, this runs counter to many prescriptions for effective SCM and partnering, which stress the importance of decentralised and flexible structures. In effective SCM practices, the team is expected to operate with considerable autonomy and discretion. It is important that management is able to relinquish control to the development and design teams to allow creative and productive solutions in manufacturability.

Deeply related to incremental (small changes to processes) and radical (major changes to processes) product development is the concept of manufacturability or New Product Manufacturability (NPM). According to Adler (1995), McDermott (1999), and Swink (1999; 2000), NPM is an assessment of the fit between specifications of the new product designs and the capabilities of the production process. The key aspects in NPM are the perceptions of attitudes of participants (Robey, 1979), ease and reliability with which a product can be produced within an organisation's manufacturing resources (Adler, 1995), and within the time frame to ramp-up production to desired volume, yields, product cost and quality levels (McDermott, 1999; Swink, 1999; 2000).

Successful technological applications through project team integration processes require the development and nurturing of trust to make investments necessary for NPD/NPM processes and to discourage opportunistic behaviour. Technological development would clearly reduce the opportunity for greater disinformation over time (Hart and Saunders, 1997). Trust enhances the probability of a company's willingness to expand the amount of information sharing through project team integration processes and explore mutually beneficial arrangements that improve inter-firm coordination and communication. Mutual trust in NPD teams allows members to deal with the problems derived from technological uncertainties and supplier influences on design requirements as well (Zaheer *et al.*, 1998).

Parkhe (1998) discussed two kinds of uncertainty: uncertainty regarding unknown future events, and uncertainty regarding partners' response to the future events. These uncertainties result in reduced confidence not only in reliability of B2B transactions transmitted electronically, but also regarding other parties with whom they are dealing, an important issue in SCM (Iacovou *et al.*, 1995; Wang and Seidmann, 1995). Both the major tenets of Dependency and Complexity Theories support these notions that project team success must be rewarded and that individual team members must be able to visualise their importance and dependency within the NPD team. Any company must have a comprehensive business plan that is supported by a marketing strategy, operations strategy, and a financial strategy. SCM is a total systems approach to managing the entire flow of information, materials, and services from raw materials suppliers through manufacturing plants and warehouses to the end customer. Marketing must determine the extent to which mass customisation is needed to fulfil customers' requirements.

Manufacturing and distribution must coordinate both the supply and redesign of materials and plan manufacturing processes in the most efficient locations. Finance must provide activity-based cost information and financial analysis of the alternatives. Simply, SCM is an integral part of the marketing, operations, and financial strategies of any organisation.

1.2 Upper management's involvement

A top-down SCM approach led by the chief executive officer that is initiated and endorsed is critical to securing senior management buy-in and insuring that the strategy will provide good results. A recent survey found that companies that assign SCM to functional leaders achieve 55% less in savings than those whose CEO plays a hands-on role in linking SCM to overall corporate strategy (Heckmann *et al.*, 2003). The core message from respondents, according to Heckmann *et al.* (2003), is that top management which includes chief operating officers, chief financial officers, chief administrative officers, manufacturing/operations vice presidents, and logistical/shipping directors is the need to take a far broader view of SCM.

Top management formulates supply chain overall performance objectives derived from corporate strategy and corporate objectives. In addition, top management supports the application of overall supply chain objectives all the way down to the functional level by means of aligning functional goals with supply chain strategy. SCM represents a powerful tool to achieve corporate objectives. Broad ranges of different supply chain levers support specific corporate objectives, including levers for working capital improvement, inventory reductions, cycle time reductions and improved asset utilisation. Sales growth can be achieved through product variety without additional costs, capacity and service improvements as well as responsive cycle times for customers. Total cost structure improvements result from improved capabilities, flexible and reliable manufacturing and integrated short cycle times. The following chart reveals the results of the respondents to the statement that SCM is a top issue at their company. In the opinion of the respondents from the empirical aspect of this study, only 12.8% felt that SCM is a top issue at their firm. This finding is similar to the survey conducted by Smith (2003) and Smith and Flanegin (2004), which indicated a need for management to take a broader view of SCM.

While supply chain managers should understand what the major efficiency goals of SCM and promoting vendor relationships, people in other parts of the organisation may not. If SCM were more fully understood and applied across organisation's functional areas, it could increase operating and financial performance, provide new sources of competitive advantage, and lead to a better-managed business. Non-supply chain managers may not need to know specific activities or strategies but the broad overall objectives set forth by the organisation, and that supply chain initiatives are not narrow projects but rather core components of organisational goals. Much needed support across the organisation will help supply chain initiatives if others understand the importance of SCM. Fundamentally, as a cross-functional activity, SCM requires functional support before companies can create a world-class supply chain. A research study authored by Bain & Company[1] and US Department of Commerce revealed that the opportunity for improved supply chain performance is largely unrealised (Cook and Tyndell, 2001).

It could be argued that this opportunity gap is partially driven by a lack of clear understanding among non-supply chain managers. The risks involved in not creating this wider understanding are as great as the potential benefits. "They [suppliers] are in on the engineering meetings. They can drop in on the research guys. They know more about our requirements than some of our own people do and are instrumental for concurrent engineering of new products" (Cook and Tyndell, 2001, p.23).

A comprehensive evaluation of supplier technical capabilities usually falls into the hands of engineers. As engineers increasingly participate in supplier evaluations that may reach beyond their area of technical expertise their understanding of SCM must increase accordingly. A comprehensive review of knowledge and competency areas by the Society of Manufacturing Engineers found that SCM was the second highest-rated knowledge shortfall for engineers.[2] The author of the present study recently witnessed first hand the gap that can exist between SCM requirements and a non-supply chain manager. To illustrate these types of problems, the chief chemical engineer Michael Mullens of one of the companies (NOVA Chemicals) investigated in the empirical aspect of the present study (Personal Note 1) requested spare pressure indicators in August through the proper purchasing procedures. Due to a stock out the transmitters were not available for several weeks. The search for additional suppliers ended. Normally against policy, Mullens then searched a popular auction site on the web and found several transmitters available through a distribution centre that was overstocked. Mullens was able to purchase the same transmitters at the tenth of the cost offered by the manufacturer, which amounted to a cost savings of $98,000. The transaction also resulted in an electronic issued company-wide reminder of the purchasing policies. During the interview, Mullens complained that the constraints of supply chain purchasing requirements could hinder both cost savings and the ability to get spare parts in a timely manner. Though both parties were aware of the technical requirements of the requested parts, the process of purchasing a fairly common and critical spare part should not become a detriment to the operations of a production facility. Mullens also indicated that this is not an isolated case that he has seen other purchases that could have been more effective if SCM had taken more initiative to search for alternate vendors and avenues to locate and purchase parts at reasonable costs or solicited the advice of the requestor. Demand and supply management require persistent and continuous evaluation of cross-functional operational goals, risks, metrics, controls, and performance at all levels of the organisation. Senior management must own and drive the process and resulting decisions.

The following are SCM risks that may be encountered by sales and operations personnel that can have a negative impact in managing a supply chain:

1. lack of teamwork, shared risk management, and accountability among internal functions
2. lack of true integration among business partners-internal and external in the value chain
3. unacceptable levels of forecast error and lack of ownership of sales plans and forecasts
4. ineffective bottleneck and constraints management

5 material/product shortages and increased expediting and freight costs

6 supply interruption leading to production delays and on-time delivery issues with customers

7 longer than necessary lead times

8 excessive on-hand inventories and obsolescence and lower inventory turns

9 reduced confidence in planning systems and working around the system is common

10 poor utilisation of resources and lack of resources when needed.

The responsibilities of other non-supply chain managers are closely tied to those who directly participate in SCM. It is necessary for marketing to develop accurate and timely demand requirements, share end-customer requirements with supply chain planning groups. Finance must validate cost savings from supply chain activities; identify the impact of supply chain initiatives on corporate performance indicators, including ROI and RONA. Assessing the impact of inventory improvements on cash flow and working capital requirements are also integral finance functions to SCM. Accurate accounting provided by accounting to support internal and external cost analyses. Since SCM heavily relies on IT to support the development of supply chain information systems, including performance measurement systems. Human resources support the recruitment to staff supply chain positions, and provide training and education programs related to supply chain knowledge and skill areas. Supply chain contracts need timely and effective review by legal personnel.

For example, NOVA Chemicals of Moon Twp., PA recently announced their plan to invest $20 million in Business Process Improvement (BPI). NOVA planned to concentrate its investment in six key enterprise investment projects including SCM (Wheeler, 2004). According to Wheeler, the supply chain continually looks for ways to reduce costs on materials and services that account for $600M in spend. Until recently, capturing and analysing the details of this spend was difficult, as the data was delivered from several sources, including SAP, external service providers, and Microsoft Excel, with no central place to capture or analyse the information. Members of the Logistics team saw the tremendous value by the analysis and reporting capability of the Logistics data warehouse, and knew there was an opportunity to help the supply chain with their reporting efforts. Data warehousing projects typically require a very detailed analysis of the origins and uses of the information to be captured. As a result, they usually have an extended time frame and require a commitment from the business stakeholders to ensure various types of information are captured and reported appropriately. In the end, strategic business decisions are made as a result of the analysis, so attention to detail is critical (Smith and Flanegin, 2004; Talluri and Ragatz, 2004; Wheeler, 2004).

Sales, marketing, finance, new product management, supply, and operations must work closely to reconcile plans, identify risks, and scenarios, and present recommendations and choices to senior management. Firms that are capable of identifying their own weaknesses and identify those processes that bring the greatest return through improvement will be the most successful. Blue Circle Cement, a $5 billion Atlanta-based cement manufacturer and distributor, recognised their capabilities in demand forecasting were a weakness. Blue Circle implemented SCM planning and forecasting software from Rockville, MD based Manugistics Group Inc., which utilises complex forecasting algorithms to help companies direct the flow of products from raw material stage through manufacturing, distribution and deliver. Blue Circle owns and operates nine manufacturing plants, 22 distribution terminals, 500 rail cars and a number of barges that sail on the Great Lakes and up and down the East Coast. Prior to implementing its supply chain software, the cement company had little visibility to its supply chain. Without forecasting tools, when capacity was low, they had two choices: "offer horrible customer service and deliver it late or not at all; or even worse, source it from a competitor", stated Jeff Smith, Vice-President of chemical and energy of Manugistics (McGarr, 2000, p.45).

