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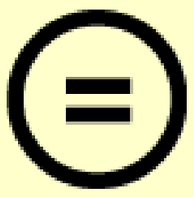
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Configurations in Manufacturing Planning and Control (MPC) Systems: Manufacturing Environment Perspective

By

CHAN Wai Kuen

A Doctoral Thesis

Submitted in partial fulfilment of the requirements

for the award of

Doctor of Philosophy of Loughborough University

March 2001

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In the beginning was the Word,
and the Word was with God,
and the Word was God.

(John 1:1; RSV*)

Tao (i.e. Way) existed before words and names,
before heaven and earth,
before ten thousand things.
It is the unlimited father and mother
of all limited things.

.....

This is the beginning of all understanding.

(Lao Tsu**, 571 B.C. – ?)

For the LORD gives wisdom;
from his mouth
come knowledge and understanding.

(Proverbs 2:6; RSV*)

*Revised Standard Version
**The Tao Te Ching of Lao Tzu, San Francisco, Calif.: Mercury House (Translated by Walker, B.B., 1995).

Abstract

The quest for a viable manufacturing planning and control (MPC) system that supports organizational strategy is a crucial issue in operations management. Previous studies on MPC discipline have paid little attention on the basic performance differences that associated with strategic and organization environmental issues. This thesis addresses these issues by exploring the configurations in MPC systems in a macro perspective that integrates several areas, namely: organizational environment, competitive strategy, manufacturing strategy, supply chains, MPC system and organizational performance.

This thesis attempts to shift the conventional research focus of MPC processes and mechanisms to environment-strategy-system-performance (E-S-S-P) paradigm. In this respect, the configurational research in MPC systems requires the study of a wider body of knowledge (Chapters 2 – 5) including: (1) a detailed assessment of the current state-of-the-art of MPC practices; (2) the review of the relations between strategies and MPC systems; (3) a study of organization environmental variables and their influences; and (4) an identification of methodological issues relating to configuration research.

Thirty hypothesized relationships are proposed (Chapter 6) and tested (Chapters 8 and 9). The research methodology has been concentrated in three distinctive areas. The first area is in the design of instruments (Chapter 7) for the measurement of manufacturing environments, competitive strategy, manufacturing strategy, and MPC systems in several manufacturing industries. Five databases are gathered to test the hypotheses, i.e. trade census and industrial production statistics, published business data, published survey data (for content analysis), data from field visits, and questionnaire survey data. The second area is the construction of a 3-dimensional organization environment (Chapter 7). Besides, a reference model is proposed that takes into account of the theory of autopoiesis and enacted environment, based on several field visits (Chapter 8). The third area is the study of correlations between the organizational environment, competitive strategy, manufacturing strategy, and MPC systems (Chapter 9). The quantitative analyses are used such as Pearson correlation, linear regression, and causal modeling.

There are seven main contributions of this thesis: (1) It is the first study of the configurations in MPC systems that will have significant theoretical implications for the development of MPC practices. (2) It develops the network relationships of E-S-S-P research paradigm. (3) It broadens the knowledge in operations management by exploring the hypothesized relations between organizational environment, strategies, supply chains and MPC systems. (4) It shows the adoption of new thinking, i.e. the theory of autopoiesis, in the configuration study. (5) It develops a reference MPC model that adds to the body of knowledge in this discipline. (6) It constructs the task environment classification framework for the study related to manufacturing environment in Hong Kong. (7) It proposes path modelling analysis to explore the causal relationships of MPC system and other organizational variables, which is rarely applied in this field.

List of Publications

- Chan, J.W. K., Burns, N. D., and Yung, K.L. (1995), "General Systems Theory for the Design of MPC System", *Proceedings of the 7th International Manufacturing Conference in China*, 19-21 October, Harbin, China, pp.375-380.

- Chan, J.W. K., Burns, N. D., and Yung, K.L. (2000), " Environment-strategy Fit: A Study of Hong Kong Manufacturing Logistics", *Logistics Information Management*, vol.13, no.5, pp.286-300.

- Chan, J.W. K., Burns, N. D., and Yung, K.L., "A Framework for Manufacturing Planning & Control (MPC) System: Manufacturing Environment Perspective". (Submitted to the *International Journal of Technology Management*).

- Chan, J.W. K., Burns, N. D., and Yung, K.L., "Organizational Environment and Inventory Performance: A study of Hong Kong Manufacturing Industries". (Submitted to the *International Journal of Operations & Production Management*).

- Chan, J.W. K., and Burns, N. D., "Benchmarking Manufacturing Planning and Control (MPC) Practices: An Empirical Study of Hong Kong Supply Chains". (Submitted to the *Benchmarking: An International Journal*).

- Chan, J.W. K., and Burns, N. D., "Manufacturing Planning & Control (MPC) Practices: Effects on Organization Performance". (Submitted to the *Industrial Engineering Research: An International Journal of IE Theory and Application*).

- Chan, J.W. K., and Burns, N. D., "Configurations in Manufacturing Planning & Control (MPC) Systems: A Causal Model Analysis". (Pending to submit).

- Chan, J.W. K., and Burns, N.D., "Manufacturing Planning & Control (MPC) Reference Model: An Autopoiesis View". (Pending to submit).

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Research Hypotheses

Hypothesis 1: Manufacturing strategy will have a direct effect on the MPC system effectiveness.

Hypothesis 1a: Manufacturing strategy will have a direct effect on the MPS performance.

Hypothesis 1b: Manufacturing strategy will have a direct effect on the CRP performance.

Hypothesis 1c: Manufacturing strategy will have a direct effect on the MRP performance.

Hypothesis 1d: Manufacturing strategy will have a direct effect on the purchasing performance.

Hypothesis 2: Competitive strategy will have a direct effect on the MPC system effectiveness.

Hypothesis 2a: Competitive strategy will have a direct effect on the MPS performance.

Hypothesis 2b: Competitive strategy will have a direct effect on the CRP performance.

Hypothesis 2c: Competitive strategy will have a direct effect on the MRP performance.

Hypothesis 2d: Competitive strategy will have a direct effect on the purchasing performance.

Hypothesis 2e: Defender organizations, adopting a pure-cost strategy, will tend to keep a higher inventory level than analyzer organizations which adopt pure-differentiation or cost & differentiation strategy.

Hypothesis 3: Operational environment will have direct effect on the MPC system effectiveness.

Hypothesis 3a: Product development is positively associated with the MPC system effectiveness.

Hypothesis 3b: External relationship is positively associated with the MPC system effectiveness.

Hypothesis 3c: Internal relationship is positively associated with the MPC system effectiveness.

Hypothesis 4a: Inventory performance has been continuously improved over time for high performing manufacturing organizations.

Hypothesis 4b: In the context of inventory performance, high performing manufacturing organizations out-perform low performing organizations.

Hypothesis 4c: The inventory performance for the lean supply chain is better than the agile supply chain.

Hypothesis 4d: For organizations adopting extended supply chain, the inventory performance is better than their previous undertaking that operated as either an agile or a lean supply chain.

Hypothesis 4e: For organizations employing (sub)contractors to execute a large proportion of manufacturing orders, the inventory performance would be better than the organizations undertaking most of the manufacturing themselves.

Hypothesis 4f: The inventory level is positively related to the level of environmental munificence, i.e. the inventory investment is high under high environmental munificence, or otherwise.

Hypothesis 4g: In the condition of low environmental munificence, organizations operating as lean supply chain will have better inventory performance than organizations operating as agile supply chain, or otherwise.

Hypothesis 4h: The inventory level is positively related to the level of environmental dynamism, i.e. the inventory investment is high under high environmental dynamism, or otherwise.

Hypothesis 4i: In the condition of high environmental dynamism, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.

Hypothesis 4j: The inventory level is positively related to the level of environmental complexity, i.e. the inventory investment is high under high environmental complexity, or otherwise.

Hypothesis 4k: In the condition of high environmental complexity, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.

Hypothesis 4l: Organizations adopting IT have their improvement rates in inventory performance faster than organizations not adopting IT.

Hypothesis 4m: In condition of high environmental dynamism or high complexity, organizations adopting IT have the faster rates of improvement in inventory performance than organizations not adopting IT.

Hypothesis 5a: The manufacturing and competitive strategies have a moderating effect between organizational environment, operational environment and MPC system.

Hypothesis 5b: The configurations in MPC systems are related to particular organizational and operational environment.

Glossary

A

Aggregate Production Planning (APP) It is used to determine an optimal production schedule that will meet the forecast demands in the specific planning horizon, usually ranged from six to eighteen months. An APP model, representing the entire MPC system quantitatively, is usually solved by a wide variety of operational research (OR) techniques. The objective is to minimize the cost of production and variables of organizational resources for a specified planning horizon. Varying work-force size and utilization, inventory buildup/backlogging, and subcontracting are well-known alternatives in APP.

Agile Supply Chain The agile manufacturing has been coined by Nagel and Dove[345]. Agility is the core competence of a company to market successfully high quality products at low cost with short lead times and in varying order quantities. Therefore, the aim of an agile supply chain is to supply innovative products with the prime focus on speed, flexibility and quality in a value stream. It particularly emphasizes on its market knowledge and a virtual organizational structure to exploit profitable new niches in a volatile market place.

Application Service Provider (ASP) It is an online outsourcing or hosting service for software applications, typically for large companies with hundreds of users or more. It allows its customers to hire the use of e-business applications over secure Internet connections. Many experts expect the use of ASPs to grow very quickly in the coming years. In Hong Kong, MPC software applications are available for small manufacturing companies to pay for the applications on the basis of their usage rather than purchasing a software license.

Assemble-to-Order (ATO) Strategy The production strategy a company adopts in order to manufacture a number of basic models with a wide variety of options and variants. The number of possible configurations will be extremely large. Such strategy is therefore based on forecasts for models, options, and variants with final assembly taking place only after customer orders have been received (see also Positioning Strategy).

Autopoiesis It was originally a biological model of a living system and has inspired some social researchers to inquiring about possible implications and applications. It refers to the notion that self-production can take place when there are distinct and autonomous individuals (or agents) interacting and communicating in a specific environment according to specific behavioral rules of conduct. Morgan created an interpretation of autopoiesis in the field of social sciences which led him to intriguing new insights on self-referential closure, ego-centrism and self-reflective evolution of organizations[58]. Autopoietic organization can be defined as a network of interactions and processes, involving at least: production (poiesis), bonding (linkage), and degradation (replenishment). The autopoiesis model seems to offer new insights into the self-production of organizations and it opens a fundamentally different perspective on the relationship between organization and environment.

B

Best Practices Strategy The strategy of a company to identify business practices, processes, or applications that are perceived as the best-in-class. They apply practices, processes, or applications until they think they have successfully improved their companies on a particular process.

Bill of material (BOM) It is a listing of all subassemblies, parts, and raw materials that go into a parent assembly showing the quantity of each required to make the assembly.

Capacity requirements planning (CRP) It is the medium- to short-range planning function to determine what capacity resources are needed to produce the requirements generated by the MRP system. Detailed available capacity of a plant must be determined and compared to the required capacity. Both open (released) shop orders as well as planned orders are considered in the determination of the required capacity (the work load). CRP takes material requirements from the MRP system and then converts them into standard hours of labour and machine for each work center. Detailed schedules for all orders are calculated based on the routing files, lot sizes, and work center files. These schedules, released and anticipated, are required in order to place each work center's load in the proper time period.

Causal Model It is an analytic model or a conceptual model to identify the cause-and-effect relationships among variables where the problem has already been defined. In this study, the relationship between MPC system variables, organization strategy, and organization and operating environments are initially hypothesized. Causal models are then constructed and validated by statistical experiments. Figure G.1 is an example of a causal model that is used to link organization and operational environments, organizational Strategies, and MPC System. See also SEPATH.

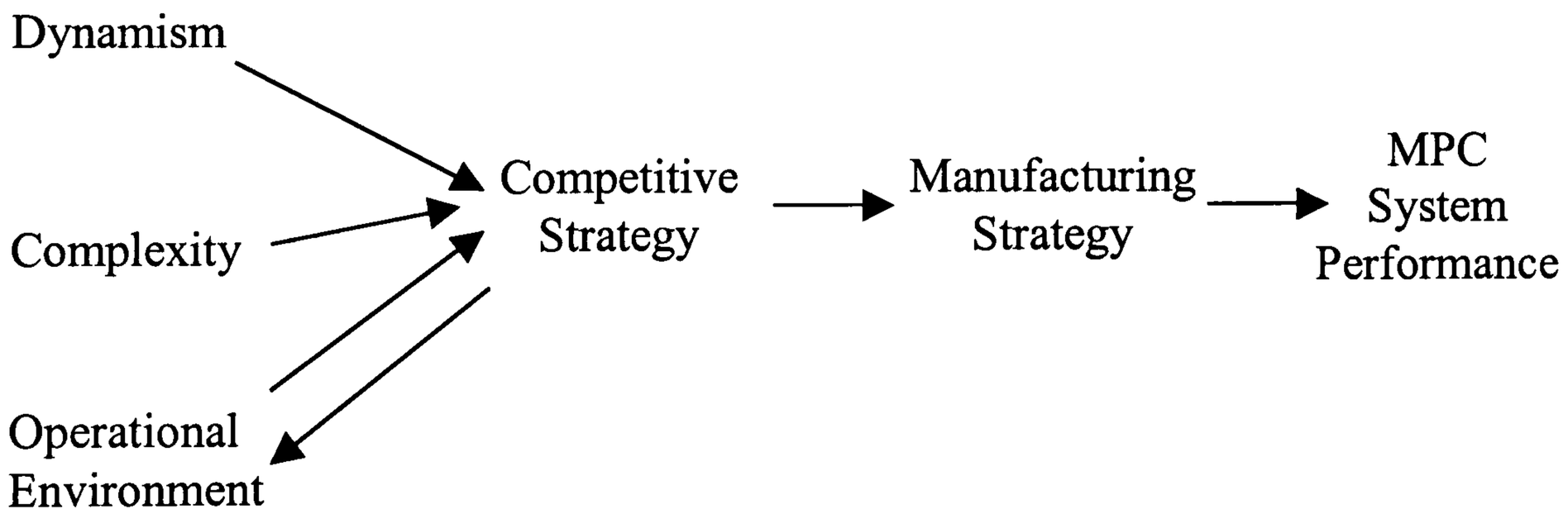


Figure G.1: An Example of a Causal Model for the Relationships between Organization and Operational Environments, Organizational Strategy, and MPC System

Classification It is the general process of grouping entities by similarity. It can be either one-dimensional or multidimensional. In a one-dimensional classification, the grouping is based on a single characteristic. For a multidimensional classification, the grouping is based on a number of dimensions that are generally assumed to be correlated or related (see also Typology and Taxonomy).

Closed-loop MRP It is a system built around material requirements planning (MRP) that includes production planning, master scheduling, capacity planning, and the means for executing the capacity plans, material plans, and vendor schedules. The term "closed loop" implies that there is feedback provided by the execution functions so as to maintain a valid plan.

Competitive Strategy The specific actions deployed by a company to align its plans and resources with both external and internal environments in an attempt to gain a competitive advantage. Since Skinner's[51] early writings, a common thread in operations strategy research[e.g. 2, 47, 202, 203] has identified the needs of manufacturing companies for choosing among and achieving a number of key "competitive priorities". Although semantic differences exist, it is widely agreed that competitive priorities can be expressed in terms of at least four basic components: cost, quality, delivery time (responsiveness), and flexibility[214]. For this study, these four broad competitive strategies are used.

Configuration of the Organization The classification of organizations is derived from multivariate analysis of empirical data on multiple dimensions or variables referring to organization structures, systems, strategies, processes, and environments. As noted by Miller and Friesen[282, p.32]: "Attempts are then made to identify natural clusters in the data, and these clusters, rather than any a priori conceptions, serve as the basis for the configurations".

Constant Work in Process (CONWIP) It is a hybrid push-pull approach introduced by Spearman et al.[130]. Similar to Kanban, it relies on an information signal either in the form of cards, electronic, or containers. For example, in a manual CONWIP system, the card is attached to a container at the beginning of the line and travels with it until the end of the line. At the point, the card is removed from the container and returned to a card queue at the beginning of the line. Eventually, the card will leave the queue (also called a backlog list) and be attached to another container of parts in order to transverse the production line again. The CONWIP with the backlog list carries out the push function. However, it has a built-in feedback system and therefore performs like a pull system in this regard (see Figure 2.8, Chapter 2).

D

Drum-Buffer-Rope (DBR) It is one of the MPC techniques to implement the exploiting, subordinating, and evaluating steps of TOC in order to pace the materials flow to the capacity constraint.. The "drum" acts as a control point that strikes the beat to drive the system when the bottleneck is identified. A "buffer" is placed on the line in order to protect the bottleneck from fluctuations and variations in the feeding rate of the bottleneck (i.e. exploit the bottleneck). A "rope" is a feedback loop that communicates the bottleneck production back to the raw material dispatching point. The dispatching point will release only the pre-determined amount of materials and thus will keep the buffer inventory built up (see Figure 2.6, Chapter 2). See also TOC and OPT.

E

e-Business Companies conduct their business transactions over the Internet.

Economic Order Quantity (EOQ) It is based on the formula that balances setup or ordering costs with the cost of carrying inventory. The validity of the EOQ is based on the assumption that the requirements are uniform and continuous. The formula is:

$$EOQ = \sqrt{\frac{2 \times annual\ demand \times setup\ cost}{carrying\ cost(percent) \times \text{unit cost}}}$$

Efficient Supply Chain The term is proposed by Fisher[230]. It is similar to a lean supply chain. For definition, see lean supply chain.

Electronic Data Interchange (EDI) It is the data communications standard used for traditional, private-network that links between companies and their suppliers. EDI is defined as "the paperless (electronic) exchange of trading documents, such as purchase orders, shipment authorizations, advanced shipment notices, and invoices, using standardized document formats."[347]

Engineer-to-Order (ETO) Strategy The customer provides the company with specifications in terms of product performance that requires unique engineering design or significant customization. The company designs the product, produces the material, fabricates the parts, assembles and tests the product, and makes delivery. Bills of material, part numbers, drawings, routings and manufacturing instructions must be prepared for each customer order (see also Positioning Strategy).

Enterprise Resources Planning (ERP) It is the use of complex applications employed by large companies to manage inventory and integrate all the different processes of a business across multiple divisions (intra-enterprise systems) and organizational boundaries (inter-enterprise supply chain). It focuses on global planning, business processes, and execution across the whole supply chain network. Used typically on an intranet, it allows different parts of large organizations to speak common language and share information more readily. Read[96] lists three key elements of ERP that assist the management of manufacturing processes: client/server architecture, real-time planning and work flow. ERP therefore is directly related to the sophisticated information infrastructure.

Environmental Complexity It is measured as the degree of heterogeneity and the dispersion of a company's activities[244,252]. For example, when companies become larger and involve a greater number of interactions, both internal and external, the underlying management processes will be more complicated and the difficulties increase. As such, the larger the interaction a company handles, the higher is the environmental complexity[255,256].

Environmental Dynamism It is measured as the rate of change in the organization environment due to market instability and environmental turbulence[244]. For example, companies that are experiencing high dynamism will face more environmental changes such as fluctuating demands, random production volume, varying material prices, disruptions in supplies, changing engineering requirement, and frequent introduction of new products, etc.

Environmental Munificence It is measured as the extent to which the availability of environmental resources supports sustained organizational growth (e.g. Starbuck [252]). Aldrich[244] asserts that a firm seeks the environment that has abundance of resources, i.e. high munificence, to permit organizational growth and stability. For example, in the conditions of high environmental munificence, companies have more means and higher flexibility to achieve their goals.

H

Hierarchical Production Planning (HPP) The pioneer of the hierarchical production planning (HPP) framework has been defined by Hax and Meal[89]. It is a hierarchically integrated system that enables a company to make decisions with better resources planning and control. The plan consists of an ordered set of decisions that sequentially assess the operational areas, including size, location, and facility that produces the products. The prime objective is to meet a pre-specified customer service level at minimum overall costs. Besides, it attempts to coordinate the overall decision-making

process of the manufacturing system (see Figure 2.1, Chapter 2). HPP usually incorporates the multi-echelon structures and hierarchical planning procedures, based on a product family structure. The basic algorithmic framework is necessary to construct in order that it can transform the plans into operational procedures.

Hybrid MPC System This is a combination of two or more MPC systems. For example, De Toni et al.[161], and Flapper et al.[157] discussed how JIT-Kanban was embedded into MRP. Foo et al.[160], Pun et al.[170], and Betz[181] described the successful real-life cases in adopting the hybrid JIT/MRP systems in a variety of manufacturing situations.

I

Internet It is the worldwide collection of computers, networks and communications links.

Inventory Turnover It is a measurement of inventory performance by a turnover ratio. For this study, the computation of the ratio is set as below:

$$\text{Inventory Turnover} = \frac{\text{Annual Sales of Goods}}{\text{Year - end Aggregate Inventory}}$$

J

Just-in-time (JIT) It is a philosophy for guiding manufacturing management with the goal of achieving maximum customer service while improving both quality and productivity. Emphasis is based on continuous improvement through the elimination of non-value-added activities.

K

Kanban It is a Just-in-time (JIT) pull system in which work centers signal with a card (kanban) to withdraw parts from feeding operations. A second card may be used to authorize production (see Figures 2.4 and 2.5, Chapter 2).

L

Leagile Supply Chain The term is coined by Mason-Jones et al.[231]. It combines the lean and agile paradigms for effective and efficient manufacturing in a value stream. On the upstream side of decoupling point, lean manufacturing is adopted in order to achieve cost-effectiveness. On the downstream side, agile manufacturing is applied in order to achieve a high service level for the end-users.

Lean Supply Chain The lean concept was promoted by the International Motor Vehicle Program's (IMVP) study of the world auto industry[222]. It is based on the thinking that Japanese auto manufacturers have developed a new package of production methods that is more efficient than mass Fordism. As a result, lean production became the model for 1990s. A lean supply chain adopts the lean concept that emphasizes on the elimination of all wastes in order to develop a value stream in a supply chain.

M

Make-to-Order (MTO) Strategy It is a strategy in which a product is finished after receipt of a customer order. The final product is usually a combination of standard components and other items that are custom designed to meet the specific needs of the customers (see also Positioning Strategy).

Make-to-Stock (MTS) Strategy It is a strategy in which a product is shipped from finished goods "off the shelf" which has already been manufactured and finished prior to

the receipt of the customer order. The MPS and the final assembly scheduling are carried out at the finished goods level. Besides, the stock level is based on forecasted demand (see also Positioning Strategy).

Manufacturing Execution System (MES) It is a software management system where coordination and integration between various production activity applications are established. It is used to link manufacturing planning system and the shop floor control system. MES initiates, guides, responds to, and reports on production activities on-line and in real time to production management for greater efficiency.

Manufacturing Planning and Control (MPC) System According to Vollmann, Berry and Whybark[63, p.2], MPC system provides information to manage the flow of materials efficiently, utilize labour and machines effectively, coordinate internal activities with those of suppliers, and communicate with customers about market requirements (see Figure 2.2, Chapter 2).

Manufacturing Resource Planning (MRPII) Developed by Wight[6], it is an outgrowth and extension of closed-loop MRP for effective planning and control of all resources of the manufacturing organization. It is considered as the total management system for hierarchically structured organization in order to integrate and coordinate manufacturing with marketing, engineering, finance, and related functions.

Manufacturing Strategy It is the management principle that determines how a product is manufactured, how the resources are deployed, and how the manufacturing infrastructure should be organized to support an organization[2,203]. It creates and adds value by assisting the manufacturing company to establish and sustain the competitive advantages. Manufacturing strategy reflects the business goal and competitive strategies that enable the manufacturing system can be used as a strong source of competitiveness and to contribute to higher organization performance[e.g. 48, 210, 217]. However, a number of researchers have mixed up the definition of manufacturing strategy with competitive

strategy[e.g. 46, 214, 224]. For this study, the four broad competitive strategies will not be used for the measurement of manufacturing strategy in order to avoid duplication. Krajewski and Ritzman's[201] manufacturing (positioning) strategy will be used.

Master Production Schedule (MPS) It is an anticipated build schedule that specifies starting time and finishing time of each job. It must support long-term strategic and production plans and drives material requirements planning (MRP). MPS may be expressed in timing and quantities of end times, components, pseudonumbers, or planning bills of material.

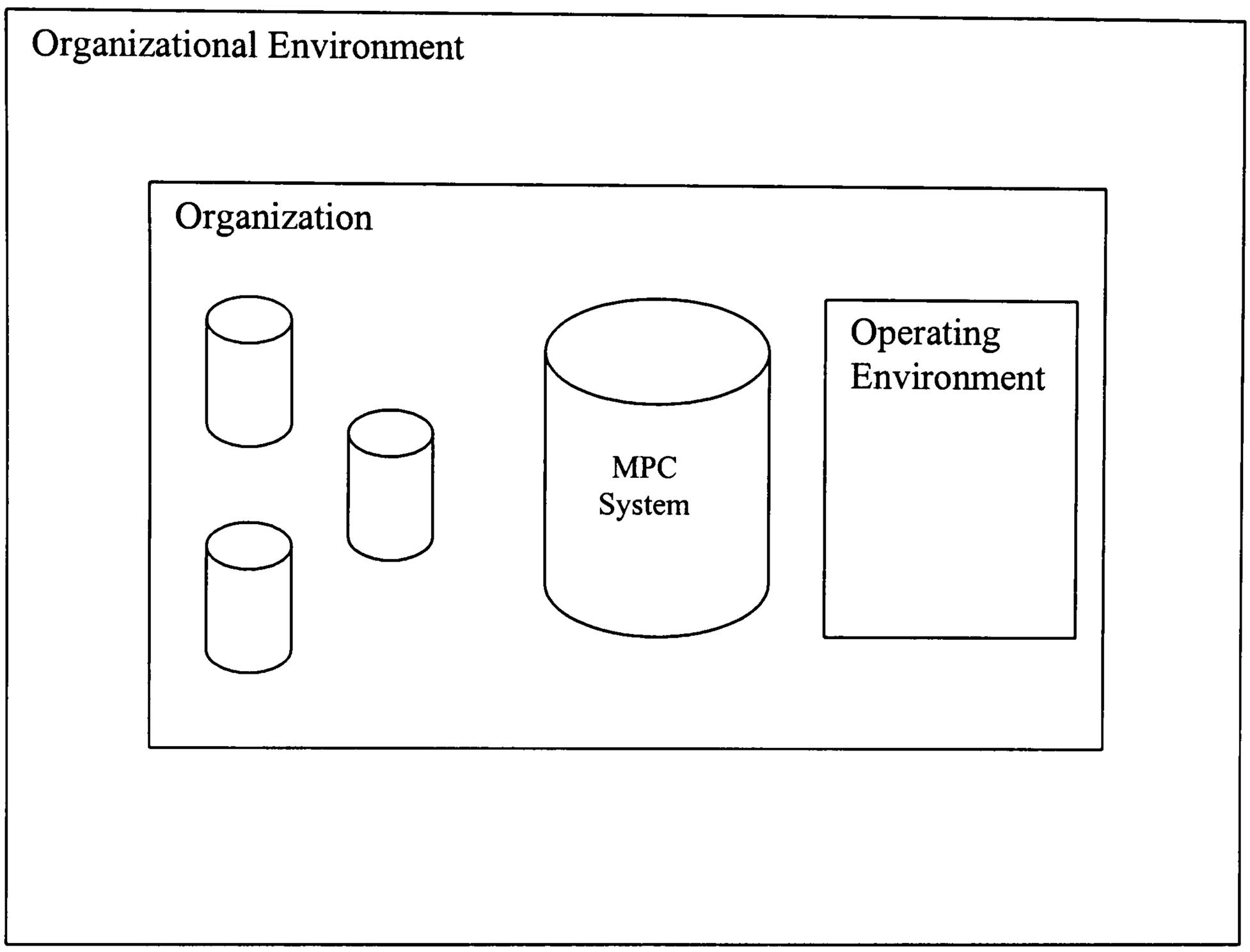
Material Requirements Planning (MRP) Orlicky[4] published the classic book *Materials Requirements Planning: The New Way of Life in Production and Inventory Management* in 1975 that provided the computational logic for dependent-demand materials planning. It is a set of techniques that uses bill of material (BOM), inventory data, and the master production schedule (MPS) to calculate material requirements. It makes recommendation based on time-phased net requirements of components.

O

Operating Environment The internal environment that integrates all the manufacturing operations in a manufacturing system such as industrial engineering, product design and development, quality control, shop floor control etc. It will provide the company with solutions to reconcile the operational variables in achieving the organizational objectives (see Figure G.2). For this study, it is measured by the extent of computerization, internal and external relationships.

Optimized Production Technology (OPT) OPT, a commercial name and a proprietary algorithm of Creative Output, is developed by Eliyahu Goldratt during the late 1970s in order to maximize limited resources[7]. It is a scheduling philosophy centering on the

management of bottlenecks through finite loading procedures and it addresses the variability in an operational facility. See also Drum-Buffer-Rope and TOC.



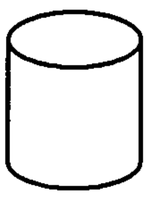
Legend:  represents sub-systems within organization. (Note: Not drawn to scale.)

Figure G.2: Diagrammatic Representation of Organization Environments, Operating Environment and MPC System

Organizational Environment It is the external environment (see Figure G.2) outside the organization boundary that includes government, consumer groups, suppliers, competitors, legal system, technologies etc. In this study, the objective assessment of organization environment is based on Dess and Beard's[239] generalised characteristics of task environmental conditions, i.e. munificence, complexity and dynamism.

Path Analysis It is the modeling technique that defines the structural relationships of a system among a set of observed variables. The analysis depends on the knowledge of causal relationships and the degrees of correlation among variables, i.e. path coefficients, in the manufacturing system. The diagrammatic representation (known as path diagram) can be used to show the logic, direct and indirect effects of the structural relationships of a system. Several properties of a path diagram are illustrated in Figure G.3 below.

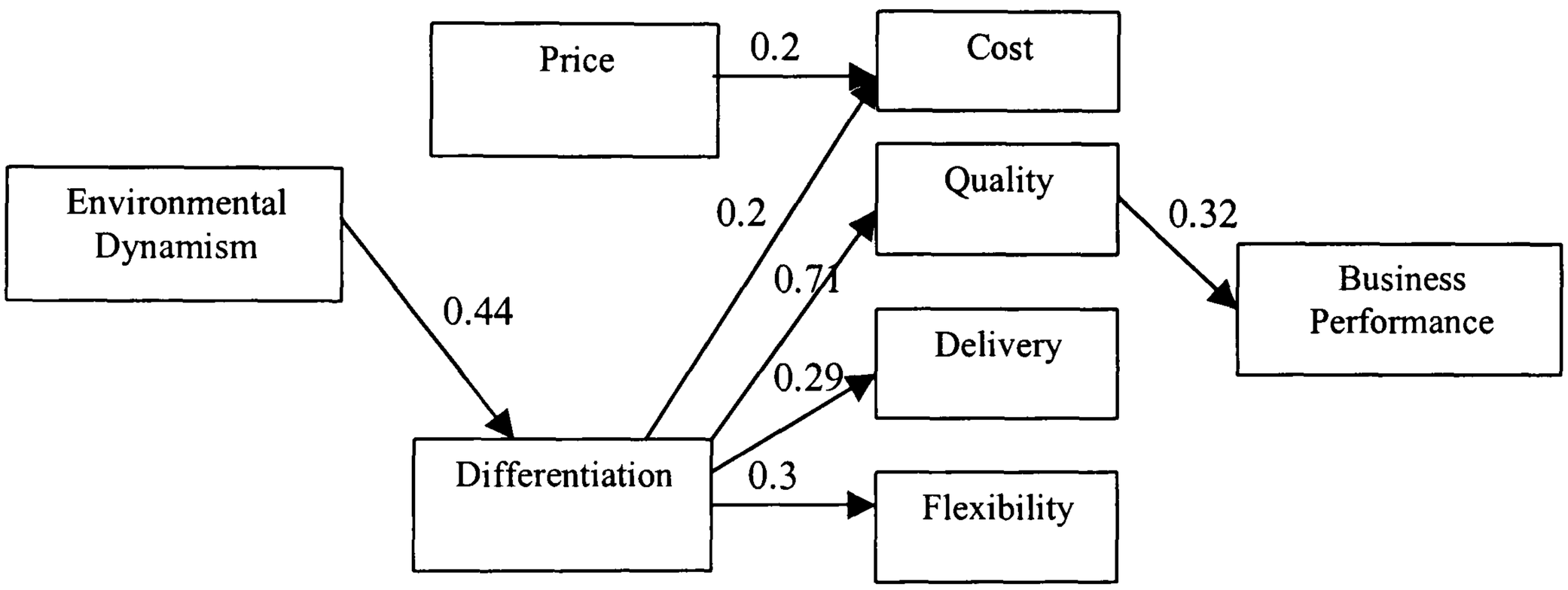


Figure G.3: An Example of Path Diagram with Estimated Path Coefficients That Linked between a Set of Observed Variables (Source: Ward and Duray[54,p.131])

Perceived Environment The organizational and operational environments (internal and external) are considered to be created through a process of attention and interpretations[265] by managers. It is the degree to which the managers use their own perceptual filters in determining the organizational and operational environments. The assessment of the extent to which managers' perceptions of the strategic and environmental factors can help understanding both the internal and external environments they face[247, 49]. Conventional researches suggested that decision makers in organizations designed a set of strategies and the organization systems in response to perceived environment and internal organizational constraints (see Figure G.4).