Successful companies have long understood how significant inventory reductions, coupled with high and profitable consumer availability provides competitive edge. They also recognise that using Point of Sale and Stock Keeping Unit level data for forecasting provides a more timely and accurate picture of demand for their supply chain, and is a significant contributor to improving forecast accuracy and making appropriate and profitable inventory decisions.

1.3 Supply chain strategies and forecasting

"When SCM is a CEO-level agenda item, annual savings improvements in the 'cost to serve customers' are nearly double", Heckmann *et al.* (2003, p.1). Effective SCM can impact a firm's success in many ways. It can produce higher customer service levels, which leads to greater revenue and net income. Higher inventory turnover, which frees up working capital. Higher worker productivity, which lowers operating expenses and higher capacity utilisation, resulting in increases the return on assets. Lower logistics costs, which decreases operating expenses. Lower costs of goods sold, which increases net income. Each one of these will increase an enterprise's return on assets. That, in turns, leads to increased return on equity and shareholder value (Lee, 2002). Corporations work endlessly to increase their competitiveness by product differential, high quality, low cost, and speed to market; the supply chain then becomes an integral part in supporting the firm's strategy.

Supply-chain management is simple when product demand is predictable, but this is rarely the case. The key to managing unpredictable demand is to identify the point in the supply chain where consumption is relatively predictable and where it is not. Supply chain advancements have frequently been achieved by reducing risk and uncertainty through the employment of sophisticated forecasting techniques, with a low degree of cooperation between the manufacturing and logistics process (Pagh and Copper, 1998).

Heizer and Render (2001) suggested three supply chain decisions that impact strategy. The first is the low-cost strategy, supply demand at lowest possible cost, since the selection is for lowest cost. This requires inventory to be minimised throughout the supply chain to hold down costs. Also shorten the lead-time as long as it does not increase costs, and finally maximise performance and minimise cost. Response strategy requires the chain to respond quickly to changing requirements and demand to minimise stock outs. This usually requires a firm to invest in excess capacity and flexible processes, develop responsive system, with buffer stocks positioned to ensure supply. Invest aggressively to reduce production lead-time and use product designs that lead to low setup time and rapid production ramp-up. Differentiation, the third strategy, requires firms to share market research; jointly develop products and options. This would appeal to those seeking a high level of product development skills. This strategy also employs modular processes that lend themselves to mass customisation; inventory in the chain must be minimised to avoid obsolescence. Characteristically, an aggressive approach would be used to reduce development lead-time, and use modular design to postpone product differentiation for as long as possible.

Accurate and timely performance metrics are needed to gauge demand chain performance. Referring back to the bulleted list of ways the supply chain can affect a firm's success; key performance indicators such as achieved service levels (including units, dollars, lines, zero inventory occurrences), inventory on hand and in the pipeline, supplier fill rates and lead times within the demand chain. Lee recommends data should be substantial to support a root cause analysis when the key performance indicators reveal performance inadequacies. Key Performance Indicators (KPIs) help to identify what is meaningful and productive versus what is not. KPIs can achieve this by providing feedback to top management where inadequacies can be evaluated and action(s) implemented to improve the indicator.

2 Forecasting – key component of SCM

2.1 Key contributor to corporate success

A forecasting process has two primary goals, namely make the forecast more accurate (reduce forecast error) and make the forecast less biased (not chronically too high or too low). Forecasting is one of the key components of SCM. Forecasting is a management function that companies often fail to recognise as a key contributor to corporate success. When demand can be predicted accurately, it can be met in can be met in a timely and efficient manner, keeping customers satisfied. Accurate forecasts help a company avoid lost sales or stock-out situations, and prevent customers from going to competitors. Forecasts are vital to every business organisation and critical to every management decision. Forecasting is the basis of corporate long run planning. In the functional areas of finance and accounting, forecasts provide the basis for budgetary planning and cost control. Marketing relies on sales forecasting to plan new products, compensate sales personnel, and make other key decision. Production and operations personnel use forecasts to make periodic decisions involving process selection, capacity planning, and facility layout, as well as for continual decisions about production planning, scheduling, and inventory. Effective management of a supply chain includes thinking creatively about how to integrate and perform logistics and manufacturing activities. Supply chain advancements have frequently been achieved by reducing risk and uncertainty through the employment of sophisticated forecasting techniques (Bowersox, 1997).

Cost-effective purchasing of raw materials and component parts can be much more cost-effective if forecasts are accurate. Inaccurate forecasts can cause higher expense if purchasing occurs periodically or regularly on the spot market. Unnecessary expenses can be avoided by accurately forecasting production needs. Additionally, logistics services can be purchased at a lower cost through long-term contracts rather than through spot market arrangements. But these arrangements can only be made if accurate forecasts are available.

Possibly one of the most important areas that accurate forecasting can have a profound effect is on a company's inventory levels. Inventory exists to provide a buffer for inaccurate forecasts. The more accurate the forecast the less inventory that needs to be carried, understandably there are cost savings to minimal inventory levels. Senior management needs to look closely at their own sales forecasting practices and recognise opportunities for improvement. Brake Parts, Inc., a manufacturer of automotive aftermarket parts, improved its own bottom line by $6 million per month after a company-wide effort to improve sales forecasting effectiveness (Mentzer and Schroeter, 1993).

Since there are so many factors in the business environment, no forecasting method can be expected to provide perfect results. It is imperative to practise continual review of forecasts and try to improve the forecasting model or methodology that is employed (Heizer and Render, 2001, p.466).

2.2 Forecasting demand/plan supply

Demand planning, supply planning, forecasting and production scheduling must be successful to have a positive impact on inventory management. Successful demand management ensures that all future demand is identified, evaluated, prioritised and scheduled efficiently. Effective supply planning and production scheduling can help manufacturers optimise the use of their inventory, supplier capabilities and transportation resources. A few years ago Nike suffered significant financial problems largely because of a poor implementation of demand and supply planning systems and process in its footwear division. Poorly synchronised demand signals and supply signals have created more problems with inventory availability across the supply chain than is reasonable (Sengupta, 2004).

At the beginning of the forecast cycle, it is important to create predictions that are not constrained by the firm's capacity to produce. Consider the forecaster for a certain product who questions the company's sales force and learns they could sell 1000 units per month. At the same time, current manufacturing capacity for that product is 750 units per month. If the forecaster takes that production capacity into account when creating initial forecasts, and predicts 750 units, there is no record of the unmet demand of 250 units per month, and the information on where to expand manufacturing capacity is lost. When capacity is inadequate, the resulting shortages can mean undependable delivery, loss of customers, and loss of market share. This is exactly what happened to Nabisco in 1993, when it underestimated the huge demand for its low-fat Snackwell Devil's Food Cookies. Even with production lines working overtime, Nabisco could not keep up with demand, and lost customers (Heizer and Render, 2001).

This problem may occur when historical shipments are used as the basis for generating forecasts. Forecasting shipments will only predict a company's previous ability to meet demand. For example, demand for a particular product in the past had been 1000 units per month, but the supplier could only ship 750 units each month. Historical data would show shipments at 750 units per month, causing this amount to be projected and produced again the following month. Though the results indicate an accurate forecasting system, but in reality there is a recurring unfulfilled monthly demand of 250 units. Forecasting based on shipping history only leads a company to repeat its former mistakes of not satisfying customer demand. Predicting actual demand allows measurement of the difference between demand and supply so it can be reduced in future periods through plans for capacity expansion.

The difficulty is determining actual customer demand than predicting the company's ability to supply. A key foundation for the supply chain process is an effective and accountable sales planning and forecasting process. Firm's efforts to improve demand management by replacing historical-data-based forecasts with actual consumption signals are stymied by their existing process since building forecast consensus is time consuming.

To agree on a forecast, firms must reach a consensus across sales, marketing, production, and finance – a task that is not easy when each group has its own objectives and demand streams, making unification a battle each time. One CPG firm told us it takes them five days of long meetings to agree on a forecast across the organisation. The problem? They begin this cycle each week (Radjou, 2002). Systems and processes are needed to capture demand that was not fulfilled. Mechanisms are needed to allow salespeople to provide valuable information about customers who would order more if they could. Records of orders accepted but not filled in the period demanded adds to the demand versus supply level of information.

Electronic Data Interchange (EDI) information as Point of Sale (POS) demand, retail inventory levels, and retailer forecasts are all valuable sources of information that increase a company's ability to handle demand forecasting more efficiently (Kahn and Mentzer, 1996; Son *et al.*, 2005). To integrate demand forecasting, Radjou (2002) suggests building consensus-based forecasts by streamlining and expediting a consensus-building process for forecasts to accommodate consumption patterns by synchronising operational groups, tune forecasts by exception, single out drivers of forecast accuracy and using applications to drive consensus. Drive demand signal accuracy. After speeding internal forecasting processes, firms should focus on improving signal accuracy for baseline demand. Accuracy needs to improve in POS systems; Forrester claims POS data is historically 6% wrong due to scan-based errors and theft. Replace historical order information with real-time demand signals and offer network wide visibility into inventory contribute to signal accuracy. Finally, Radjou's last recommendation for demand integration – adjust supply and distribution levels. Once forecasts are generated from consumption, firms must optimise production and inventory to meet with them. His solutions are to use near term forecasts to alter inventory deployment and replace forecast driven supply with consumption-driven plans.

In building internal consensus, software is available to digest information that otherwise may be neglected or suspect. For example, NCR uses PwC to help identify and remove demand drivers such as promotions or competitor relocations that artificially raise or lower consumption to reflect an accurate picture of real demand; i2's Demand Planner benchmarks key metrics against 'best-practice' work flows, fundamentally this keeps all departments focused on a forecast with consensus rather than a department overriding to meet their own goals. Re-forecasting on an exception basis can be done with Oracle's multi-dimensional application. An example would be when the forecast and actual demand exceeds a certain percent. Unilever uses SAP tools that mine actual sales data to warn marketing of significant forecast variations for an individual brand (Radjou, 2002).

To migrate from a forecast-based to consumption-driven supply network firms must tackle the basics of POS data, which is according to Radjou (2002) and Smith and Flanegin (2004) often inaccurate. Before investing in RFID, firms should consider piloting RFID at distribution centres and regional distributions centres until accuracy improves. Though it may be more difficult, forecasting demand will help a company make reasonable, long-term decisions that can make a positive affect on its market position. By identifying where capacity does not meet demand forecasts, the company has valuable information on where to expand capacity through capital planning. Having a long-term programme of matching capacity planning to forecasts will help reduce under-forecasting and result in higher levels of customer satisfaction.