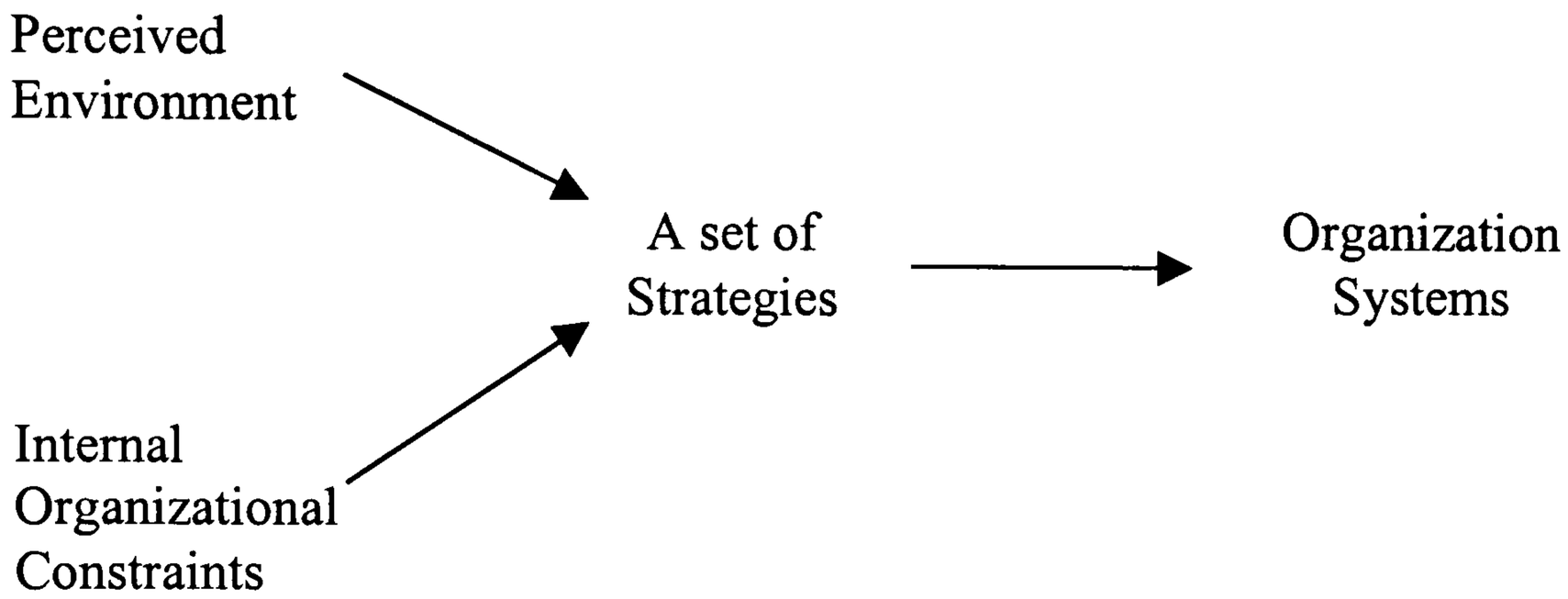


Figure G.4: The Environment-Strategy-Structure Network

Performance Measurement The performance measurement function is an integral part of MPC system. It is the tracking of actual results of selected activities and comparing them to organization goals. The process reflects the MPC policies and describes how well the work is done in terms of cost, time, and quality. Through this function, MPC managers ensure that resources are obtained and used efficiently and effectively in accomplishing the goals. To be effective, performance measures need to reflect the changes in competitive organization environment and it must balance between different views, i.e. a mix of financial and non-financial data. Frequent assessments will enable a company to reinforce new behavior and accomplishments with the new business objectives. For this study, three types of measures are used: financial, growth and inventory.

Positioning Strategy It refers to the stages of engineering design, procurement, fabrication, assembly and delivery that a company will position its operations. It relates to the competitive manufacturing lead time, that is the length of time a customer must wait between placing an order and receiving shipment (see Figure G.5). Such strategy will also affect the operations position that a company places.

Pull System In a Just-in-time material control, the withdrawal of inventory from an outbound stock point or supplier as demanded by signal from the using operations. This

signal is frequently a kanban (card) that authorizes a supplying workstation to provide the parts in need (see also Kanban).

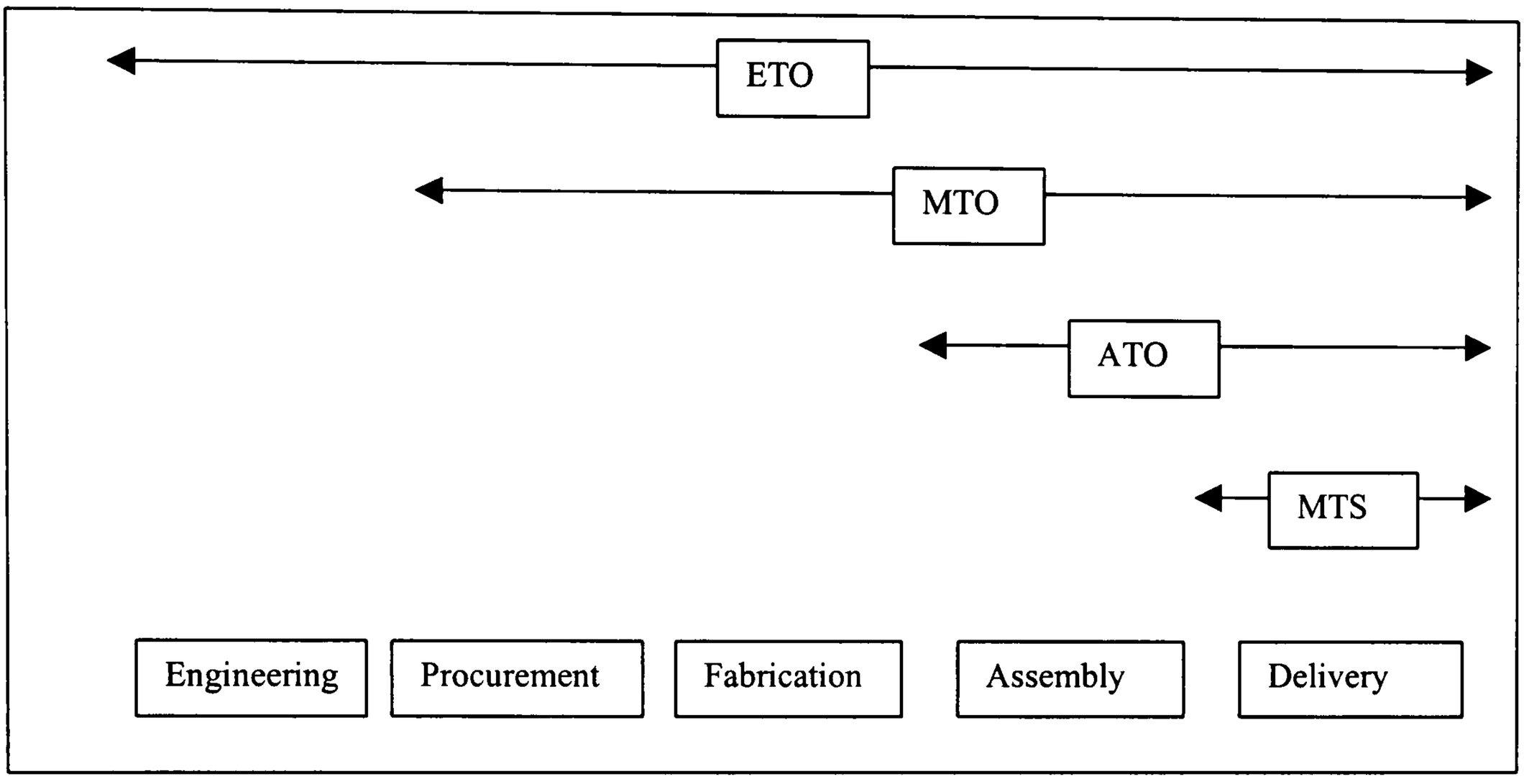


Figure G.5: Positioning Strategy

Push System In material control, the production of items or the issuing of material based on schedules planned in advance.

R

Reference Architecture It is a type of architectures for manufacturing companies and it contains the conceptual models and a body of rules that define those system features directly affect the organization and operating environments. The architecture must be applicable to many types of manufacturing system.

Reorder Point (ROP) A predetermined inventory level where if the sum of the stock on hand and on order drops below the indicative point, management will take action to replenish the stock.

Responsive Supply Chain The term is proposed by Fisher[230]. It is similar to an agile supply chain. For definition, see agile supply chain.

S

SEPATH It is a short form of Structural Equation Modeling and Path Analysis. SEAPTH is one of the modules of Statistica software program for analyzing structural equation models, causal models, and any other models that can be conceptualized as special cases of path analysis (see also Structural Equation Model, Causal model, and Path Analysis).

Shop-floor Control (SFC) It is a system using shop floor data schedule, update status, and monitor material movement through the shop. Its main functions are: releasing orders, collecting shop floor data, monitoring and controlling lead times, establishing order priorities, planning capacity at work center level, controlling work queues, and controlling work-in-process.

Statistical Inventory Control It is a technique that applies statistical analysis to identify an order point for any single inventory item that is different from the desired inventory level.

Structural Equation Modeling It is one of the statistical methodologies that seeks to represent hypotheses about the means, variances, and covariances of observed data in terms of a smaller number of "structural" parameters defined by a hypothesized system of equations. For example, the equation model can be represented by:

$$y = By + \Gamma x + \zeta$$

Where y is a vector of endogenous variables but whose behaviour is not explained;

x is a vector of exogenous variables that are used to explain y;

ζ is a vector of disturbance terms;

B and Γ are coefficient matrices.

Supply chain It refers to an integrated and sequentially interrelated value system of suppliers, manufacturers, subcontractors, distributors and retailers, working together with an aim to create value to the output for the ultimate end-users. According to Porter[206], each supply chain has a collection of some nine generic and discrete activities that can be divided into two broad groups: primary processes and support processes. The primary processes consist of five areas: inbound logistics, production or operations, outbound logistics, marketing and sales, and service. The support processes consist of four areas: procurement, technology development, human resource management and the organization's infrastructure (see Figure G.6).

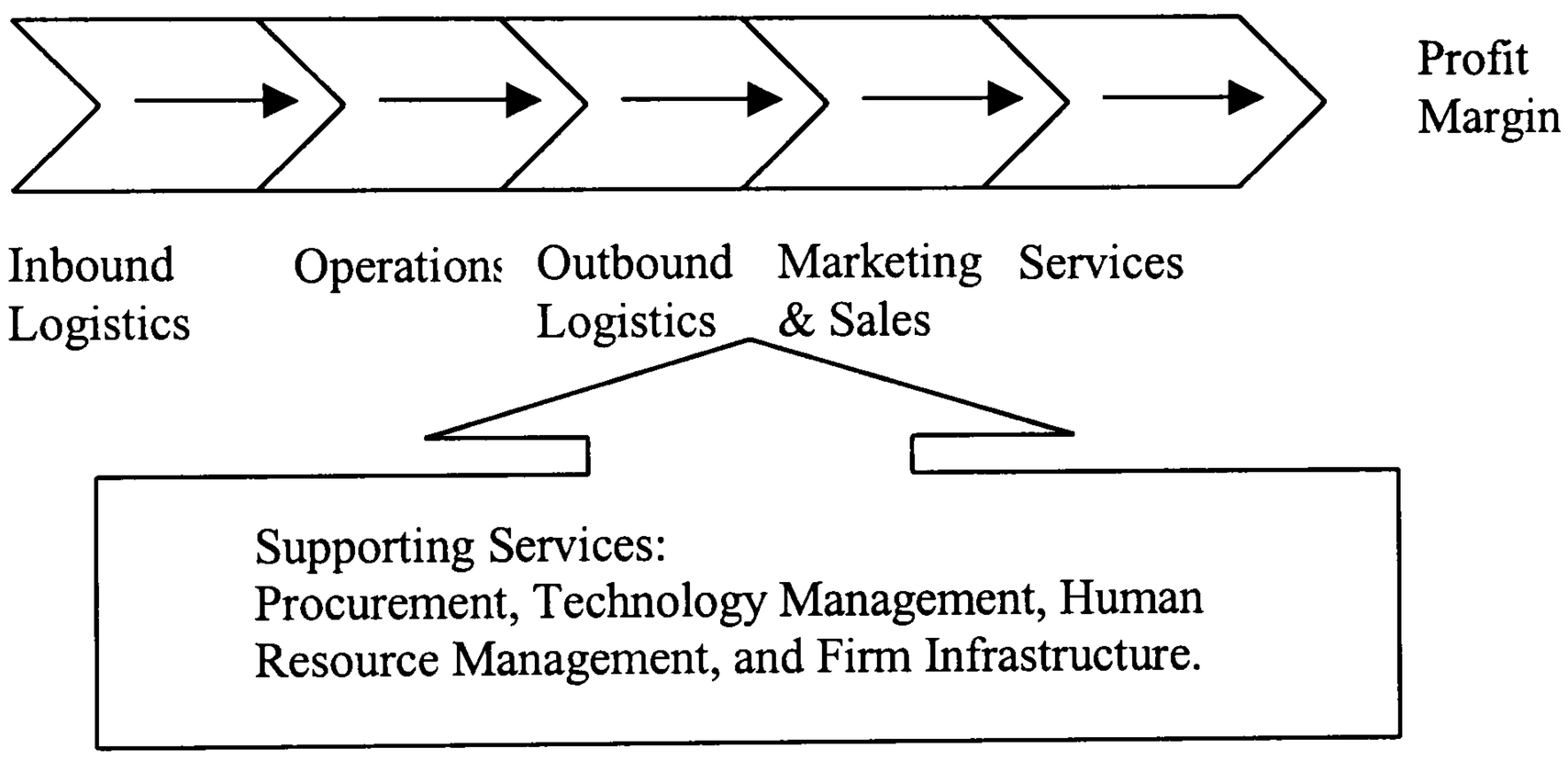


Figure G.6: A Supply Chain (Source: Porter[206])

T

Taxonomy It is another term for a classification and is a theoretical study of identification. Some researchers use the typology and taxonomy interchangeably. Bailey[346] indicates the difference of the two terms. A typology is conceptual and taxonomy is empirical. For example, based on a hierarchical cluster technique, Barber and Hollier[275] defined a six-fold taxonomy production control complexity. See also Classification and Typology.