2.3 Forecasts and cross-functional consensus

Time can be very expensive. Consider all the resources involved in forecasting at the typical organisation. This would include sales people and their managers, financial analysts and their managers, production and inventory planners and their managers, as well as marketers, strategic planners, executives and even full-time forecasters. IT resources also are needed to load the historical data and maintain the systems. All of this is high-cost management time that companies may be failing to get much return on resources invested in the forecasting process. Forecasting participants may not have the training, skills, experience, tools, and particularly the motivation to do a good job forecasting. Also, many forecasting process participants may have their own political agendas that contribute to their forecast. Marketers might chronically over forecast to better sell their new product ideas to top management. It is doubtful that a product manager forecast that his or her new product is going to flop even though most new products fail upon introduction. Sales representatives might chronically under forecast to help lower expectations and quotas and make it easier to achieve their targets and bonuses. Executive management might require a certain amount of revenue and margin in the forecast show that it meets commitments made to Wall Street.

Companies who obtain input from people in different functional areas, each of who contribute relevant information can accomplish effective and efficient forecasting results. This requires a great deal of communication across organisational boundaries, and not all communication is equal; some companies are simply better at it than others. To reiterate, demand and supply management require persistent and continuous evaluation of cross-functional operational goals, risks, metrics, controls, and performance at all levels of the organisation. Senior management must own and drive the process and resulting decisions.

Communication is a general term and depending on the degree of communication, may take on the form of one-way reports, in which one department responsible for forecasting informs other functional areas of the results of its efforts. The problem? The group that created the forecast may dominate any discussion of forecast results and work to persuade other functional groups to accept the forecast it has created (Swink, 1999; 2000). Coordination between functional groups at least allows opportunities for discussion, but still not as effective as total collaboration. Collaboration allows the views of each functional group to receive equal consideration, and no one group dominates. For example, if marketing is the responsible group for generating forecasts, critical information such as production lead times, or capacity constraints may not be considered in their forecast. Because this information is missing, forecast users have little trust in projections they did not help develop. This lack of trust leads to duplicate forecasting efforts.

Another consequence of not working cross-functionally is a lack of understanding of the assumptions that go into forecasts, which leads to further distrust. For example, a production scheduler may adjust the forecast to take into account the seasonality believed was present in the marketplace. However, the scheduler was not aware that the marketing department had already accounted for that seasonality in the information they gave the scheduler. Had production planning been involved in a consensus-based forecasting process, the scheduler's adjustments, which skewed the forecasts, would not have been made. Effective collaboration may thrive easier if management of the forecasting process is an independent department instead of being part of marketing, finance, logistics, or production. In achieving effective forecasting, it is important to establish a process that brings people from multiple organisational areas together in a spirit of collaboration. This ensures that all relevant information is considered before forecasts are created. Bringing together sales, marketing, production planning, logistics, and finance will eliminate duplicate efforts, foster trust among all parties, with a final result of a more accurate and relevant forecast.

2.4 Elimination of independent analysis in forecasting

Independent analyses are distinct areas within an organisation that perform similar functions. Each area maintains a separate process; redundant tasks and same responsibilities are performed. Independent analysis occurs primarily due to independent computer systems, which are not electronically linked to other systems within the organisation, information contained within the separate systems is not shared. Independent analysis may occur in logistics, production planning, finance, and marketing. They have usually occurred because of a lack of inter-functional collaboration between units, which leads us back to a lack of credibility associated with the forecast. Since the 'official' forecast created by a particular department may not be credible to forecast users, efforts will most likely occur to implement their own agenda to create their own forecast. As discussed earlier, independent analysis may be detrimental to corporate performance, since forecasts developed in this process are often inaccurate and inconsistent. Redundancies generated by independent systems cost the organisation both money and valuable personnel time and energy. Employee morale can suffer due to a lack of confidence in the process.

To eliminate the negative affects of independent analysis, top management must devote attention to eliminating the factors that encourage independent analysis. As previously discussed, effective collaboration may thrive easier if management of the forecasting process is an independent department instead of being part of marketing, finance, logistics, or production. The creation of a 'forecasting infrastructure' established to bring together dependent analyses, people, and resources (Kahn and Mentzer, 1996). Data should be capable of accessing from a centrally maintained 'data warehouse' that are electronically available to all functional areas.

Once this forecasting infrastructure is in place, effective training aimed at a common understanding of the process and its system should be implemented for both users and developers. Employees should be trained to comprehend the overall process, each individual's role in the process, and the importance of accurate forecasting. They must be able to use the system effectively and efficiently (Smith and Flanegin, 2004). Once independent analyses are eliminated, the company should expect improved forecasting performance and significant cost savings. Forecasts will be more precise, mover credible, and better able to meet the needs of various departments. Breaking down barriers such as information systems will reduce errors, redundancies, and make information available to all functional areas.

3 Methodology and results

3.1 Measurement and data collection

Some of the more important aspects of SCM in terms of forecasting and project-team integration have been discussed, including a variety of perspectives that have been explored as to portray some of the major views on upper management's involvement in manufacturability. However, there is a need to empirically explore selected internal and external project characteristics and the perceived effectiveness of forecasting on the part of project managers and their perceptions of management involvement and its effects on the performance characteristics of entire supply chain.

However, to support the various research propositions inherent in the previous discussion, a number of statistical techniques are used to test specific hypotheses that deal with the elements in the model are made. As a result, survey instruments were sent and collected from project managers of various manufacturing companies in and near the Pittsburgh, PA metropolitan region, resulting in 122 completed (118 usable) surveys out a possible of 300+ in the sampling frame. The survey consisted of critical success factors and practices in regards to SCM, forecasting, and production and supply constraints. The initial survey, focused on a wide variety of aspects dealing with the characteristics of forecasting, SCM, management's impact, and performance factors associated with new product offering and/or ventures, and is available upon request. A variety of data reduction techniques (factor analysis and Principle Components Analysis (PCA)), multiple regression, graphical analyses, and cross-tabulation procedures were employed. However, principal components and factor analyses techniques will be the dominant multivariate statistical procedures to be used in this research effort.

PCA is a classical linear transform statistical method, which has been widely used in data analysis and compression (Bishop, 1995; Cumming, 1993). The technique is based on the statistical representation of a random variable X (Oja, 1989). For p such random variables:

$$X' = \left[X_1, X_2, \ldots, X_p\right] \tag{1}$$

The objective of PCA is to make p linear combinations of these variables in such a way that each captures as much of the variation in X as possible. In doing so though, each of the principal components must be linearly independent of the others. Thus, the linear combination of a principal component Y_j, of p variables with unknown coefficients $\hat{\beta}_1, \hat{\beta}_2, \ldots \hat{\beta}_p$ is given by:

$$Y_j = \hat{\beta}_1, X_{1j} + \hat{\beta}_2 X_{2j} + \ldots + \hat{\beta}_p X_{pj}, \text{ for } j = 1, 2, \ldots, n \tag{2}$$

Equation (2) can be represented using a matrix notation of the form:

$$\hat{\beta} = \begin{bmatrix} \hat{\beta}_1 \\ \hat{\beta}_2 \\ \cdot \\ \cdot \\ \cdot \\ \hat{\beta}_p \end{bmatrix}, Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \cdot \\ \cdot \\ \cdot \\ Y_p \end{bmatrix}, \text{ and } X = \begin{bmatrix} X_{11} & X_{21} & \cdot & \cdot & \cdot & X_{p1} \\ X_{12} & X_{22} & \cdot & \cdot & \cdot & X_{p2} \\ \cdot & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot \\ \cdot & \cdot & & & & \cdot \\ X_{1n} & X_{2n} & \cdot & \cdot & \cdot & X_{pn} \end{bmatrix}.$$

With this matrix representation, the principal component can be written as:

$$Y = X\hat{\beta} \tag{3}$$

In general, if the data are concentrated in a linear subspace, this provides a way to compress data without losing much information and simplifying the representation. Hence, by picking the eigenvectors having the largest eigenvalues, little information as possible in the mean-square sense is lost. Therefore, by choosing a fixed number of eigenvectors and their respective eigenvalues, hopefully a consistent representation, or abstraction of the data will emerge. This procedure preserves a varying amount of energy of the original data. Alternatively, we can choose approximately the same amount of energy and a varying amount of eigenvectors and their respective eigenvalues.

This would, in turn, give approximately consistent amount of information at the expense of varying representations with regard to the dimension of the subspace. Unfortunately, when using principal components analysis, there are contradictory goals. On one hand, we should simplify the problem by reducing the dimension of the representation. The other choice is to preserve as much of the original information content as possible. PCA offers a convenient way to control the trade-off between loosing information and simplifying the problem at hand. Thus, it may be possible to create piecewise linear models by dividing the input data to smaller regions and fitting linear models locally to the data. However, PCA is only a transformation process.

The factor analysis process is a representation of the general case with no regard to which components of the input vector are either composed of independent or dependent variables. This arrangement will have not committed the reseacher to a certain relationship between the vector components or named any components as the inputs or the outputs of the researched relationships consumer behaviour towards file sharing activities. Therefore, through these statistical procedures the ability to constrain any component of the input vector to be constant and to fetch the rest of the vector values with the aid of known values will be possible. Suppose that as in Equation (4) p is the set of responses for the multivariate system of interest. Then, the general factor analysis model is:

$$Y_j = \hat{\beta}_1, X_{1j} + \hat{\beta}_2 X_{2j} + \ldots + \hat{\beta}_m X_{mj} + d_j U_j, \text{ for } j = 1, 2, \ldots, n \tag{4}$$

Each of the m terms in Equation (4) represents factor contributions to the linear composite while the last is the error term.