Theory of Constraint (TOC) It is a management philosophy to identify core problems of a manufacturing company and is a method to deal with the problems (constraints) i.e. internal resource constraint, market constraint, and policy constraint. A constraint is defined as anything that limits the performance of the manufacturing system relative to its goals (see also Drum-Buffer-Rope and OPT).

Time-phased Order Point (TPOP) It is a technique to control distribution or independent demand inventories using MRP logic. Time periods are used and therefore allow for lumpy demand.

Typology It is another term for a classification. As distinguished from a generic classification, a typology is generally multidimensional and conceptual. A conceptual classification represents type concepts rather than empirical cases. Typologies generally are characterized by labels or names[346]. For example, Miles & Snow strategic archetypes are conceptual typologies that could be summarised into four different strategic types, i.e. defender, prospector, analyser, and reactor (refer to Section 3.6.1, Chapter 3). See also Classification and Taxonomy.

W

Work-in-process (WIP) These are the products in various stages of production (or semi-finished goods) throughout the shop floor from released raw materials through finished good at final inspection.

Chapter 1 Introduction

This chapter introduces the area of research that lays down the foundations for this thesis. The research issues such as background to the research, statement of problem, research objectives and the methodology are presented. Then the research is justified. The limitations and delimitations are defined. Finally, an outline of the following chapters is described. On these foundations, the thesis can proceed with a detailed description of the research.

1.1 Background to the Research

A comprehensive and efficient manufacturing planning & control (MPC) system has historically, and increasingly, played a particularly significant role in the field of operations management. It is considered as one of the critical infrastructures for the development of a competitive manufacturing strategy[1,2,28]. Before the 1960s, most of the manufacturing organizations adopted the quantitative approaches for the planning and control of production, such as economic order quantity (EOQ), statistical inventory control (SIC), reorder point (ROP), aggregate production planning (APP) and hierarchical production planning (HPP) etc. Since then, various system approaches have been developed for manufacturing planning and control. For example, the conceptual integrated MPC model[3] was defined in the 1960s; Orlicky's materials requirements planning (MRP) system[4] and just-in-time (JIT) manufacturing[5] were designed in the 1970s; optimised production technology (OPT)[7] was invented in the late 1970s; manufacturing resources planning (MRPII)[6] and synchronized manufacturing (TOC/JIT)[10,11,135] were developed in the 1980s; enterprise resources planning (ERP) such as SAP/R3[8] and customer-oriented manufacturing management systems (COMMS) were proposed in the 1990s (see Figure 1.1).

The implementation of MPC systems differs widely from one company to another. Ingersoll-Rand Mocksville[27] drew much attention to organization system, communication process and employees in building an effective MRP system. Some companies like Hewlett-Packard[13] and Harley Davidson[9], stated that their JIT systems were based on

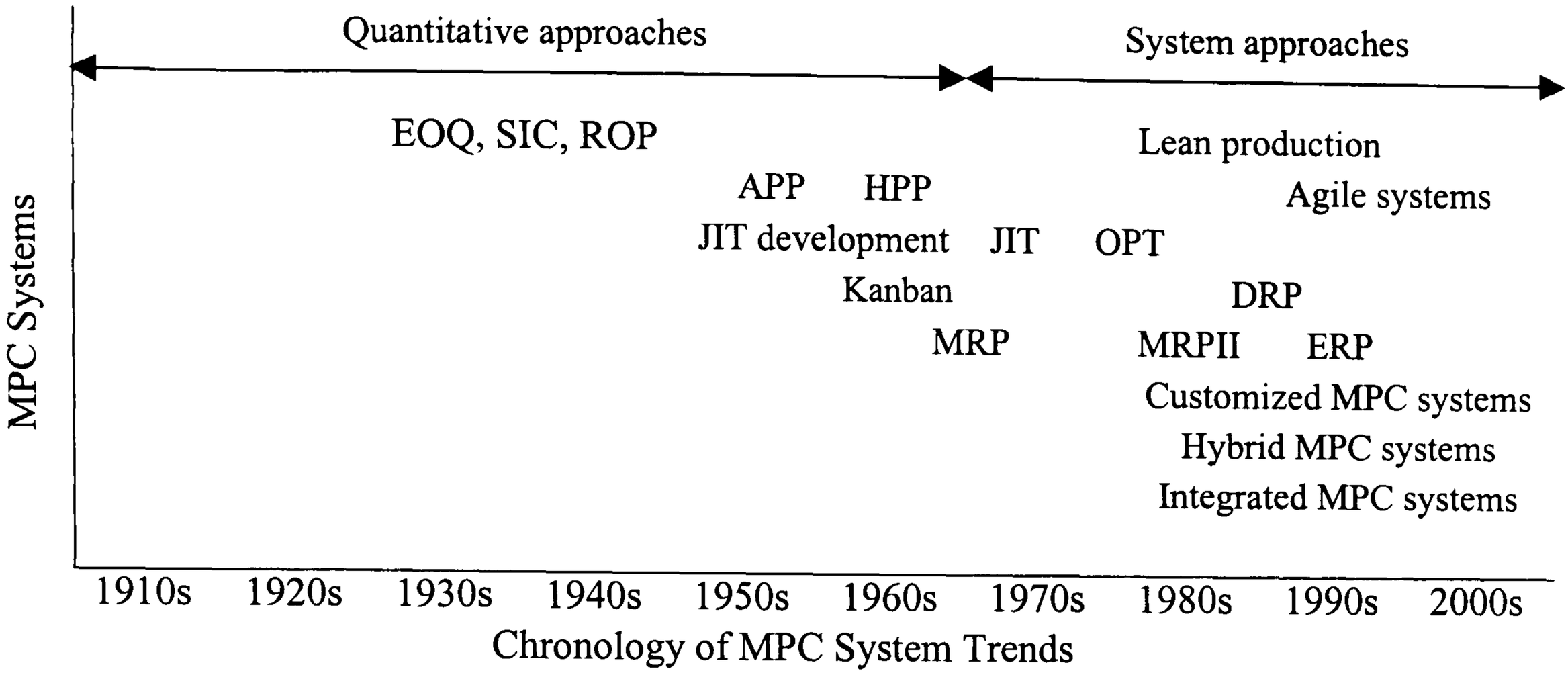


Figure 1.1: Evolution of PMC Systems

internal considerations, i.e. reduction in production line set-up and employee involvement etc. Companies such as General Motors[34], IBM and Ford[17] adopted an external approach by improving the supplier partnerships; whereas companies such as Toyota[5] and Xerox Mitcheldean[14] emphasized both external and internal considerations. Some companies, say, General Electric[10] and AT&T[11], operated with a hybrid TOC/JIT system for waste reduction, cultural changes and synchronized production flow.

In addition, MPC system will be subject to reconfiguration continuously over time in responding to the changing environmental demands. Two examples are cited: (a) Based on an EDI (electronic data interchange) JIT inventory control system, Compaq changed its build-to-forecast system to build-to-order manufacturing control system[12]. Their MPC effort extended beyond their system boundaries by coordinating inter-organizational management with suppliers in different geographical locations. (b) Black & Decker, a pioneer of MRP[15] with remarkable success[34], initiated its computerized MRP system in the early 1960s and slowly shifted the system toward JIT in the middle 1980s[26]. The company is now instituting its MPC system as one of the important vehicles in its supply chain management (SCM) strategy for the optimisation of information and product flows among the globalization of business and processes [16].

Although the past three decades saw the rapid developments of MPC systems, the system effectiveness has been controversial among researchers and practitioners. The MPC

developments have received significant negative criticism (say, Saad[20], Silver[21], Buffa[22,23]) with the following reasons:

- The MPC models do not accurately reflect the real-life situations since a number of operating variables that are relevant in the context of the manufacturing organization as a whole are neglected[18,19].
- One of the insidious problems associated with MPC development is that the researchers have concentrated predominantly on implementation and refining of MPC methodologies and models whilst ignoring the environmental influences.

As a matter of fact, the manufacturing system is no longer self-contained and closed. The organizational environment constantly demands that a highly flexible and responsive manufacturing system copes with the dynamic, complex and uncertain conditions. Therefore, some researchers (say, Duchessi et al.[24], Monniot et. al.[25]) indicated that there was a need for a structured approach to formulate and implement realistic MPC systems. Wacker and Hanson[28] suggested that an investigation of the empirical relationship between MPC system and organizational competitiveness was critical to the successful MPC implementation.

Several studies (e.g. Ritzman et al.[30]; Krajwesji et al.[31], Gelders & van Wassenhove[32]; Seward[33]; Aggarwal[34]; Plenert and Best[35]) compared various MPC approaches such as MRP, JIT/Kanban, OPT, HPP and ROP. They contended that there was no single MPC system that suited all kinds of organizational environments. All of them proposed that the success of a MPC system depended on selecting a proper technique.

As we are in the era of globalization and information revolution, manufacturing organizations become more international, more interconnected, more independent, more informative, more aware, and more collaborative in the globalization of business. Many organizations have undergone massive re-engineering efforts in order to cope effectively with the rapid changing environments. Newman and Sridharan[29] asserted that the relationship between MPC systems and their organizational environment must be addressed. Surprisingly, although extensive research in MPC techniques and systems have been done in the past thirty years, the study to explore the specific way in which environmental dimensions relate to the MPC systems and the performance

implication[35,36] is scarce. Unless the relationship between MPC system and organizational environment becomes more visible, the MPC development will continue to be limited in the future. The selection of a proper MPC system that suits a particular manufacturing environment is often difficult, uncertain and not treated with the appropriate attention[36]. There is therefore an urgent need to clear the uncertainties[34,37,38].

Traditionally, the choice of MPC is based on the standard MPC systems such as MRP, MRPII, JIT/Kanban, OPT and ERP. Many researchers[39,40,41,42,43] contested that these standard MPC systems were not the solutions for existing manufacturing problems. Biemans[39] and Bertrand et al.[40] proposed a tailor-made structural MPC system for a particular manufacturing environment. Shivnan et al.[41], Schonberger[42] and Van der Linden et al.[43] suggested that a "hybrid" MPC system was the solution for manufacturing organizations operating in a combination of manufacturing situations. The wrong choice of MPC system is generally dangerous[44]. For these reasons, the successful implementation of MPC systems requires a precise research study that inquires into all aspects of a manufacturing system, i.e. MPC system performance, competitive strategy, manufacturing strategy and organizational environment.

1.2 Statement of the Problem

The great advances of information technology (IT) and the growing tension of the global market have brought many changes in the way that the information and materials flow through the firms' value-added chains. It is apparent that the changing organizational environment is shaping the manufacturing system on a global scale. The rising stream of supply chain management (SCM) and logistics system, among the many inter-organizational studies, indicates the importance of managing the whole spectrum of business for competitive advantage or survival. Related to this phenomenon, the development of an MPC system that has the capability to accommodate the environmental changes becomes increasingly important. With manufacturing competitiveness as the imperative issue, the central focus of this research is the development of the configurations

in MPC systems that take into account the organization environmental influences. In this context, the research addresses the following:

Firstly, it is argued that what will separate the winners from losers is an effective process that would transfer the manufacturing strategies into an action plan. Such process assists the winning organizations to perform excellently in meeting with the external demands set by the competitive business world[45]. Amongst a number of systems of an organization, the MPC system is recognized as one of the pivotal elements in achieving business competitiveness. It is important to implement an effective MPC system that firmly supports the organization's manufacturing strategy.

The problem addressed in this research issue is:

> How is the MPC system related to manufacturing strategy with performance implication?

Hayes and Wheelwright[2] identified eight decision categories that comprised a manufacturing strategy: capacity, facilities, process technology, vertical integration, work force, quality, production and inventory control, and organization of the manufacturing function. Since the MPC system is responsible for the planning and control functions of the flows of products, materials and information, it is directly related to the manufacturing strategies in terms of capacity, production and inventory control, and organization of the manufacturing function. Therefore, it is expected that a proper MPC system supports the manufacturing strategy.

Secondly, manufacturing strategy is defined as "...a sequence of decisions that, over time, enables a business unit to achieve a desired manufacturing structure, infrastructure, and set of specific capabilities"[2,p.32]. It is considered as one of the functional strategies that creates a key link between competitive strategy and organizational success, measured by business performance[e.g.53,54]. Hill[46] advocated some manufacturing-oriented dimensions as order-winning criteria in the marketplace.

Vickery et al.[57] contended that when manufacturing strategy did not link with competitive strategy, poor business performance would result. Ward and Duray[54] further observed that overlooking either environment or competitive strategy may miscast the true relationships between environment, competitive strategy and manufacturing strategy. Therefore competitive strategy is also taken into consideration in this research.

The problem addressed in this research issue is:

How do MPC system, manufacturing strategy and competitive strategy to affect the organizational performance?

There are two expectations. First, manufacturing strategy is a mediator between competitive strategy and the MPC system since competitive strategy directly influences manufacturing strategy[e.g.47,48]. It is supposed that it has an indirect effect on the choice of MPC system. Second, some organization theorists[e.g.208] assert that the development of a competitive strategy is a business unit problem that considers with the entirety of all organization functions and requires an inter-functional approach to bring various sub-systems together. It implies that the competitive strategy has a direct effect on the MPC system.

Thirdly, organizational strategy research has often emphasized the importance of aligning strategy with the environment[e.g.55;56] in order to create competitive advantage in the marketplace. This forms a condition not only for the survival but also for the success of an organization. Organizational environment has been identified as the key force that directly influences the competitive strategy[e.g.49,50], manufacturing strategy[e.g.1,2] and MPC system[52]. Therefore, the fit among organizational environment, competitive strategy, manufacturing strategy and MPC system is critically important. There is a need to gain an insight into how the environmental pressures and changes affect the business performance and what types of MPC system will fit with the organizational environment.

The problem addressed in this research issue is:

How can relationships between MPC systems and organizational environments be defined?

Essentially it is argued that both organizational environment and MPC approach are heterogeneous in nature. There is no global MPC system that suits all kinds of manufacturing environments. There will be considerable performance differences for a supply chain operating under various environmental conditions. This leads to a key area for research: What are the configurations in MPC systems taking organizational environments into consideration? This forms a major tenet of the research that the choice of MPC system is directly related to a particular organizational environment.

Fourthly, the organizational performance is one of the ultimate aims for most, if not all, business organizations. Within the context of MPC-environment fit, it is essential to test the linkages among organizational environment, business strategy, manufacturing strategy, MPC system and organizational performance. The result will provide an insight about the effects of organizational environment on the choice of MPC system.

The problem addressed in this research issue is:

> How can relationships of organizational environment, competitive strategy, manufacturing strategy and MPC system be aligned in order to achieve high organizational performance?

Further to the fourth research issue mentioned above, it is predicted that high performing organizations will select the most appropriate MPC system that suits a particular environment that the organization faces. In this regard, path models are used to test the relationships. Configurations in MPC system could then be developed.

Figure 1.2 shows a representative view of the MPC system in a context that addresses the above four issues. Competitive strategy and manufacturing strategy are cast in a mediating relationship between organizational environment and MPC system. This model suggests that:

- MPC system is indirectly linked with organizational environment.
- The relationship of environment, business strategy, manufacturing strategy and MPC system is linked to organizational performance.

A sound methodology for testing the relationship between organizational environment and MPC system is needed as a fundamental prerequisite to formalize the configurations in MPC systems.

1.3 The Objectives of the Study

As mentioned in Section 1.1, there is little work done on the relationship between organizational environment and the MPC system. As such, this thesis attempts to formalize the configurations in system characteristics and the relationships between MPC systems and their environments, which govern the operational behaviour of the MPC systems.