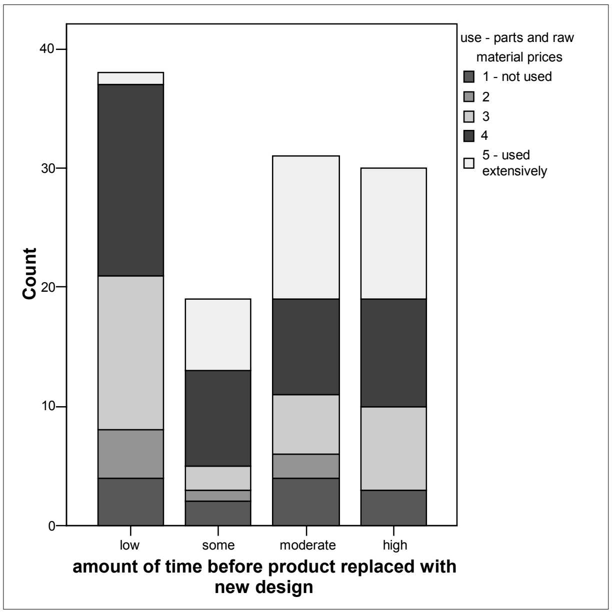
3.2 Basic analysis and results

When the traditional models of NPD/NPM processes and/or technology acceptance (Szaina, 1996; Venkatesh and Davis, 2000) were created, the reality of development team integration and implementation within organisations required modifications to these frameworks. In essence, NPD development must meet two critical objectives: minimise time-to-market and maximise fit between customer requirements and product characteristics. The implementation of successful project processes, which is often the case with NPD/NPM scenarios, requires an understanding of the complex interaction of many factors that occur with technical project team integration and successful design and manufacturability of new products. Typically, many product-development teams that are leveraged to organisational adoption and implementation of technology innovations common in NPD/NPM processes are under an organisational mandate to adopt the innovation regardless of individual feelings. Through an application of Dependency Theory, team members must coordinate and delegate authority within a group structure to accomplish the task at hand. As suggested by Bresnen and Marshall (2000), it is only by management fully appreciating the effects of complexity that surround the Project Management (PM) culture can be a more realistic and certainly practical approach to the development and implementation of partnering emerge.

Hart and Saunders (1997) as well as Munson *et al.* (1999) added support to the concept that power should be used cooperatively to promote the general utility and management benefits of the supply chain. Hart and Saunders (1997) as well as Pfeffer and Salancik (1978) collectively argued that while the coercive approach reflects a short-term strategy, the persuasive approach is a long-term strategy for building inter-organisational relationships through team integration processes within the supply chain. In dealing with international supply chains and external environments, Malnight (2001) discovered through an empirical research that Multinational Corporations (MNC) respond to complex global competitive environments by increasing internal structural complexity. That is, a systematically differentiated structural response to relevant process sub-environments. These phenomena can be witnessed as one compares the graphs of amount of time before replaced current design, recoded into a categorical variable for display purposes, versus selected questions or items on the survey, as demonstrated in the various graphical components in Figure 1. Figure 1 is essentially a cross-tabulation of years before replacing existing products with new designs versus selected use of tools and techniques associated with improved manufacturability.

Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability

A. Degree of use of existing parts and raw materials



B. Degree of use of forecasts to expose production inventory problems

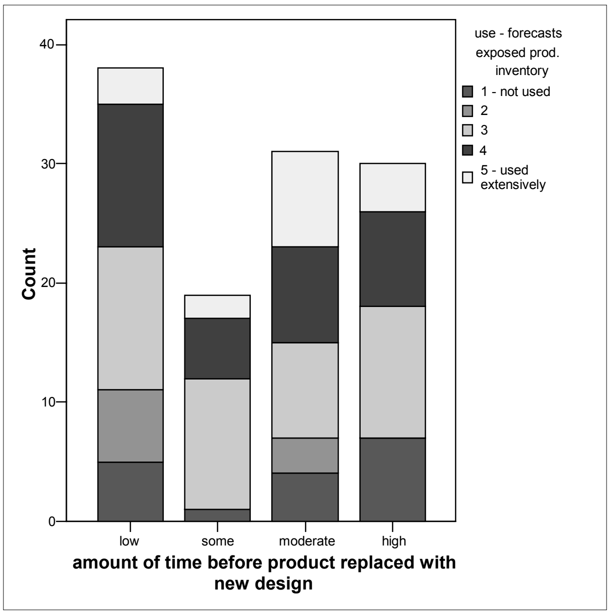
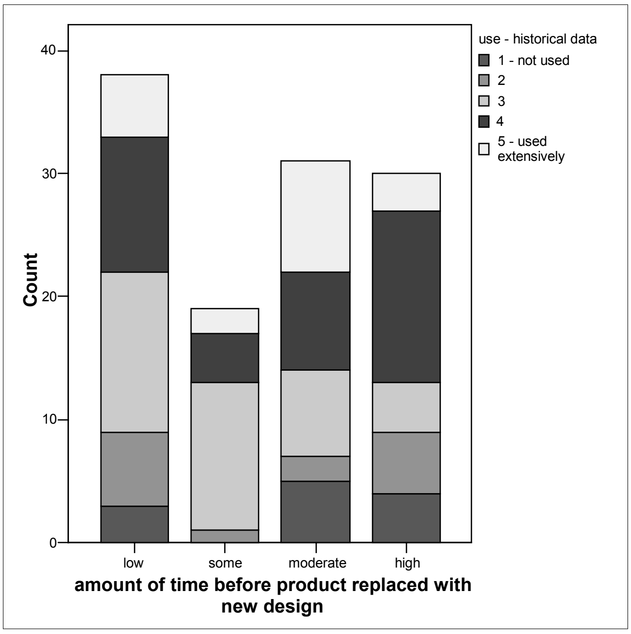


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

C. Degree of use of historical data in forecasts



D. Degree of use of real time demand signals

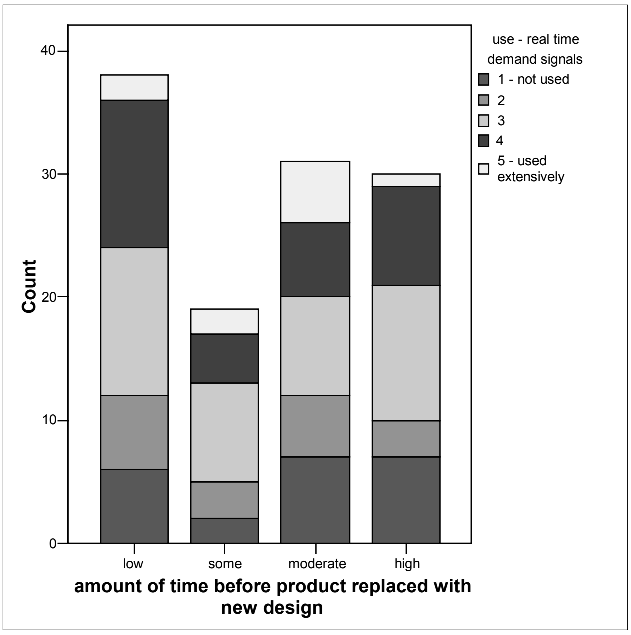
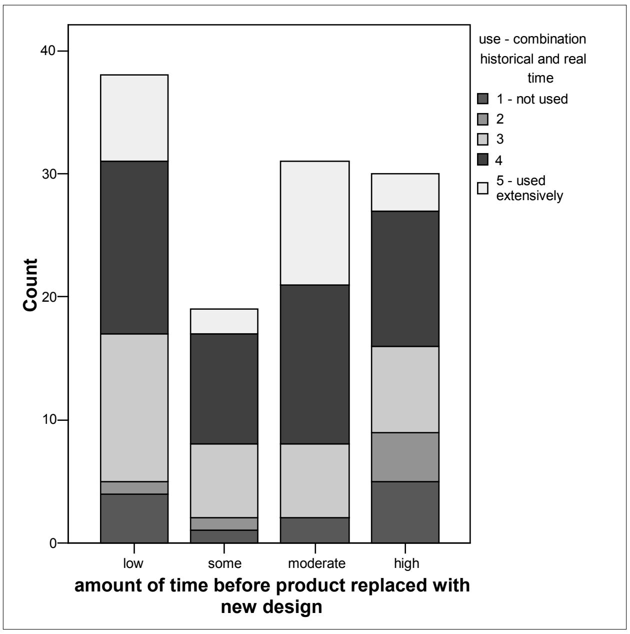


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

E. Degree of use of combination historical and real time



F. Degree of use of demand management variables

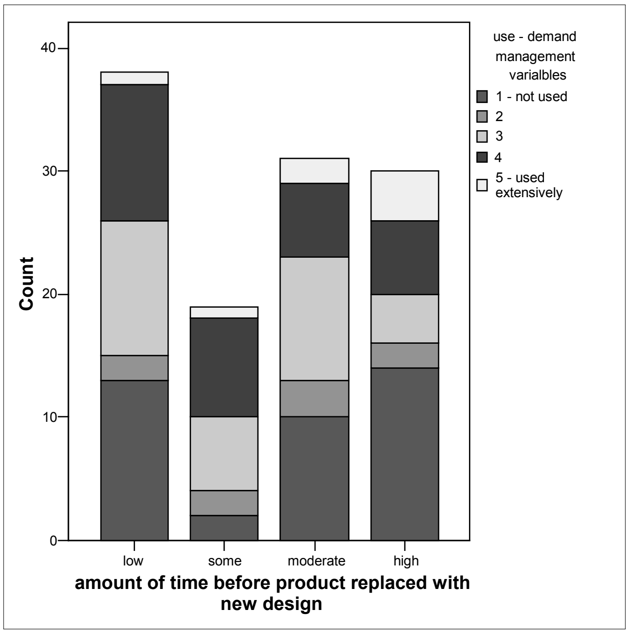
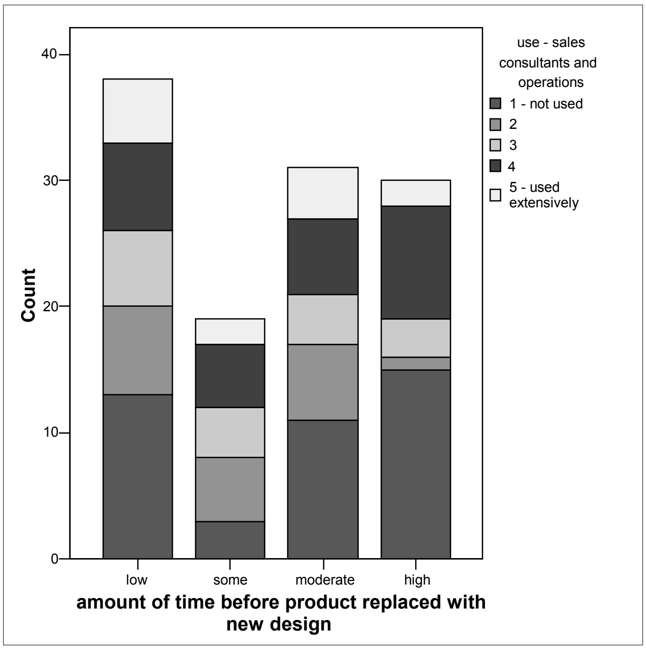


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

G. Degree of use of sales consultants and operations



H. Degree of use of Quality Function Deployment (QFD)

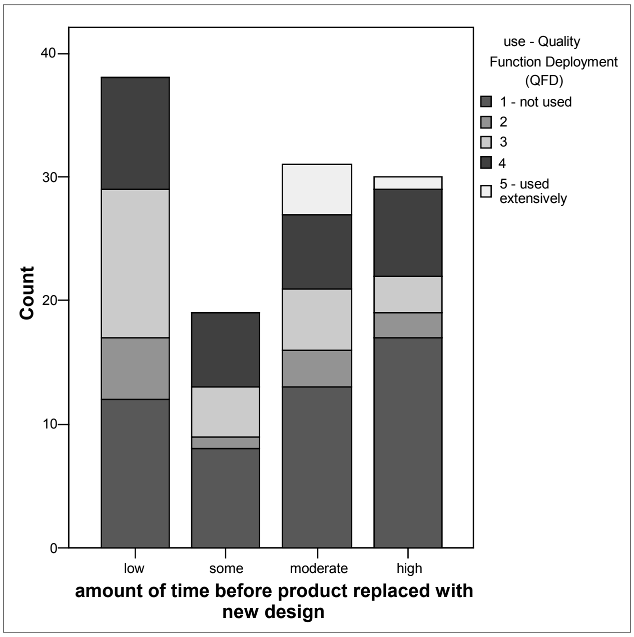
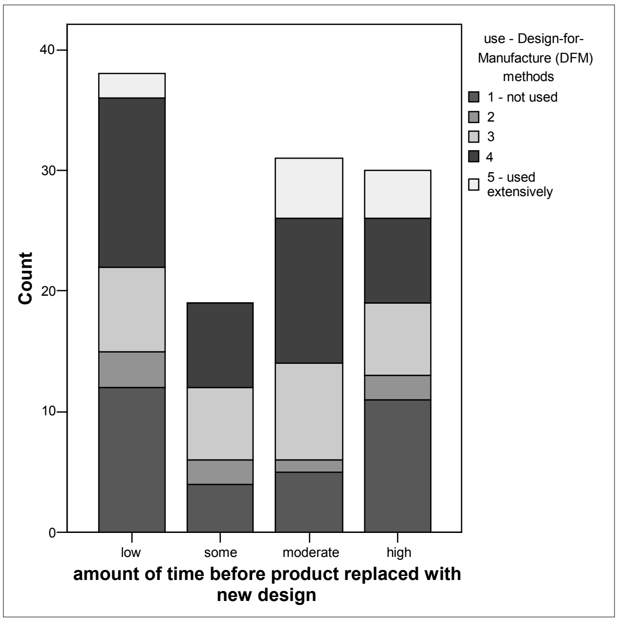


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

I. Degree of use of Design-for-Manufacture (DFM) methods



J. Degree of use of quality tools and full-scale models

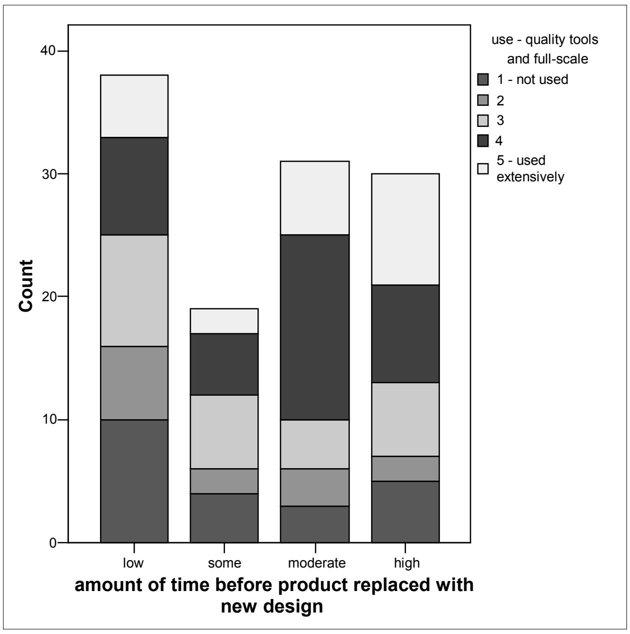
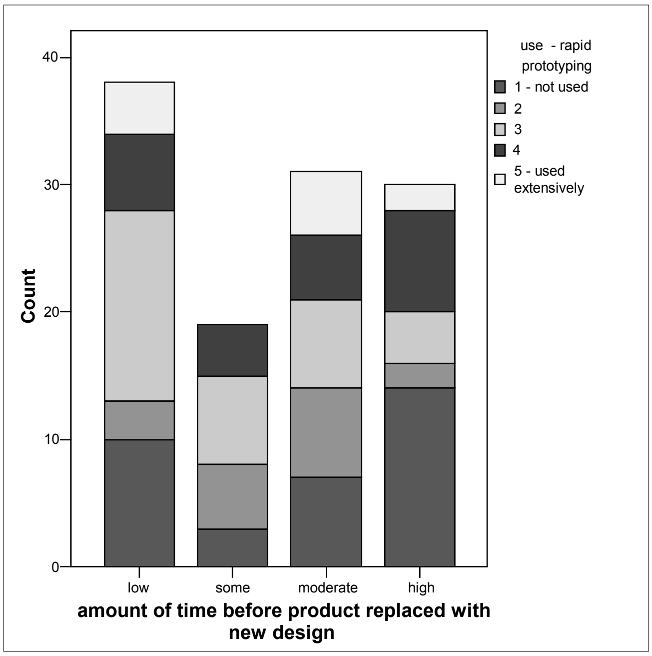


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

K. Degree of use of rapid prototyping



L. Degree of use of ISO 90002 certified suppliers

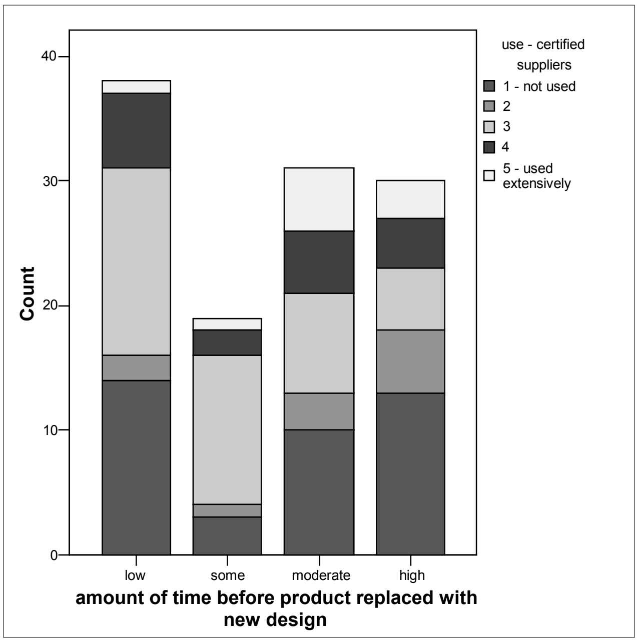
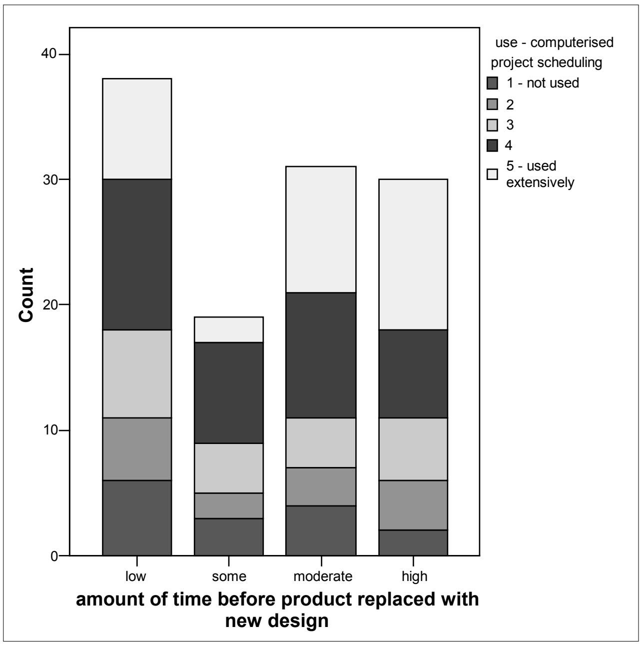


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

M. Degree of use of computerised project scheduling



N. Degree of use of computer-aided-design tools

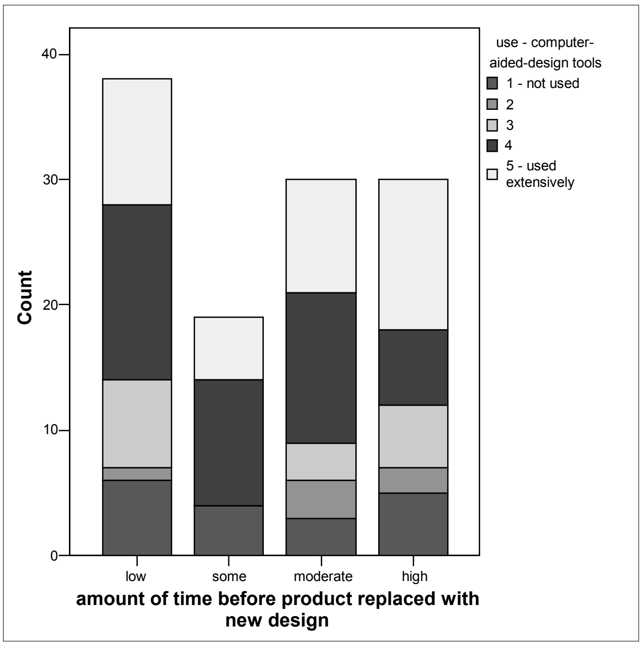
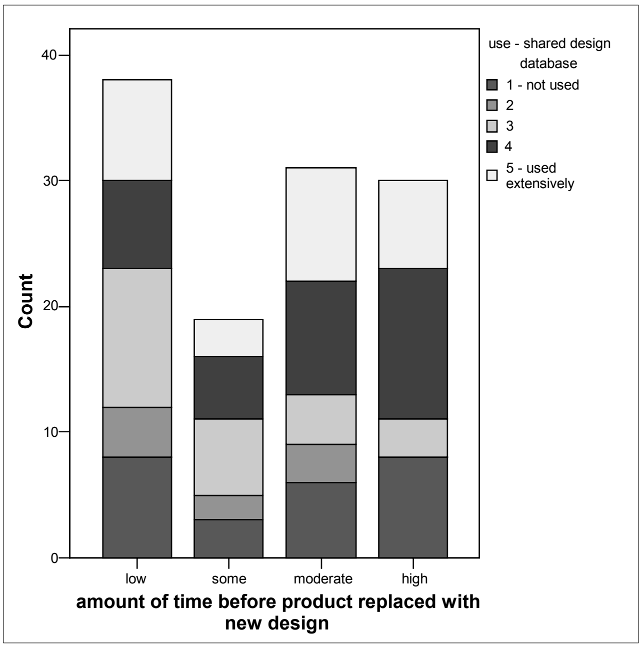
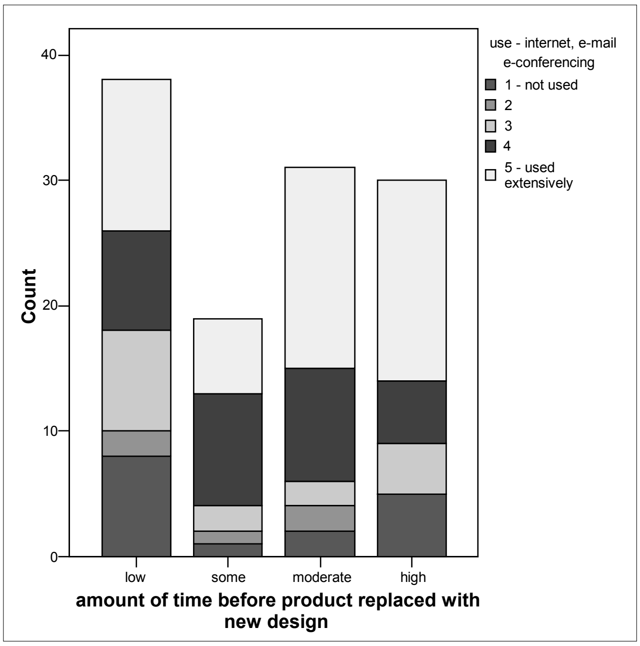