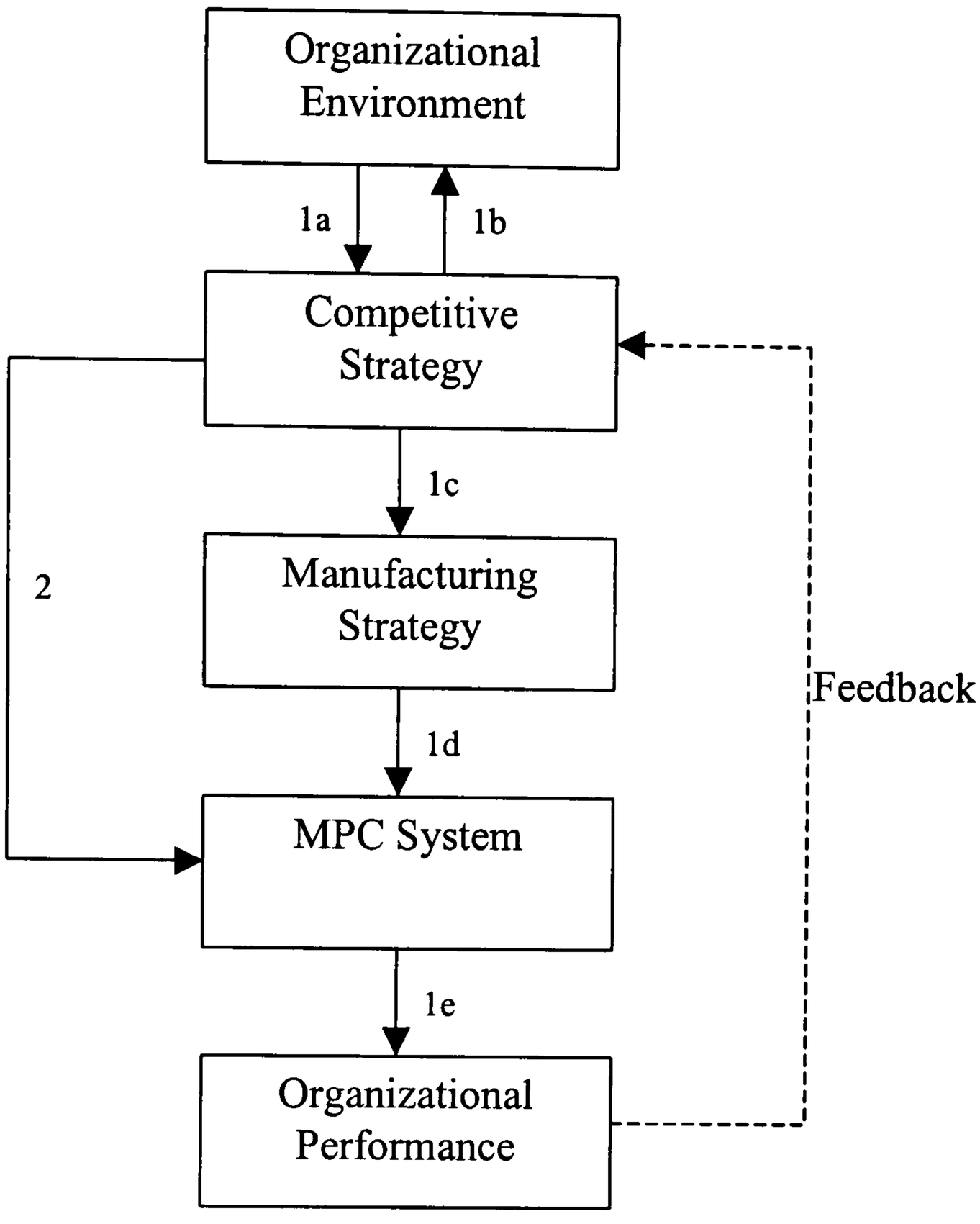


Figure 1.2: A Conceptual Model of MPC System and Its Context

The objectives of this research are as follows:

1. The development of the scores and categories of environmental constructs for the 116 samples of twenty manufacturing industries under study. This provides a useful platform for the investigation of the MPC system behaviour related organization environments.
2. The development of a reference model for MPC system for unlocking the confusion in selecting the appropriate MPC systems, which assures the consistency among the manufacturing strategy, competitive strategy and organizational environment.
3. The development of the configurations in MPC systems, based upon the proposed reference model (objective 2, above). The result will act as a basis for easy data retrieval about MPC systems, and, meanwhile, it will increase the generalizability and predictability in the future development of MPC systems.

4. The validation of the configurations and the reference model for MPC systems via questionnaire survey and quantitative techniques such as factor analysis, path model analysis, trade statistics and consensus.

Research objective 1 (environmental constructs):

The environmental constructs should reflect the following characteristics:

i. The attributes of the organizational environment.
ii. Selected measures of various attributes of the organizational environment, which leads to building a useful platform for the following research objectives 3 and 4.
iii. The validation of the environmental constructs.

Research objective 2 (reference model of MPC system):

The reference model of MPC system should reflect the following characteristics:

i. The components of the reference model, which is derived from the literature study and will be subjected to an intensive "face-validity" check by explaining it in detail to the MPC practitioners for the test of the logic and reasonableness. This model will be continuously modified as appropriate subsequent to a number of "face-validity" checks.
ii. The reference model should provide a generic representation of the MPC system which can be applied in a defined range of environmental conditions.
iii. It should be in consistent with the manufacturing strategy, competitive strategy, operational environment, and organizational environment.

Research objective 3 (configurations in MPC systems):

The configurations in MPC systems should reflect the following characteristics:

i. The components of various MPC systems, which are consistent with the manufacturing strategy, competitive strategy and organizational environment.
ii. The research instrument, i.e. the survey questionnaire for the study of the configurations in MPC systems must be based not only on the literature review, but also on the proposed MPC reference model (research objective 2, above).

iii. The components of various MPC systems should be in consistent with the manufacturing strategy, competitive strategy, operational environment, and organizational environment.

iv. The configurations of MPC systems are derived from path model analysis of empirical data based on dimensions referring to Miles & Snow strategic archetypes and supply chain strategies.

v. Selected measures of performance are to be incorporated into the configurations. It provides information to aid the evaluation of the appropriateness of MPC system in a particular organizational environment with competitive strategy and manufacturing strategy as mediators.

Research objective 4 (validation):

The validity of the reference model and configurations in MPC systems should be verified by an extensive amount of data and information collected through questionnaire survey and quantitative techniques, i.e. Pearson correlation, regression, and path model analysis.

1.4 Research Method

There are three phases of this research:

The first phase of the research is to carry out a comprehensive literature survey to review the following:

- Various MPC practices and the MPC variables;
- The manufacturing strategy and competitive strategy;
- The attributes of the manufacturing environment;
- Research being carried out which has a similar nature;
- The conceptual MPC framework;
- The organizational configurations for the MPC systems.

The second phase of the research is to carry out a mail survey and field-based interviews within the region of Hong Kong and South China. This research is set to study in both Hong Kong and South China regions since a number of Hong Kong manufacturing companies in recent years have distributed, diversified or moved their plants to the South

China region. The cross-border manufacturing is largely influenced or controlled by the Hong Kong head office, acting as the manufacturing control centre. In this phase, the conceptual MPC framework is tested by a field study. The questionnaire, as measurement instrument for the research, is designed and is improved by field-based interviews. Then the questionnaire survey is conducted during two executive development programmes in which the participants are senior managers working in Hong Kong manufacturing companies. In addition, statistical data and data from a sample of 116 public firms in Hong Kong was also used.

The third phase is to generalise and to summarize the data collected. A comparative study of MPC practices between highly effective and less effective MPC systems is done. Configurations and reference architecture of MPC systems are derived.

1.5 Justification for the Research

It is expected that the findings of the study have significant theoretical and practical implications. These are listed as follows:

i. The quest for a viable supply chain that has the capability to accommodate the environmental changes has gained currency in recent years. An effective MPC system, as part of the supply chain, is not just only optimized in terms of the usage of resources but also supports manufacturing strategy for competitiveness. The research on the MPC discipline continues to be of strategic importance since it will enhance manufacturing excellence and competitiveness.
ii. Unfortunately, the literature on the MPC discipline often has not treated Environment-MPS fit with appropriate attention. Therefore, this research intends to fill the gap by exploring the importance of environment-strategy-MPC system fit within the domain of Hong Kong manufacturing. The research has implications for the wider body of knowledge since it takes into account the relationships among organizational environment, competitive strategy, manufacturing strategy and MPC system.
iii. Previous researchers have also neglected the consideration of environmental constructs in a macro perspective. It is expected that by contemplating measures of

environmental dimensions, say, environmental dynamism, complexity and munificence, a deeper understanding of the relationship between organizational environment and MPC system with performance implication can be attained in this research.

iv. The development of MPC configurations and a reference model will provide a comprehensive classification and understanding of MPC systems. In this regard, it will help an organization to clear the difficulty in choosing the most appropriate MPC system that suits a particular organizational environment. Further, it will also open up research on new paradigms of future MPC systems that have the capability to accommodate the environmental changes.

1.6 Limitations and Delimitations of the Research

The limitations of the research are listed as follows:

i. It is important to state that the MPC system is one of the key sub-systems in the manufacturing organization and it is a part of whole organizational processes that transfer the manufacturing strategies into an action plan. Nowadays, the emphasis of sustaining competitive advantage is on the management of the whole spectrum of business, not just from the contributions of a few sub-systems. For the purpose of this research, only MPC system and environmental influences with strategies as mediators are considered. There exists a host of variables, associated with other sub-systems in the manufacturing organization which has direct effect on organizational performance, but is not included in this research.

ii. The data is collected from manufacturing industries within the region of Hong Kong and South China to verify and validate the reference model and the configurations of MPC systems. Therefore, the findings of the MPC system behaviour may represent the particular aspects of this organizational environment.

iii. The selection of variables of this research depends on the following:

    a. Literature study drawn from more than 300 refereed journal and conference papers related in MPC discipline;

b. Field interviews in which a sample of MPC practitioners was selected to give comments;

c. My personal judgement and experience from 10 years' managerial work related to the MPC discipline.

These elements will influence the design of a questionnaire as a critical instrument in this research. It is unfortunate that most of the respondents (perhaps it is a reflection of Hong Kong manufacturing) adopted the standard MPC systems and preferred the Western techniques such as MRP, MRPII etc. Therefore, the variables of the research may be epitomized by a sample of Hong Kong manufacturing managers and myself.

iv. This research is based on the competitive and manufacturing strategic conceptual construct proposed by Ward and Duray[54]. This construct, already validated but yet to be accepted as general strategy construct, is a crucial aspect in this thesis. The major reason for the adoption of the construct is that most of the well-known strategic constructs are conceptual in nature and not yet validated.

v. There is possibility that some unmeasured variables will impose certain effects on measured variables. As such, a very great number of variables in the survey questionnaire would be a demerit because of the resultant impediment to drawing conclusions. Unfortunately at the moment the theory to determine the high-order constraints on measured correlations has not yet developed[59, chapter 10]. Without the necessary correlation theory, the estimates for the measured variables depend on an assumption of normality. In the simulation study with normal variates, SEPATH is used for the estimation of the latent correlations.

vi. Most of the Hong Kong managers, if not all, responded to the questionnaire in the following manner:

a. They treated some of the organization's financial data as confidential and were unwilling to provide them for the research;

b. They are busy and therefore prefer to answer a questionnaire of only a few pages.

The element in part (a) will lead to the search of the financial data via public annual reports for a limited number of public firms for analysis. As such, two separate

sampling populations will be created. The element in part (b) will impose the constraint of not including too many variables in the questionnaire.

vii. The responding rate via a mailed survey has been relatively low in recent years since most of the Hong Kong managers have no interest in answering the questionnaires. For example, among three of the surveys being carried out between 1997 and 1998, the responding rate is less than 2%. To alleviate the problem, the survey could best be taken from a forum or an executive development programme. However, this will create the problem of obtaining a randomized sample for the study. Unfortunately, at the moment the theoretical work regarding the perfect predictions of experimental outcomes from the uncontrolled observations has yet to be developed[59]. The reliability of the statistical analysis of this research is limited by the availability of superior mathematical tools.

viii. The questionnaire survey of this research is a cross sectional study in which the sampled data is collected at a single point in time. Therefore, any issues related to the changes in MPC system characteristics over time will not be considered.

The delimitations of the research are listed as follows:

i. Other than MPC system, this research will not attempt to study a number of other manufacturing sub-systems, say, quality system, information systems, product and process development system, and computer-integrated manufacturing (CIM) system etc.

ii. Other than the samples taken from Hong Kong manufacturing industries, this research will not attempt to study the industries in other parts of the world.

iii. Because of the broad range of strategic planning definitions found in the literature and many types of planning used, this research will focus only on manufacturing organization and its MPC system that plans in accordance with the definitions of manufacturing strategy and competitive strategy.

iv. This research will not attempt to carry out longitudinal study of MPC system.

v. This research will not attempt to construct models of manufacturing strategy and competitive strategy.

vi. This research will not attempt to develop a new environmental construct of manufacturing organization.

vii. This research will not attempt to create new measures for organizational performance.

viii. Since only the MPC system perspective is considered, this research will not test the separate links between environment and competitive strategy (paths 1a and 1b, Figure 1.2), and between competitive strategy and manufacturing strategy (path 1c, Figure 1.2).

1.7 Thesis Outline

Chapter 2 is a review of the literature related to the standard, hybrid and customised MPC systems/approaches. The chapter also presents the comparisons among various MPC systems that may influence the selection of an appropriate MPC system subject to a specific manufacturing environment.

Chapter 3 extends beyond the scope of MPC systems/approaches to examine the linkage between organizational strategies and MPC system. This Chapter reviews several types of strategies: competitive strategy, focused strategy, process design strategy, product/process matrix, manufacturing system typology, manufacturing strategy typology, best practice strategy, positioning strategy, supply chain strategy, and Miles & Snow's strategic archetypes.

Chapter 4 further broaden the scope of literature review by studying the linkage between organizational environmental, competitive strategy, manufacturing strategy, and MPC system. Besides, the organizational environment and environment-strategy (E-S) fit are considered.

Chapter 5 goes on to consider the configuration approach for the study. It attempts to identify the methodological issues in developing organizational configurations at MPC level. Elemental configuration and relational configuration are discussed.

Chapter 6 describes the hypothesized relationships among organizational environment, operational environment, competitive strategy, manufacturing strategy, MPC system and the performance implications in the study. Thirty hypothesized relationships are presented.

Chapter 7 outlines the research sample, the design, methods, measures, a description of the questionnaire development, and the data analytic procedures.

Chapter 8 proposes a reference model for the configuration research in MPC systems. The validation of the model by field study is illustrated.

Chapter 9 examines the hypothesized relationships as suggested in Chapter 7, based on perceptual-based and archival-based approaches. Statistical analysis such as Pearson correlation, linear regression, ANOVA, and path models are used to test the bivariate and multivariate relationships.

The final chapter draws conclusions from the results of hypotheses in Chapter 9. The research outcomes, contributions, limitations, and future research directions are discussed.

Chapter 2 Manufacturing Planning & Control (MPC) Methods

In this chapter, a review of literature is presented for two major MPC approaches, namely, systems approach and quantitative approach. The systems approach includes: MRP, MRPII, JIT, OPT, HPP, CONWIP, and hybrid system. The quantitative approach includes: SIC, APP, and ROP. Hybrid and customized MPC systems are discussed. The comparative studies of these approaches are briefly described.

2.1 Introduction

MPC system is diverse and extensive. It relates to demand management, production scheduling, capacity planning and management, inventory management and control, materials management, logistics and transportation, shop floor control, performance measurement, management of information flows, and production decision support system. Similar to other manufacturing sub-systems, its primary purpose is to ensure that the organization behaves in a desirable way under a business setting. For more than 30 years, many standard MPC practices have been developed but they are restricted to cope with standard problems. These standard practices are discussed in Section 2.2 and sub-sections.

2.2 Standard MPC practices

Many standard MPC practices have been developed and implemented in different manufacturing organizations. The results of employing these standard practices are mixed. Some organizations reported the successful implementations, while many were often disappointing. The mismatch of a standard MPC practice in a particular manufacturing environment could be one of the reasons. For example, Taylor reported that the production control practice in the process industry would be different from production control elsewhere[60]. The general issues about these standard systems or practices are discussed in Sections 2.2.1 and 2.2.2.