Figure 1 Cross-tabulation of years before replacing existing products versus selected use of forecasting and design tools and/or techniques associated with improved manufacturability (continued)

O. Degree of use of shared design databases



P. Degree of use of internet, e-mail, e-conferencing technologies



3.3 Factor analysis and hypothesis-testing

In terms of PCA and factor analysis, Table 1 is a listing of variables that were a product of the degree of use of the selected forecasting and product management tools displayed in Figure 1 with the perceived impact of these same variables in order to use the PCA techniques in an efficient manner. These and other independent variables were clustered to find the major constructs (Tables 2 and 3) in the data reduction stage of the present study, with the varimax rotation method and eigenvalue greater-than-one criterion. The eight independent factor groups were renamed to suit their description of the variables that loaded into the groupings at least 0.5 and were similar to the labels generated by theoretical constructs from the literature review. The variable loadings defining each major factor are highlighted in bold print for easy recognition in Table 2. The renamed factor groupings included the following constructs: SCM problems, Scheduling and development concerns, Supply shortages, Quality and design, Forecasting problems, Price of inputs and vendor relations, Capital problems and Lead-time problems. As illustrated in Table 3, four significant constructs were found to be statistically significant, with a combined explained variance of 76.4%. The components were listed in order of importance of grouping factor, with the specific variables that had a factor loading of 0.5 or greater highlighted in bold. Tables 4 through 14 illustrate the hypothesis testing results to determine the significant contributors of these SCM and manufacturability constructs (SCM problems, Scheduling and development concerns, Supply shortages, Quality and design, Forecasting problems, Price of inputs and vendor relations, Capital problems and Lead-time problems) in predicting the need to innovate new designs to keep placed with the marketplace as measured by the dependent variable, years produced before new design.

Table 1 Listing of moderating or interacting variables, computed by the product of the degree of use and impact on the manufacturability of the project

Product of degree of use and impact of price factors
Product of degree of use and impact of inventory factors
Product of degree of use and impact of historic forecasting factors
Product of degree of use and impact of signal forecasting factors
Product of degree of use and impact of combination factors
Product of degree of use and impact of vendor factors
Product of degree of use and impact of consulting factors
Product of degree of use and impact of QFD factors
Product of degree of use and impact of design factors
Product of degree of use and impact of quality tools factors
Product of degree of use and impact of prototype factors
Product of degree of use and impact of ISO certification factors
Product of degree of use and impact of scheduling factors
Product of degree of use and impact of CAD factors
Product of degree of use and impact of development factors
Product of degree of use and impact of internet factors

Table 2 Total variance explained on the eight independent factor-based constructs

	Initial eigenvalues			*Extraction sums of squared loadings*			*Rotation sums of squared loadings*		
Constructs	*Total*	*Percentage of variance (%)*	*Cumulative (%)*	*Total*	*Percentage of variance (%)*	*Cumulative (%)*	*Total*	*Percentage of variance (%)*	*Cumulative (%)*
SCM problems	6.400	20.001	20.001	6.400	20.001	20.001	3.637	11.366	11.366
Scheduling and development concerns	3.109	9.714	29.716	3.109	9.714	29.716	3.206	10.019	21.385
Supply shortages	2.553	7.979	37.694	2.553	7.979	37.694	3.037	9.489	30.874
Quality and design	2.220	6.938	44.632	2.220	6.938	44.632	2.655	8.297	39.171
Forecasting problems	1.700	5.312	49.944	1.700	5.312	49.944	2.243	7.011	46.182
Price of inputs and vendor relations	1.474	4.606	54.550	1.474	4.606	54.550	2.021	6.317	52.499
Capital problems	1.260	3.937	58.486	1.260	3.937	58.486	1.647	5.148	57.647
Lead-time problems	1.205	3.766	62.253	1.205	3.766	62.253	1.474	4.606	62.253

Note: Extraction method: principal component analysis

Table 3 Varimax rotated-component matrix displaying the factor loadings into each major independent construct, in decreased order of importance

	SCM problems	*Scheduling and development concerns*	*Supply shortages*	*Quality and design*	*Forecasting problems*	*Price of inputs and vendor relations*	*Capital problems*	*Lead-time problems*
Product of price factors	–5.628E-02	–9.812E-02	–.275	.215	.462	**.551**	.147	1.165E-02
Product of inventory factors	–2.314E-02	.101	.140	.142	.412	.490	–.217	1.116E-02
Product of historic forecasting factors	7.719E-02	–.106	.102	–4.804E-02	**.679**	–4.408E-02	7.817E-02	–.382
Product of signal factors	8.426E-02	.117	.240	1.993E-02	**.638**	5.222E-02	7.157E-02	8.201E-02
Product of combination factors	–5.139E-02	.163	–.147	–8.860E-02	**.737**	5.525E-02	5.511E-02	.105
Product of vendor factors	.183	.226	.294	.146	–1.254E-02	**.686**	5.868E-02	5.864E-02
Product of consulting factors	.160	.224	**.645**	.313	.101	.124	1.125E-02	.131
Product of QFD factors	.207	.124	.229	**.571**	–1.801E-02	.360	–.197	9.822E-02
Product of design factors	.254	.334	3.775E-02	**.552**	–7.476E-02	.308	–5.567E-02	.115
Product of quality tools factors	–4.733E-02	–1.481E-02	–.223	**.754**	.138	–.109	.154	.106
Product of prototype factors	.341	.128	9.091E-02	**.735**	1.538E-02	4.344E-02	1.542E-02	–8.735E-02
Product of ISO certification factors	.225	.207	.139	**.562**	–.249	.146	–.128	.119
Product of scheduling factors	–.113	**.759**	.217	.169	7.565E-02	–.124	–2.546E-03	–.164
Product of CAD factors	.136	**.811**	–.103	8.458E-02	8.106E-02	9.780E-02	3.855E-03	–7.526E-02
Product of development factors	7.427E-02	**.626**	.118	.317	8.136E-02	–2.202E-02	.133	–.130
Product of internet factors	–3.436E-02	**.782**	.109	1.865E-02	2.992E-02	.136	7.567E-03	.128
Demand – insufficient domestic	.192	–9.424E-02	8.382E-02	.113	–4.152E-02	5.117E-02	.144	.762
Demand – insufficient foreign	.330	.189	**.666**	–9.414E-02	2.018E-02	.238	–1.021E-02	–.191
Supply – shortage of equipment	–7.600E-02	.187	**.717**	-.141	–4.164E-02	6.374E-02	5.276E-02	.142
Supply – insufficient capacity	2.419E-02	–5.531E-02	**.746**	.138	.146	–1.493E-03	.174	6.205E-02
Supply – shortage of labor	5.133E-02	–6.685E-02	**.497**	2.330E-05	–3.249E-02	**.526**	.257	–.113
Supply – shortage of raw materials	8.830E-02	.494	.278	-.121	–7.987E-02	.379	3.532E-03	.223
Supply – shortage of capital	.234	6.077E-02	5.427E-02	–2.710E-02	–6.081E-02	1.627E-04	**.685**	.331
Supply – longer lead times	.415	–7.057E-02	.183	.158	.387	–6.608E-02	–.173	**.516**
Supply – excessive inventories	**.515**	.233	.181	.173	.177	–5.118E-02	–.180	2.296E-02
Supply – poor use of resources	**.478**	6.159E-02	.253	–.124	6.509E-02	.164	.493	2.521E-02
Supply – interruption	**.586**	.295	.225	.198	.110	–.286	–6.647E-02	.115
Supply – unacceptable forecast errors	**.673**	.181	.255	9.288E-02	–3.481E-02	7.831E-02	–.128	.186
Supply – lack of teamwork	**.752**	–.296	–3.019E-02	.109	.178	–2.119E-02	.208	–3.757E-02
Supply – lack of integration	**.710**	–4.666E-02	–.101	.106	–.166	8.426E-02	.226	.145
Supply – bottleneck management	**.696**	–3.439E-02	–8.454E-02	.218	–6.367E-02	.262	4.326E-02	5.916E-02
Supply – reduce confidence in planning	.111	–4.027E-02	–.140	–4.354E-02	–.179	–1.399E-02	–.671	.113

Notes: Extraction method: principal component analysis; Rotation method: Varimax with Kaiser normalisation; Rotation converged in 13 iterations

Table 4 ANOVA results of testing the first specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (SCM problems)	1414.353	1	1414.353	14.977	.000
Residual	10 670.877	113	94.433		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 1 for analysis
Dependent variable: years produced before new design

Table 5 ANOVA results of testing the second specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (scheduling and development concerns)	44.798	1	44.798	.420	.518
Residual	12 040.432	113	106.552		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 2 for analysis
Dependent variable: years produced before new design

Table 6 ANOVA results of testing the third specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (supply shortages)	223.190	1	223.190	2.126	.148
Residual	11 862.041	113	104.974		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 3 for analysis
Dependent variable: years produced before new design

Table 7 ANOVA results of testing the fourth specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (quality and design)	4.761	1	4.761	.045	.833
Residual	12 080.469	113	106.907		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 4 for analysis
Dependent variable: years produced before new design

Table 8 ANOVA results of testing the fifth specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (forecasting problems)	21.041	1	21.041	.197	.658
Residual	12 064.189	113	106.763		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 5 for analysis
Dependent variable: years produced before new design

Table 9 ANOVA results of testing the sixth specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (price of inputs and vendor relations)	93.526	1	93.526	.881	.350
Residual	11 991.705	113	106.121		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 6 for analysis

Dependent variable: years produced before new design

Table 10 ANOVA results of testing the seventh specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (capital problems)	121.289	1	121.289	1.146	.287
Residual	11 963.941	113	105.876		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 7 for analysis

Dependent variable: years produced before new design

Table 11 ANOVA results of testing the eighth specific hypothesis, predicting years produced before new design

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (lead-time problems)	497.318	1	497.318	4.850	.030
Residual	11 587.913	113	102.548		
Total	12 085.230	114			

Notes: Predictors: (constant), REGR factor score 8 for analysis

Dependent variable: years produced before new design

Table 12 Results of testing the ninth specific hypothesis, testing all eight independent constructs combined, predicting years produced before new design

A. Model summary

R	*R square*	*Adjusted R square*	*Std. error of the estimate*
.448	.200	.140	9.55

Notes: Predictors: (constant), REGR factor score 8 for analysis, REGR factor score 7 for analysis, REGR factor score 6 for analysis, REGR factor score 5 for analysis, REGR factor score 4 for analysis, REGR factor score 3 for analysis, REGR factor score 2 for analysis, REGR factor score 1 for analysis

Table 12 Results of testing the ninth specific hypothesis, testing all eight independent constructs combined, predicting years produced before new design (continued)

B. ANOVA results

	Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Regression (SCM problems, scheduling and development concerns, supply shortages, quality and design, forecasting problems, price of inputs and vendor relations, capital problems, lead-time problems)	2420.277	8	302.535	3.318	.002
Residual	9664.954	106	91.179		
Total	12 085.230	114			

Notes: Predictors: (Constant), REGR factor score 8 for analysis, REGR factor score 7 for analysis, REGR factor score 6 for analysis, REGR factor score 5 for analysis, REGR factor score 4 for analysis, REGR factor score 3 for analysis, REGR factor score 2 for analysis, REGR factor score 1 for analysis

Dependent variable: years produced before new design

Table 13 Hypothesis-testing and associated coefficient results with the dependent variable predicting years produced before new design

	Un-standardised coefficients		*Standardised coefficients*		
	B	*Std. error*	*Beta*	*t*	*Sig.*
(Constant)	5.987	.890		6.724	.000
REGR factor score 1 for analysis (SCM problems)	–3.522	.894	–.342	–3.939	.000
REGR factor score 2 for analysis (scheduling and development concerns)	.627	.894	.061	0.701	.485
REGR factor score 3 for analysis (supply shortages)	–1.399	.894	–.136	–1.565	.121
REGR factor score 4 for analysis (quality and design)	–.204	.894	–.020	–0.229	.820
REGR factor score 5 for analysis (forecasting problems)	–.430	.894	–.042	–0.480	.632
REGR factor score 6 for analysis (price of inputs and vendor relations)	.906	.894	.088	1.013	.313
REGR factor score 7 for analysis (capital problems)	–1.031	.894	–.100	–1.153	.251
REGR factor score 8 for analysis (lead-time problems)	–2.089	.894	–.203	–2.335	.021

Note: Dependent variable: years produced before new design

Table 14 Summary of hypothesis-testing results

Hypothesis number	*Description of hypothesis*	*Present study's results*
H1	There will be a significant negative or inverse relationship with the dependent variable success amount of time before replacing existing current products' design with the factor-based construct of SCM problems associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	HS, Accepted
H2	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Scheduling and development concerns associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H3	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Supply shortages associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H4	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Quality and design associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H5	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Forecasting problems associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H6	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Price of inputs and vendor relations associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H7	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Capital problems associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	NS, Rejected
H8	There will be a significant negative or inverse relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of Lead-time problems associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability.	S, Accepted

Note: NS denotes not statistically significant at the 0.05 level for a one-tailed test; MS denotes marginal support, S denotes statistically significant at the 0.05 level for a one-tailed test, HS denotes highly significant at the 0.01 level for a one-tailed test

In terms of SCM problems independent construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- supply concerns, lack of teamwork (.752)
- supply concerns, lack of integration (.710)
- supply concerns, bottleneck management (.696)
- supply concerns, unacceptable forecast errors (.673)
- supply concerns, interruptions (.586)
- supply concerns, excessive inventories (.515).

The listed variables indicate the importance of collaborative efforts and accountability among functional groups in addressing SCM concerns associated with lack of teamwork, bottlenecks and forecasting errors.

The individual factor loadings for the Scheduling and development concerns construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- product of degree of use and impact of CAD factors (.811)
- product of degree of use and impact of scheduling factors (.759)
- product of degree of use and impact of internet factors (.782)
- product of degree of use and impact of development factors (.626).

The use of electronic tools to share information is key to successful communications in building forecasts. Easier access to information by all functional groups keeps everyone up to date as well as eliminates any one group having sole influence over a forecast.

The individual factor loadings for the Supply shortages construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- supply concerns, insufficient capacity (.746)
- supply concerns, shortage of equipment (.717)
- demand concerns, insufficient foreign orders (.666)
- product of degree use and impact of consulting factors (.645)
- supply concerns, shortage of labour (.497).

Shortages and insufficient capacity on a consistent basis will ultimately cause companies to lose customers and profits. Corporations work endlessly to increase their competitiveness by product differential, high quality, low cost, and speed to market; the supply chain then becomes an integral part in supporting the firm’s strategy.

The individual factor loadings for the Quality and design construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- product of degree use and impact of quality tools factors (.754)
- product of degree use and impact of prototype factors (.735)
- product of degree use and impact of QFD factors (.571)
- product of degree use and impact of ISO certification factors (.562)
- product of degree use and impact of design factors (.552).

Threats to optimal quality performance and design can include initial production problems that can cost millions of dollars in re-tooling, labour, and warranty expenses. Time delays required to ramp-up production frequently miss early market opportunities and result in negative effects on a firm's market value. "Poor manufacturing also compromises initial product quality and reliability defects and product failures reduce initial customer satisfaction, which in turn damages future sales" (Swink, 1999, p. 692).

The individual factor loadings for the Forecasting problems construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- product of degree use and impact of combination of historical and real time factors (.737)
- product of degree use and impact of signal factors (.638)
- product of degree use and impact of historic forecasting factors (.679).

A collaborative effort by functional groups helps to create sound forecasting and results in building consensus. The use of historical data, real time data and the involvement of manufacturing indicate a climate that is conducive to a solid forecasting platform. It is essential that top-management create systems that allow functional groups to collaborate in forecast planning.

The individual factor loadings for the Price of inputs and vendor relations construct, the selected variables that loaded with 0.5 or greater included the following in decreasing order (actual factor loadings are in parenthesis):

- product of degree use and impact of vendor factors (.686)
- product of degree use and impact of price factors (.551)
- supply concerns, shortage of labour (.526)
- product of degree use and impact of inventory factors (.490).

SCM represents a powerful tool to achieve corporate objectives. Top management must formulate supply chain overall performance objectives derived from corporate strategy and corporate objectives and foster a climate of importance where SCM is a key component of corporate strategy.

The individual factor loading for the Capital problems construct, the selected variable that loaded with 0.5 or greater included only the supply concerns, shortage of capital (.685). To effectively forecast demand as well as manage within the supply chain a comprehensive understanding of the products manufactured and their impact on the business is needed by functional groups in order to research like products, assess competition, and understand consumer demand for the product. Financial concerns that are addresses in a timely fashion are critical to the success of any manufacturing project.

The individual factor loading for the Lead-time problems construct, the selected variable that loaded with 0.5 or greater included Supply concerns, longer lead times (.516). To effectively forecast demand as well as manage within. For example, only 31% of the respondents agreed that SCM was a top management issue in their companies, while 47% felt that lack of teamwork existed, and 41% indicated a lack of true integration among business partners-internal and external in the value chain. These concerns may all promote lead-time problems through the supply chain.

As shown in the hypothesis-testing summary found in Table 14, there will be a significant negative relationship with the dependent variable amount of time before replacing existing current products' design with the factor-based construct of SCM Problems (H1) associated with the proper implementation of forecasting and design tools and/or techniques associated with improved manufacturability (Table 13, $t = -3.939$, $p = 0.000$). The same significant was true for H7, Lead-time problems (Table 13, $t = -2.335$, $p = 0.021$). Tables 15 through 21 display frequencies and descriptive statistics of selected variables used in the analysis. The majority of the respondents were project managers (42%); products' components were highly varied as well as the customer base, with mixed responses over the degree of agreement that management relinquished authority over the project.