2.2.1 Quantitative Approaches

The traditional Western MPC concept before the 1960s was dominated by the quantitative approaches. In order to solve the MPC problem, a mathematical model, that represents the entire system, is developed. It is constructed on the assumption that all the decisions and their interrelationships can be quantified. The most common approach is the aggregate production planning (APP) technique that attempts to minimize the total production cost by adjusting the customer service level (through back orders etc.), workforce level, production rate, and inventory quantity (e.g. Dzielinski and Gomory[67]; Lasdon and Terjung[68]). However, the difficulty in this kind of approach does not lie on the formulation of a quantitative model, but a formidable task to solve it optimally. The resulting quantitative model that represents a real-world situation could be very large to deal with, for example, a problem with 1,000 items and 20 input variables in a 12-period, 4-week basis, planning horizon has a million data to handle. Further, the deficiencies of the model are due to the ignorance of the inherent uncertainties of MPC system and the variables of the long-term production plans. As such, researchers in this field often resort to pursuing a piecemeal quantitative approach by partitioning the global problem into sub-problems. In some cases these approaches provide significant benefits. For example, Tadei et al.[69] introduced a two-step aggregate planning and scheduling heuristic approach in a food company and improved the internal efficiency as a result. The common quantitative approaches such as statistical inventory control (SIC), reorder point (ROP), aggregate production planning (APP) and hierarchical production planning (HPP) are discussed from Sections 2.2.1.1 to 2.2.1.4.

2.2.1.1 Statistical Inventory Control (SIC)

Statistical Inventory Control (SIC) enjoyed the attention in the past until the introduction of system approaches such as MRP, JIT, OPT, and so forth. Similar to other quantitative approaches, SIC lost its impact as critiques of the models have been by and large negative. The major weakness of SIC is that it does not accurately reflect the real world that is both complex and dynamic.

The EOQ model, developed in 1915, has been the focus of the lot sizing decision in the production and inventory control system with an aim to determine an optimal batch size in order to minimize the unit cost of inventory. In a study to compare SIC and MRP, Fortuin[75] maintains that SIC mainly deals with quantities decision but ignores the dependence between the demands for the various items since it is part-oriented. Conversely, MRP is product-oriented. It deals with the dependence between the various items given by the product structure, and considers both quantity and timing decisions. Further, MRP reacts better than SIC in the changing demand conditions, with fewer stockouts and lower inventory as a result. Since MRP requires more data processing, it has higher information costs.

There are a number of negative critiques on the EOQ paradigm that includes: (a) it is short-sighted as the area of control deals with a single product and is unaware of product interaction and interdependences; (b) set-up cost is assumed to be constant – a concept refuted by the Japanese practitioners' science of set-up times reduction[70]; (c) the lot size for production and transportation is fixed and is insensitive to capacity and priorities which will result in large WIP levels due to long lead times between operations; and (d) the EOQ model is emphasized on the inventory decision but a number of major factors that influence the manufacturing system are ignored.

2.2.1.2 Reorder Point (ROP)

Reorder Point (ROP) is the replenishment system developed earlier than MRP. The process is based on the simple logic, i.e. the replenishment order is placed when the stock on-hand reaches a pre-determined reorder level. Many decision rules have been developed, for example, fixed-period demand policy, period-order quantity policy, Silver-Meal heuristic[71] for quantity decision, continuous review decision, continuous timing decision[72], periodic review for intermittent-time decision[73], and ABC analysis for control decision[74] etc. Schonberger[42] indicates that ROP is common among smaller manufacturers but its inadequacies increase when the product line expands, especially if the products are complex and share a number of parts. Burbridge[76] discusses the shortcomings of multi-cycle ROP system: (a) it has the deficiencies such as high

inventory level and heavy order loading; and (b) it is not suitable to the multiple-product environment with seasonal sales characteristics. Peterson and Silver[77] argue that the use of ROP is justified only for the planning of inexpensive parts. As such, ROP system is more appropriate to be used in a simple manufacturing environment for low-cost production.

2.2.1.3 Aggregate Production Planning (APP)

Based on an assumption that all decisions and their interrelationships can be quantified, aggregate production planning (APP) is used to determine an optimal production schedule that will meet the forecast demands in the specific planning horizon, usually ranged from six to eighteen months. An APP model, representing the entire MPC system quantitatively, is solved by a wide variety of operational research (OR) techniques. The objective is to minimize the cost of production and variables of organizational resources for a specified planning horizon. This approach provides an aggregate level of product demand that derives from product families of an organization. Stevenson[78] proposes a number of variables for solving an APP problem. These variables include: hiring and layoff of workers, overtime decisions, hiring temporary workers, hiring part-time workers, keeping inventory, and subcontracting decisions etc. The major goal of an aggregate planning is to establish an appropriate production-inventory level, which depends on achieving a balance between various costs. Chase and Aquilano[79] suggest the essential strategies for managers to implement APP techniques. These strategies include: high stability of workforce, steady output rate, constant updating of production schedule, and multiple decision rules etc.

There are numerous OR oriented techniques for solving the APP models, such as linear programming (LP)[80], linear decision rule (LDR)[80] or HMMS (Holt, Modigliani, Muth and Simon) model[81], heuristic method[82], goal programming (GP)[83], dynamic programming (DP)[84], search decision rule (SDR)[85], and discrete production-switching rule[86]. However, these techniques have been challenged by a number of researchers on issues of practicality. For example, the assumption of deterministic (known) demand does not exist in the real manufacturing environment. The linear-cost assumption is also a

departure from the real world situation, e.g. the existence of quadratic costs in LDR (or GP) models and the deviations in production rate and inventory level. This will render the OR rules insensitive to the errors in the estimation of the cost coefficients. Besides, SDR does not guarantee an optimal result but requires an expensive development and operating costs. One instance comes from Owens-Corning Fiberglas. The company attempts to put the production-switching rule into practice and finds that it takes several man-months to complete the cost-estimation activity[87].

Apparently, APP approaches have had relatively little impact on the manufacturing industries since the APP models developed so far cannot capture all the nuances of a complex manufacturing environment. It appears that the restrictive assumptions of the approach limit its widespread acceptance in practice. For example, the assumption of changing workforce level in each period by hiring and layoff employees is undoubtedly unrealistic. Nam and Logendran[88] stressed the practical importance rather than just theoretical merit when developing APP models. In a word, an APP model must reflect the realities of the production environment in which it is to be used.

2.2.1.4 Hierarchical Production Planning (HPP)

The pioneer of the hierarchical production planning (HPP) framework has been defined by Hax and Meal[89]. It is a hierarchically integrated system that enables the manufacturing organization to make decisions with better resources planning and control. This approach considers the interdependence of functions at different organizational level. Within the HPP framework, a MPC problem is partitioned into a series of sub-problems on three distinct levels of aggregation: items, families and types. By carrying out the aggregation-disaggregation procedures, the complexity of the solution process can be reduced and solved by OR oriented techniques with an assumption that the final solution is equivalent to solving a single MPC problem. For example, Graves[90] used Lagrangian relaxation technique to solve the Hax-Meal hierarchy as a natural decomposition of an optimization problem.

The HPP framework is composed of a sequence of modules that are consistent with a hierarchy of decision structure of an organization. It adopts a modular approach to link

both long-term and short-term planning decisions. Meal[91] outlined the MPC decision hierarchy of a manufacturing organization (see Figure 2.1). In this decision hierarchy, the following points are raised:

- The HPP framework must coincide with the existing organization structure.
- Aggregate decisions have to be made first and these top-level decisions impose constraints on the subsequent decisions at the lower hierarchy.
- At the lower hierarchy where detailed decisions have been made, feedback flows back to the top-level hierarchy for the evaluation of aggregate decisions.
- The decision structures at each level should be carefully integrated with the preceding and subsequent levels; otherwise, islands of decision-making are created.
- Unlike the monolithic approach (say, APP technique), HPP seeks optimal solutions to the individual sub-problems at each level.
- The effectiveness of HPP system depends on the consistency between the aggregation and disaggregating procedures, interactions and connections.

Unlike APP, the HPP framework takes into consideration the hierarchical interfaces between production and other functions. Besides, HPP is one of the means to achieve integration of manufacturing process.

However, there are a few limitations of HPP:

- The design of the planning hierarchy requires a variety of information specifying the manufacturing system such as work center details, worker details, product details, routing details, historical or forecast data etc. The development cost is high which may restrict the usage of the technique to only the large manufacturing organizations that have sufficient fund and resources.
- The approaches are effective means for achieving vertical integration within an organization, particularly when the lateral integration is low.
- The interdependence of the functional policy between MPC and marketing decisions is disregarded[20,92].
- The models have not been widely accepted by practitioners since the "aggregate-disaggregate" planning approach is restricted to solving detailed part and component scheduling problems[93].

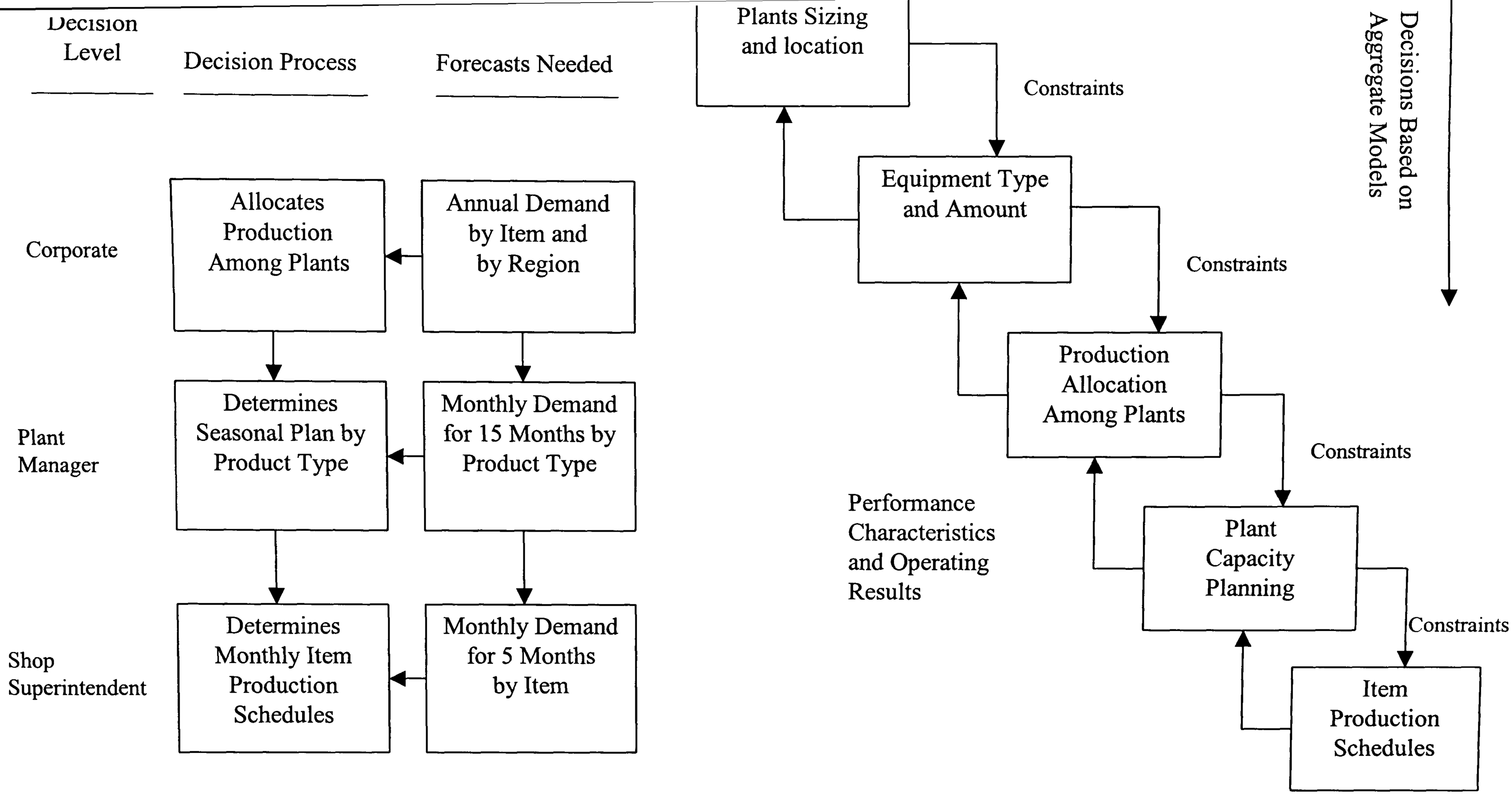


Figure 2.1: The Hierarchical Production Planning Structure (Source: Meal[91, pp.104,106])

2.2.2 Systems Approach

Since the 1960s, MPC researchers and practitioners have recognized that it is important to adopt the systems approach for solving production control problems since the interactions of MPC system with other sub-systems and external stakeholders increase gradually. The systems approach offers facilities to integrate and to control the ever-increasing complexity of the manufacturing environment. Many MPC systems have been developed taking this into account (see Figure 1.1 in Chapter 1). Unfortunately, these systems are typically strong in some areas but weak in others. Various MPC systems are discussed between Sections 2.2.2.1 and 2.2.2.6.

2.2.2.1 Materials Requirements Planning (MRP)

Materials requirements planning (MRP) was developed by Joseph Orlicky[4] to deal with the complexity of timing and inventory relationships in the discrete parts manufacturing environment. The earliest version is materials oriented. Its aim is to plan the right materials (usually fabricated components, subassemblies, and purchased parts/raw materials) in the right quantities at the right time. It is designed to schedule purchase orders or shop orders[4,34,35,61]. Based on a "backward" scheduling method, MRP executes the schedules of all the subassemblies, components and raw materials that meet the master schedule of end products. Its principal inputs include: master production schedule (MPS), bill of material (BOM), and inventory status. However, MRP cannot be treated as a decision-support system since the time-phased requirements of machines, labor, tools, and other resources are not considered. The implementation of MRP systems is often associated with computerized information systems[31] since massive data storage and retrieval, and computation process are required.

There are reports about the successful implementation of MRP in the 1970s[e.g.15,137]. However, the success rate both in the U.S.[138] and in the U.K.[191] is low. A number of studies describing the major limitations of MRP include the following points: (a) lead-time is assumed to be fixed[41], that is not consistent with the job-shop environment where the lead-times and optimal lot sizes are not known[62]; (b) lead-time has to be

overstated in order to cover for contingencies[62], thus leading to poor system performance; (c) the system functions as a planning methodology but not for controlling role; (d) it lacks technical capabilities in integration with tasks[94]; (e) the assumption of deterministic demand is contradictory to the make-to-order (MTO), or engineer-to-order (ETO), or assemble-to-order (ATO) environments; and (f) it schedules material requirements based on the assumption of unlimited plant capacity. This may result in excess inventory at each stage of production processes in order to provide a cushion for uncertainty about external demand and fluctuating supply.

2.2.2.2 Manufacturing Resources Planning (MRPII)

Manufacturing resources planning (MRPII), developed by Wight[6], is an outgrowth of MRP for solving some of the earliest version of requirement planning problems. It is the most widely implemented material control system in U.K. and U.S.A.[64,29]. Over 50% of the U.S. organizations implement MRPII systems in the early 1990s. About the same time, it is observed that about 80% of the U.K. organizations adopt MRP/MRPII[144]. MRPII is considered as the total management system for hierarchically structured organization in order to integrate and coordinate manufacturing with marketing, engineering and finance. In this regard, the traditional MRP structure is extended beyond materials planning to support demand management, master planning, rough-cut capacity planning, production activity control, capacity requirements planning, and vendor management.