Table 15 Frequencies of the role on the NPD/NPM project

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Project manager	34	27.9	29.1	29.1
Functional manager	25	20.5	21.4	50.4
Project team member	51	41.8	43.6	94.0
Other manager/team member	7	5.7	6.0	100.0
Total	117	95.9	100.0	

Table 16 Frequencies of the functional area of work within the manufacturing entity

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Marketing/sales	22	18.0	18.6	18.6
Product design and development	6	4.9	5.1	23.7
Finance/accounting	29	23.8	24.6	48.3
Personnel/human resources	18	14.8	15.3	63.6
Manufacturing/operations	27	22.1	22.9	86.4
Other	16	13.1	13.6	100.0
Total	118	96.7	100.0	

Table 17 Frequencies of the product broken down in terms of parts

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
1–5	25	20.5	21.2	21.2
6–20	35	28.7	29.7	50.8
21–100	24	19.7	20.3	71.2
101–500	18	14.8	15.3	86.4
501–5000	11	9.0	9.3	95.8
More than 5000	5	4.1	4.2	100.0
Total	118	96.7	100.0	

Table 18 Frequencies of the amount of production at peak production

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
Less than 100	15	12.3	12.7	12.7
101–1000	25	20.5	21.2	33.9
1001–20 000	35	28.7	29.7	63.6
20 001–500 000	23	18.9	19.5	83.1
More than 500 000	20	16.4	16.9	100.0
Total	118	96.7	100.0	

Table 19 Frequencies of the number of customers accounting for 50% total sales

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
1 customer	12	9.8	10.2	10.2
2–4	6	4.9	5.1	15.3
5–10	15	12.3	12.7	28.0
11–50	38	31.1	32.2	60.2
More than 50 customers	46	37.7	39.0	99.2
65	1	0.8	0.8	100.0
Total	118	96.7	100.0	

Table 20 Frequencies of the degree of agreement that management relinquished authority over the project

	Frequency	*Percent*	*Valid percent*	*Cumulative percent*
1 – strongly disagree	3	2.5	2.5	2.5
2	25	20.5	21.2	23.7
3	36	29.5	30.5	54.2
4	47	38.5	39.8	94.1
5 – strongly agree	7	5.7	5.9	100.0
Total	118	96.7	100.0	

Table 21 Descriptive statistics of selected product characteristics

	N	*Mean*	*Std. deviation*	*Variance*	*Skewness*	*Kurtosis*
Percentage of parts/components purchased/off shelf/produced outside	118	41.10	36.79	1353.306	0.453	–1.301
Percentage of parts/components previously designed/borrowed	118	19.64	26.08	680.180	1.533	1.716
Percentage of parts/components new designs	118	29.96	32.26	1040.468	0.981	–0.164
Years produced before new design	118	5.91	10.18	103.635	7.183	63.419
Percentage of division sales from concept to market	118	22.12	24.49	600.003	1.376	1.445
Percentage of division sales product	118	32.00	31.87	1015.521	1.024	–0.221

Since all companies do demand forecasting, no two firms are likely to forecast the way. As demonstrated in this study, a variety of forecasting techniques were employed in SCM. Some companies may rely solely on qualitative tools-judgment based, using subjective data or opinion based to derive a forecast. This technique may be used when with a new product when historical data is not available, or the impact of new technologies, environmental changes, cultural changes, and legal changes. Surveys may be conducted, polling customer base to estimate demand for a coming period, this will contribute a fraction of what will become the final forecast. The advantage to this approach is information is being requested from people who are in a position to know something about future demand.

There are risks to this approach. Information from sales people may include inflated projections to ensure level of finished goods will be available. The opposite may occur if the sales force for whatever reason underestimates demand based on hearsay or factors that may not be conclusive. Gathering information from customers is also expensive and time consuming, especially trying to gather data. Surveys may reveal that customers are intending to purchase, but actually when the time comes to purchase the intention may not be there. This leads to over estimation of demand. For these reason this method alone would not be the most successful in demand forecasting.

As an alternative, consensus methods are used whereby a small group of individuals develop general forecasts. In a Jury of Executive Opinion, for example, a group of executives in the firm would meet and develop through debate and discuss a general forecast demand. Individuals contribute insight and understanding based on their view of the market, the product, and the competition. Bristol-Meyers Squibb Company, for example, uses 220 well-known research scientists as it jury of executive opinion to get a grasp on future trends in the world of medical research (Heizer and Render, 2001). Though executives are experienced, there are possibilities for biased inputs.

It could be said that judgment based methods are not adequate in developing a demand-forecasting system. Judgment based methods are important for developing a firm's strategy. The experience and knowledge of sales and marketing people about sales promotions, new products, and competitor activity can somehow be incorporated into the forecast. This valuable information can also be used to add to the forecast, or modify an existing forecast rather than as the baseline to create the forecast in the first place.

Time series forecasting models try to predict the future based on past data. For example, sales figures collected for the past six weeks can be used to forecast sales for the seventh week. Quarterly sales figures collected for the past several years can be used to forecast future quarters. Though both examples contain sales, different forecasting time series models would likely be used. Simple exponential smoothing requires five to ten observations to set the weight, the data should be stationary, forecast horizon short (less than three months), this method is quite simple and easily learned. Holt's exponential smoothing model requires 10 to 15 observations, that are trends with no seasonality, short to medium forecasting horizon (three to six months), and some advanced training. Winter's exponential smoothing model requires at least four to five observations per season, uses trends and seasonality in short to medium time horizons, with advanced training.

Regression is a forecasting technique that measures the relationship of one variable to one or more other variables. For example, if we know that something has caused product demand to behave in a certain way in the past, we would like to identify that relationship. If the same thing happens again in the future we can predict what demand will be (Taylor, 2004). For example, the sales of a product might be related to the firm's advertising budget, the price charged, competitor's prices, promotional strategies, and eve the economy and unemployment rates for a particular region. In this case, sales would be called the dependent variable, and the other variables would be called independent variables. The role of the forecasting team is to develop the best statistical relationship between sales and the set of independent variables. For this example, the best quantitative casual forecasting model is regression analysis.

Time series and regression methods can be used to develop forecasts encompassing horizon of any length time although they tend to be used most frequently for short and medium range forecasts. These quantitative forecasting techniques are generally easy to understand, simple to use, and not especially costly unless the data requirements are substantial. They also have exhibited a good track record of performance for many companies that have used them. For these reasons, regression methods, and especially time series, are widely popular (Taylor, 2004). In using these forecasting models a firm should choose the model depending on time horizon of forecast, data availability, accuracy required, size of forecasting budget, and availability of qualified personnel. Another issue in choosing the correct model is the firm's degree of flexibility; hence the greater the ability to react quickly to changes, the less accurate the forecast needs to be (Chase *et al.*, 2004).

3.4 Using forecasting tools wisely

Possibly the main key is to make both qualitative and quantitative tools integral to the forecasting system in the complexities found in modern manufacturing systems, as evidence in this study illustrating the importance of SCM and Lead-time problems associated with barriers to innovation (as measured in years with exiting product before design changes). Some companies may be guilty of relying solely on qualitative tools-opinions of managers, sales and marketing personnel to create a forecast. Alternatively, some expect the application of quantitative tools, or the computer packages that make use of them to 'solve the forecasting problem'. To be effective, however, they must be understood and used wisely within the context of the companies' unique business environment. Without understanding where qualitative techniques, time series, and regression do and do not work effectively, it is impossible to analyse the costs and achieve the benefits of implementing new forecasting tools.

Qualitative information has to be available in a forecasting process that performs intensive numerical analysis of demand history and the factors that relate statistically to changes in demand since the qualitative information explains the nature of the market and what causes demand to change. Conversely, a quantitative process that is fed qualitative information is not taking advantage of quantitative techniques and their ability to analyse patterns in the history of demand. Using forecasting tools wisely requires knowing where each type of tool works well and where it does not, then putting together a process that uses the advantages of each in the unique context of the firm. Time series models work well in companies that experience changing trends and seasonal patterns, but they are of no use in determining the relationship between demand and such external factors as price changes, economic activity, or marketing efforts by the company or competitors. On the other hand, regression analysis is quite effective at assessing these relationships, but not very useful in forecasting changes in trend and seasonality.

Key personnel involved in either the quantitative or the qualitative aspects of the forecasting process need training in using the techniques, determining where they work and do not work, and incorporating qualitative adjustments in the overall forecasting process. Lee recommends data cleansing before they are entered into a forecasting model. This requires cleansing atypical outliers and patterns. Point of Sale data are the demand data retailers typically use to drive replenishment. Unfortunately, promotional activities, entry errors, unusual customer returns, incorrect returns processing, system glitches, item markdowns and external shocks to the retail operation. Lee suggests it is essential to remove, but not necessarily discard, these distorting effects from the original demand data. Otherwise, the resulting base demand forecasts will factor irrelevant effects.

3.5 Measuring forecast performance

As in any part of the supply chain, assessment of the forecasting component is necessary to measure performances of the forecasting system, people, and performance. Sales managers would be interested in a forecast stated in dollars and the territory or product line, logistics would be interested in a forecast performance at the SKU level. It is also imperative to track accuracy at each point which forecasts may be adjusted. For example, the forecasting effort of the sales team is to examine 'software generated' forecasts for their customers and make adjustments. Those adjustments are then measured against actual sales to determine whether the sales force adjustment improved the forecast or not. Similarly, the product manager's job is to take the software generated forecast, which has been adjusted by the sales team, and make further adjustments based on a knowledge of market conditions or upcoming promotional events. Again, these adjustments are measured against actual sales to determine whether they improved the forecast. In both cases, the sales force and the product manager gain feedback that helps them improve their efforts.

Finally, companies should assess forecasting accuracy in terms of its impact on business performance. Improving forecasting accuracy require expenditures of resources, both human and financial, this should be approached in a return-on-investment basis. For example, if the cost of more accurate forecasts is very high, the business may consider alternative approaches to improving customer service, such as carrying higher inventory levels. In addressing this particular scenario, this strategy should be based on sound business analysis. Measuring and tracking accuracy will ultimately help build confidence in the forecasting process. As the users realise the system in place is able to eliminate error they are more likely to utilise the developed forecast to support all operations of the company.

4 General conclusions and implications

The survey results confirm that there is a need for top management involvement. It should be a high priority investment area for organisations that lack true integration and teamwork. Management should consider running the supply chain as a process. Whereby, an aligned supply chain strategic plan is documented and kept current. The plan must include very specific objectives to address the development and implementation of a best practices process where risks, opportunities, and choices are managed. The senior executive in the business unit should lead the process.

Measurement systems represent a tool that can lead to supply chain excellence. Objective measurement supports fact-based management, it is an ideal way to communicate requirements to other members of the supply chain and to promote continuous improvement and change. Measurement also conveys to employees what is important by linking critical measures to desired business outcomes. Measurements also help identify whether new initiatives are producing the desired results. As indicated by the survey, a high percentage of managers, especially project managers, responded that a lack of teamwork existed within their supply chain; communicating measurements may help reduce this flaw. Key process indicators can be used to measure policy, processes and procedures, organisation skills, information, and methodology for decision-making, for the purpose of striving for improvement on a continuous basis. Indicators should also include sales planning, forecasting, and new-product planning. Management should also assess risk and risk impact, prioritise risk and ensure controls are part of the entire planning process. As previously stated, the main key is to make both qualitative and quantitative tools integral to the forecasting system in the complexities found in modern manufacturing systems, as evidence in this study illustrating the importance of SCM and Lead-time problems associated with barriers to innovation.

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Notes

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