Figure 2.2 shows the modular structure of a typical MRPII system proposed by Vollmann, Berry and Whybark[63]. They segregate the system into three sections, namely, front end, engine and back end. The front end (management planning) is the set of activities and sub-systems that provide direction by translating the organizational objectives into an appropriate form for an MPC system. Activities related to this section are demand management, master production scheduling and resource planning. The engine of the system (operations planning) is the set of sub-systems for accomplishing the detailed material planning and short-term capacity planning. The computation of the requirements of parts, raw materials and assemblies is processed by the MRP logic. The

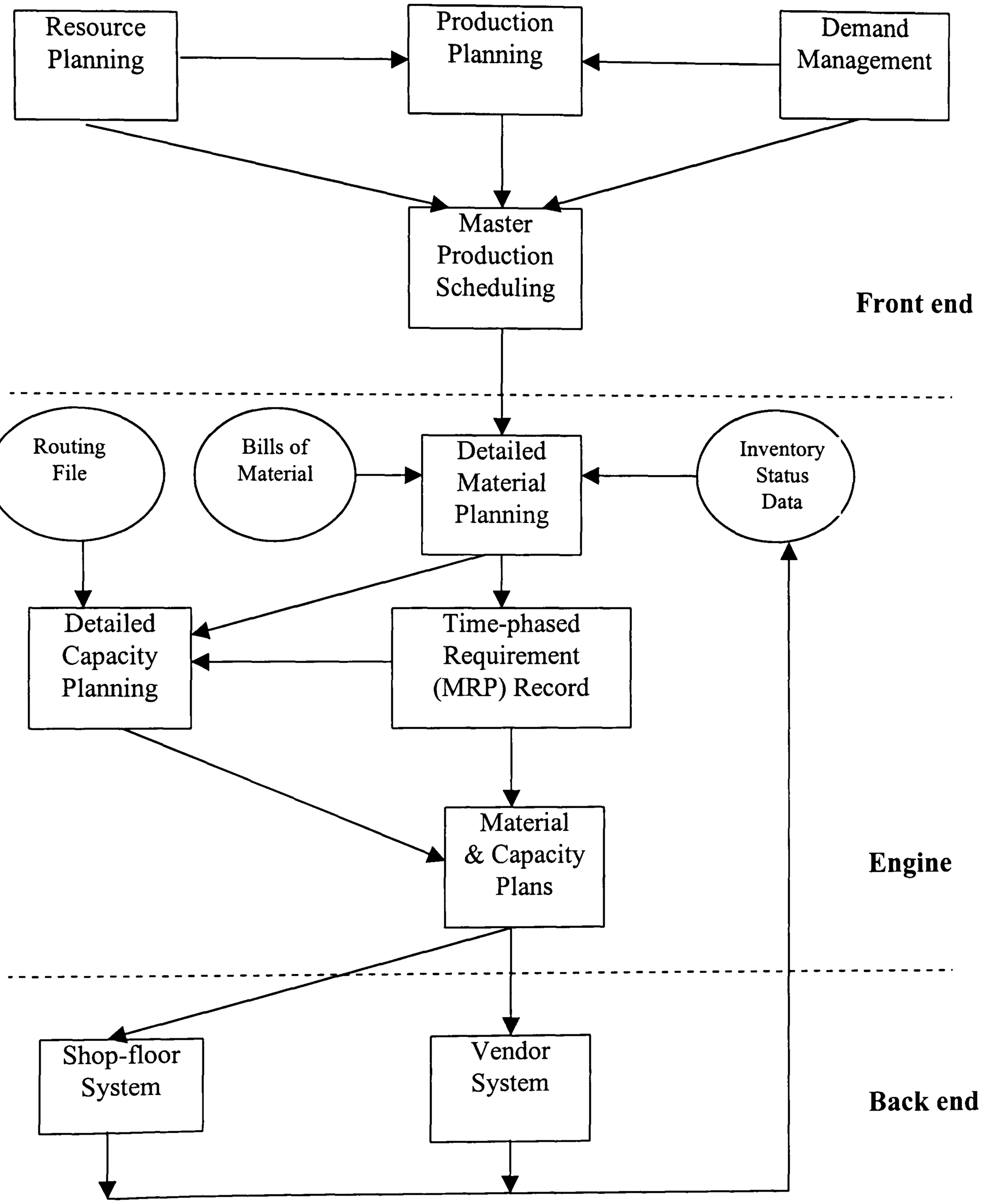


Figure 2.2: Manufacturing Planning and Control (MPC) System
(Source: Vollmann, T.E., Berry, W.L., and Whybark, D.C.[63, p.15])

data for such computation are obtained from bills of material (BOM) file, inventory status file, and the time-phased (period-by-period) requirement records file. The short-term capacity planning module will then use the MRPII output data to work out the required resources such as labor, work center etc. The back end of the system (operations execution) is the execution phase, which consists of shop-floor control system and vendor system. The shop-floor control system establishes the priorities for shop orders, while the vendor system includes the development of ground rules for contracting, purchase order release and follow-up. At the core of MRPII for manufacturing planning and control, material requirements planning plays a central role. Besides, MRPII system is a top down planning approach to get the production executed by using aggregate data at the higher level. As such, it acts as the manufacturing information system rather than a decision-making system.

Wight[9] proposes a classification scheme that evaluates how well the organizations operate their MRPII system. The scheme includes a series of 25 questions, relating to the technical capability, data accuracy, education and employees training, and output results of the MRPII software. The system is rated between 4 classes: Class "A" represents excellence; Class "B" indicates dramatic operations improvement; Class "C" means an organization has achieved reduction in inventory level; and Class "D" views as "another computer failure".

Various surveys have been taken that indicate problems with MRPII implementation. Examples of these are: (a) In 1982, it was reported that only 9.5% of MRPII users in the U.S. considered themselves as Class "A" users, while 61.3% considered themselves as Class "C" or Class "D" users[137,139]. (b) In 1986, it was reported that Class "A" users in the U.S. was only 25%[140]. (c) In the middle of 1980s, Aggarwal estimated that 90% of MRPII implementations in the U.S. were disappointing[34]. On the contrary, the benefits gained from the successful implementation of MRPII systems have been documented in the literature[e.g.,142,143]. Burns et al.'s [142] survey reported in 1991 that 57% of their samples were Classes "A" and "B" users, 40% indicating Class "C" users and only 3% were Class "D" users.

Burns et al.[142] identifies 12 methodological factors critical to successful MRPII implementation. Six years later, Sum et al.[141] have validated eight major critical

success factors (CSFs) in MRPII implementation. These CSFs includes top management support, effective project management, education and training, data accuracy, company-wide support, suitability of hardware and software, software vendor support, and type of manufacturing environment. The first seven items are internal factors of an organization, while the last item is the only external factor associated with MRPII success. They propose eight contextual elements to be used as a checklist to assess the priorities of the CSFs that a particular organization emphasizes. Sum et al.'s checklist is similar to Burns et al.'s CSFs with the exception that Burns et al. consider that the assistance of consultant(s) is also critical to the MRPII implementation.

The MRPII system has been criticized for having some inherent intrinsic drawbacks, such as: (a) lack of dynamic resolution due to its infinite capacity approach at rough-cut capacity and capacity requirements planning stages; (b) a functional and a hierarchical framework that turns the operations into an isolated planning system with barriers between manufacturing, distribution, quality and design[65,145]. There is no direct relationship between marketing and MRPII developed[63]; and (c) it is a rigid system since there is no formal feedback procedures[145] that will affect the elements such as lead-time accuracy and lot size optimization. "MRP Nervousness"[66] will result when there are small changes in lead-time and lot sizing.

Zapfel and Missbauer[61] consider that MRPII is suitable for the parts and assembly industry because of the availability of correct master schedule data. Karmarker[62] explains that MRPII becomes invaluable for planning and order release when it is applied in more dynamic and variable contexts. Apparently, MRPII systems consist of a number of separate modules that need careful interfaces (see Figure 2.2), otherwise "islands of automation" can be created[6]. It is argued that MRPII does not provide the much needed business integrated solution that suits the changing business environment[65] and it is now considered as inadequate as a capacity planner[98]. Therefore, recent attempts to modify it are enterprise resources planning (ERP) and customer-oriented manufacturing management systems (COMMs)[65].

2.2.2.3 Enterprise Resources Planning (ERP)

In the network-centric and web-based era, there is an increasing need to develop a software solution that integrates the suppliers and customers. The Internet and new solutions linking the supply chain has led to the emergence of ERP[95], an extension of MRPII with enhanced and added functionality. It encompasses functions that are not within the traditional application of MRPII, such as human resource planning, distribution, and decision support applications[100]. Read[96] lists three key elements of ERP that assist the management of manufacturing processes: client/server architecture, real-time planning and work flow. ERP therefore is directly related to the sophisticated information infrastructure. It's challenge is to transform the supply chain network, and to set up an integrated processes across geographically spread departments and/or functions to enable optimization across the organization[97], not just to integrate data within the manufacturing organization.

ERP gives a real-time window, in the cyberspace world, on every aspect of the supply chain and may become the nerve system of an organization. To facilitate the transactions along the supply chain, Papows[99] lists four enabling technologies, which combine to form the new enterprise solution, that is, intranet, extranet, internet, and world wide web (WWW). Unlike traditional MRPII systems, which are built on proprietary or hierarchical databases, ERP systems use relational database management systems (RDBMS)[100]. There are other technology changes like the use of graphical user interface (GUI)[101], open systems for building-up the distributed applications[101], and a client/server architecture[102]. Add-ons such as finite scheduling tools are extending MRP II capabilities further[101]. This represents the application of newer information technology (IT) to the MRPII model. They are all strategically important in defining the competitive position of an organization as ERP permits a logical link to external stakeholders, which the MRPII system lacks.

Most recently the integration of Manufacturing Execution System (MES) with ERP has been emphasized. MES has the finite scheduling tool to overcome the flawed MRP system of infinite capacity.

Several successful ERP implementations are cited. Examples are:

- NEC Technologies[104] moved to ERP system in 1994. They decided a rapid ERP implementation in order to save $20 million compared to the lengthy traditional

approach. The company was more able to fill customer orders and had achieved a growth of 57% in revenue 12 months after implementation. Tremendous efforts had taken place with caution, such as a move to a process-centered approach and two years of educating and persuading employees.

- A pharmaceutical company had used ERP to consolidate manufacturing support operations such as purchasing and vendor management. As a result, it employed fewer staff and had generated a return of more than 20% on its capital investments[103].

The implementation of ERP is fraught with risk. Successful ERP deployment depends on a rigorous change-management program, which is tied to the business-model blueprint, the business process reengineering effort to move the functional hierarchy into a "process" structure, the involvement of the whole organization, and the move of partnering organizations along the supply chain[105]. It requires strong leadership, a clear and well thought-out implementation plan, contingencies for dealing with uncertainty, prudent budgetary control and an explicit stake in the project for the business organization[103].

There are a few disadvantages of the implementation of ERP, listed as follows:

- It requires high investments required to purchase all the software and the hardware. It also requires a much longer time spent on the initialisation phase[106].
- It requires the disposal of older proprietary or in-house software systems in order to install the new ERP system. In reality, most organizations, especially the larger companies, still have legacy systems and are not willing to replace all their systems with ERP.
- Small and medium-sized enterprises (SMEs) do not have the robustness to tap the power of IT nor have sufficient capital to install an integrated information infrastructure for ERP implementation.

At the moment, little research has been done on ERP systems[107] since the application of recent technologies such as Electronic Data Interchange (EDI), web application, e-commerce, local area networks (LANs), and wide area networks (WANs) etc. in ERP systems are still under development.

2.2.2.4 Just-in-Time (JIT)

In the past two decades, JIT has stimulated a large number of literature that redefine and reinvent the operations management models. The increasing attention of JIT is closely linked to the competitive success of Japanese manufacturing organizations and the development of the JIT practices. JIT embraces a wide-ranging scope of concepts and philosophy. JIT production, JIT purchasing, and JIT delivery etc. have a different interpretation. The terminology, "JIT", in this thesis is associated with the Japanese Kanban system as an MPC approach. In this respect, the terms "JIT" or "Kanban system" or "JIT-Kanban" is interchangeable.

JIT-Kanban is an outgrowth of a production control technique developed at Toyota[5]. Schonberger[108] provides a list of 17 principles of JIT, based on his investigation particularly in the Kawasaki motorcycle plant at Lincoln. He has developed the cause-effect diagram, as shown in Figure 2.3, that gives a clear and comprehensive view of the approach. He maintains that the reduction in lot-size set the chain of JIT effects in motion.

JIT-Kanban consists of both a planning mechanism and a controlling mechanism, under a "pull" manufacturing environment[5,34,70,109]. The approach shows the importance of shop floor control mechanisms and uses a simple and manual method, Kanban card, to trigger the execution of the planned operation that controls work-in-process (WIP) and material flows[110]. Frequent releases and deliveries of materials are carried out so that full benefits of production in small lots can be achieved. To achieve more efficient flow, local improvements such as set-up time reduction, lead-time reduction, quality improvements, flexible workers and operations, group technology or cellular layout, and preventive maintenance should be implemented at the same time. Besides, cooperation between different departments is emphasized. Therefore, JIT-Kanban includes a number of managerial elements[114] for effective system performance.

Two distinguishing features of JIT-Kanban are raised by Ohno[111]. First, contrary to other MPC systems that stress inventory control, JIT-Kanban places more emphasis on shop-floor control. Japanese management contends that when employees are weak at shop floor management, they tend to cover the defects with inventories. Second, JIT-Kanban is

a pull system, i.e. production is initiated by the actual demand in a successive station and not by arrival of parts. This forms a lateral integrating mechanism while other MPC systems lack. Besides, the lateral integration of shop floor in JIT-Kanban extends beyond

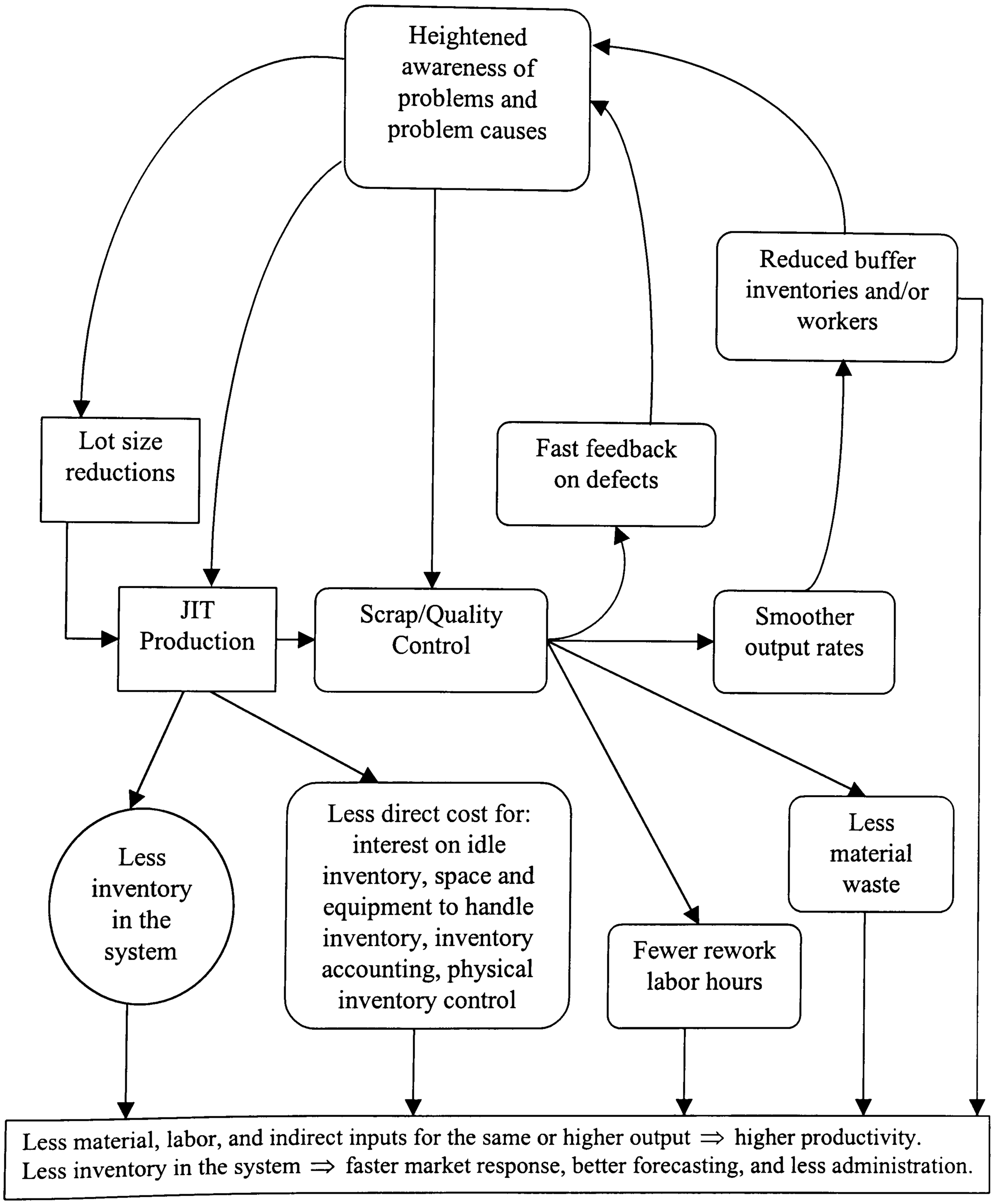


Figure 2.3: Effects of JIT Production (Source: Schonberger[108, p.26])

the organizational boundary to suppliers and customers.

The Kanban system is the most important part of the JIT Production System[70,108]. Huang and Kusiak[109] offer a broad discussion of the Kanban system. In the JIT-Kanban system, all work centers are connected to each other by cards. The materials consumption at upper stream work place, materials conveyance and the predetermined work in process (WIP) between the work centers are controlled by the kanbans. There are many different types of kanban, two of which are commonly used, namely production-kanbans (P-Kanbans) and conveyance-kanbans (C-Kanbans). P-Kanbans are used to authorize a production process at a pre-determined quantity, whereas C-Kanbans are used to authorize the transportation of a fixed amount of WIP to a work center downstream. Parts in demand are withdrawn by C-Kanban at the Final Assembly and then the preceding work center receives P-Kanban to manufacture according to the authorized quantity as stated in the kanban. In doing this, parts further up the manufacturing sequence are withdrawn and the process is repeated upstream. The flow of all materials is synchronised at the rate determined by the Kanban system. Figures 2.4 and 2.5 show the single-card and dual-card Kanban systems respectively. In a single-card system, production is designed as a push system while the delivery is controlled by a pull system.

Sophisticated shop-floor scheduling and complex materials flow will reduce the JIT-Kanban system effectiveness since a pull system is not able to cope with fluctuating demand and lead-time variability. In a word, JIT requires a stable environment to obtain a level production schedule, i.e. a uniform flow of goods through the system between operations and from the supplier to the final output. To achieve this, the production schedules must be fixed over a time horizon. Monden[70] concludes that JIT is difficult to use when there are: (1) job orders with short production runs, or (2) significant set-up, or (3) scrap loss, or (4) large, unpredictable fluctuations in demand. By running a large scale simulation model, Krajewski et al.[31] show that JIT performs poorly in an environment which has low yield rates, low worker flexibility and lack of product standardization. Therefore, JIT-Kanban system is more suitable to organizations that produce repetitive products in a stable environment [112,113].

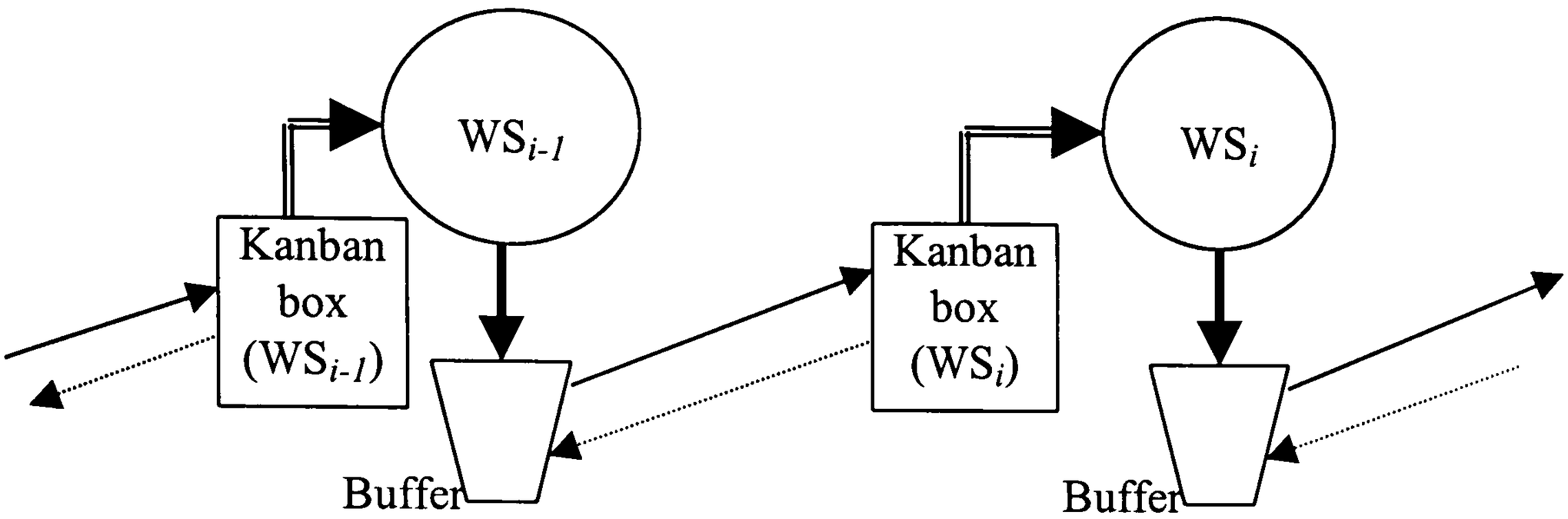


Figure 2.4: The Single-card Kanban System

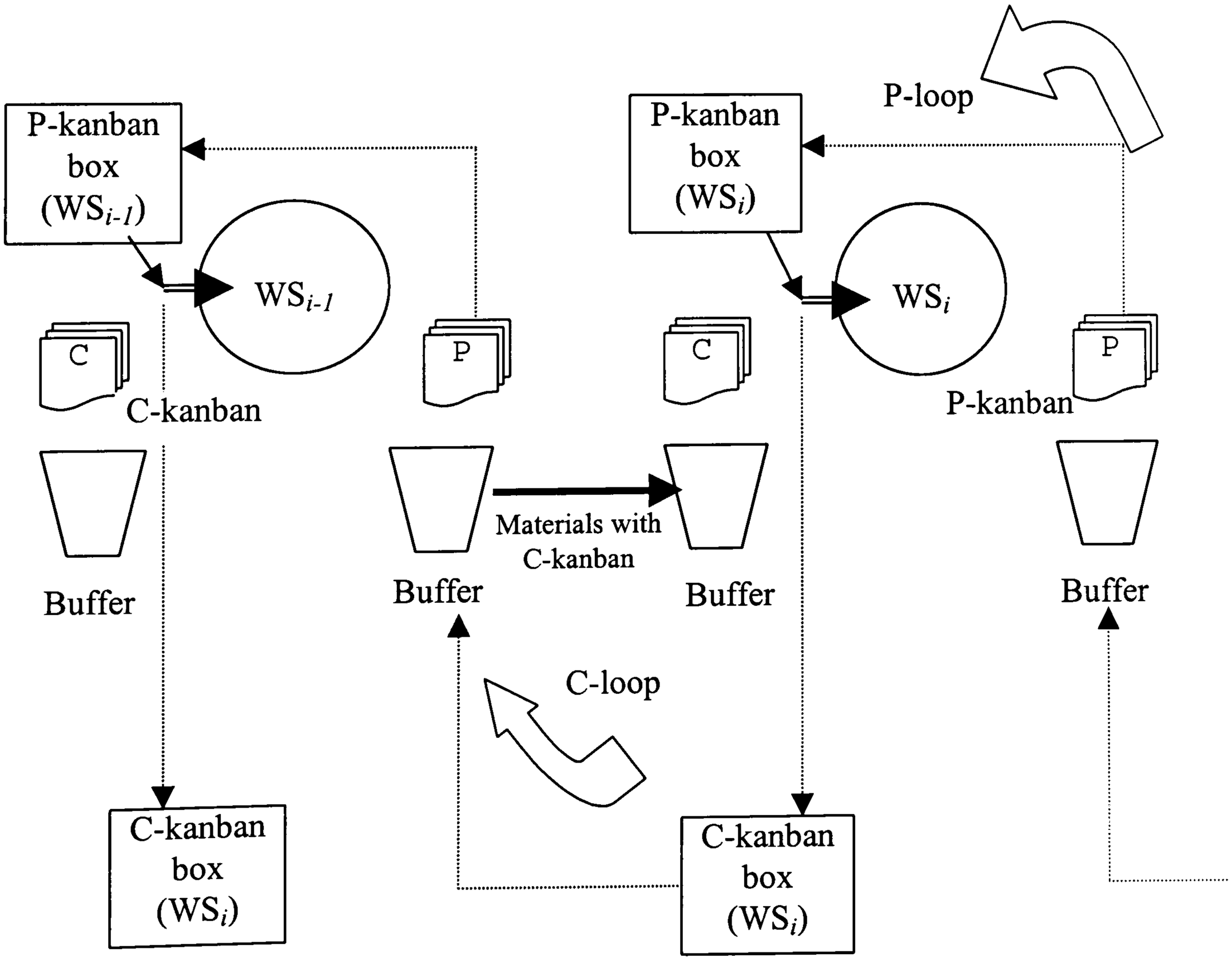


Figure 2.5: The Dual-card Kanban System

There are a number of positive published reports on JIT implementation. Bockerstette[115] provides a base of reference for successful JIT implementation. Some of these examples could be found in literature relating to the aeronautics industry[116], the automotive industry[117], and in other U.S. manufacturing industries[118]. Abernathy et al.[123] support the thinking that the success of JIT implementation is due to the willingness of employees to pay close attention to detail, while Suglmori et al.[124] argue that unique Japanese culture has been critical to the success of JIT implementation.

However, there are still some problems for the transplant of the JIT techniques. Lawrence and Lewis[119] reported that only a few Mexico companies have been successful in JIT implementation. Muchnik et al.[120] remain sceptical about the JIT implementation in American plants. Some researchers[e.g.,121,167,168] discuss the problems faced by small manufacturers in implementing JIT and conclude that some elements of JIT may not be applicable in some particular manufacturing situations. Crawford et al.[122] present the survey results of the implementation problems among 35 U.S. organizations. They conclude that enough resources must be provided for educating and training employees in order to overcome the cultural resistance to change, to prepare for the preventive maintenance and quality control programs, and the development of the interdepartmental implementation teams. A number of authors sound notes of caution about the feasibility of JIT to fit the particular circumstances of an organization. Wilson[125] alerts American management to be cautious about taking actions to reduce inventory levels too quickly, and hence result in severe stockout. He indicates that the benefits arising from inventory reduction are fairly small and the potential cost of disrupting production can be very high. Similar warnings can be found in a number of other publications (e.g. Zipkin[126]). Some problems mentioned by other local Toyoda plants are high incidences of repetitive strain injuries. Kim and Takeda[127] find that JIT manufacturing system is based on Japanese culture, namely, 'wa' culture and 'rentai' relationship. Any implementation of JIT system without Japanese culture will create "islands of JIT" and will hinder the operational processes.

Voss and Robinson[128] assert that JIT is a holistic approach and many organizations in U.K. seem to neglect some critical techniques that are central to JIT. They observe that many organizations in U.K. would seem to implement various aspects of JIT on an ad hoc

basis whilst few of them apply JIT techniques as part of a planned and integrating manufacturing policy. Further, they suggest a more complete and committed approach. Plenert[146] maintains that organizations with MRP may require the reorganization of the entire factory. Similar recommendation can be found in Keller and Kazazi's paper[129]. They argue that JIT implementation requires the adoption of many critical elements, such as Andon, Jioka, Mura, Muri and Poka Yoka etc.

2.2.2.5 Optimised Production Technology (OPT)

Optimised Production Technology (OPT), a commercial name and a proprietary algorithm of Creative Output, is the scheduling system developed by Eliyahu Goldratt during the late 1970s in order to maximize limited resources[7]. OPT assumes two types of constraints, bottleneck and capacity constrained resource. A bottleneck is a resource that constrains throughput. A capacity constrained resource is one that becomes a bottleneck as a result of inefficient utilization. Unlike MRP/MRPII, OPT assumes that production capacity is finite and will be restricted by one or more bottleneck operations. The scheduling system is designed to maximize bottleneck production and to limit non-bottleneck production. The overall production schedule in the OPT environment is driven by the schedule of the critical work centers, i.e. the centers with insufficient capacity.

Jacobs[131] provides a detailed description of "nine OPT rules", the original and elementary philosophy of OPT, which are well-known and often described in the literature. Table 2.1 shows the nine OPT rules. These rules have been complemented by five general steps (see Table 2.2) for building up a systematic approach to handle an environment within a logistical system[131].

The theory of constraint (TOC) is an outgrowth and enhancement of OPT. It can be regarded as the managerial concept to create a process of ongoing improvement. TOC, along with Synchronous Manufacturing Technology, seems to replace the OPT terminology[135]. The basic premise of TOC is that a system's outputs are determined by its constraints, which are generally defined as anything that hinders a system from achieving a higher performance. TOC defines three broad categories of constraints:

- Internal resource constraint, i.e. bottlenecks including a machine, worker, or a tool.
- Market constraint, i.e. when market demand is less than the production capacity.
- Policy constraint – a policy that limits throughput and dictates the rate of production (e.g. a policy of not working overtime).

1. Do not balance capacity.
2. The level of utilization of a non-bottleneck is not determined by its own potential but by other constraints within the system.
3. Utilization and activation are not synonymous.
4. An hour lost at a bottleneck is an hour lost on the system.
5. An hour lost gained at a non-bottleneck is a mirage.
6. Bottlenecks govern both throughput and inventory in the system.
7. The transfer batch may not, and many times should not, be equal to the process batch.
8. The process batch should be variable, not fixed.
9. Schedules should be estimated by looking at all of the constraints. Lead times are results of a schedule and cannot be predetermined.

Table 2.1: The Nine OPT Rules (Source: Cohen[131, pp.57-62])

1. Identify the system constraint(s), i.e. market demands and capacity constraint resources (CCRs).
2. Decide how to exploit the system constraint(s). Use the "drum" and "time buffer" to ensure high utilization of CCRs.
3. Subordinate everything else to the above decisions, i.e. putting a "rope" between operations.
4. Elevate the system constraint(s), i.e. expand capacity, reduce set-up times etc.
5. If, in the steps, a constraint has been eliminated, then go back to step 1, but do not let "inertia" become the system constraint.

Table 2.2: The Five Steps in Establishing a Logistics System
(Sources: Adapted from Cohen[131, pp.62-64] and Schragenheim & Ronen[134])

The purpose of TOC is to break a constraint and continuously improve system performance. There are two types of performance measures: global (financial) measures and operational measures[7]. The global measures include net profit, return on investment, and cash flow. Operational measures are: (a) throughput rate – this is directly related to the rate at which the system generates money through sales; (b) inventory – this is the investment in purchasing things, which are measured in terms of material costs; (c) operating expenses – this is the amount of money including labor, overhead, and other expenses, which the system spends in order to turn inventory into throughput. The objective of OPT is to maximize throughput while minimizing inventory and operating expenses. Since the two sets of performance measurements are related, it is possible to assess the impact of each of the operational measurements on the global measurements.

Drum-buffer-rope (DBR) is a production control methodology to implement the exploiting, subordinating, and elevating steps of TOC (see steps 2, 3 and 4 of Table 2.2). It is basically a feedback system. Figure 2.6 shows its operation. The "drum" is the bottleneck that dictates the pace of the system and strikes the beat. The production line has one bottleneck operation with a "buffer" placed next to it to prevent the bottleneck from fluctuations and variations (see rule 6, Table 2.1). The buffer is connected to the raw material dispatching point at the head of the production line via a feedback loop called a "rope". It provides communications between critical control points to ensure their synchronization. The DBR methodology synchronises the material utilization in an organization. This scheduling technique can be regarded as a combination of both push and pull. A "rope" regulates the dispatching of materials and thus this part is a pull process. Between the "gating" and the "buffer", materials are pushed from one workstation to another workstation. The difficulty of DBR scheduling is directly related to the number of bottlenecks in a system. Besides, the DBR technique advocates a kind of input-output control for MPC system.

There are four major modules of OPT software described as follows (see Figure 2.7):

- In a "Buildnet" module, a database is used to construct a consolidated network for each end product. Similar to MRPII, this database includes BOM, routings, inventories, workcenters, market demands, and other data. "Buildnet" has the

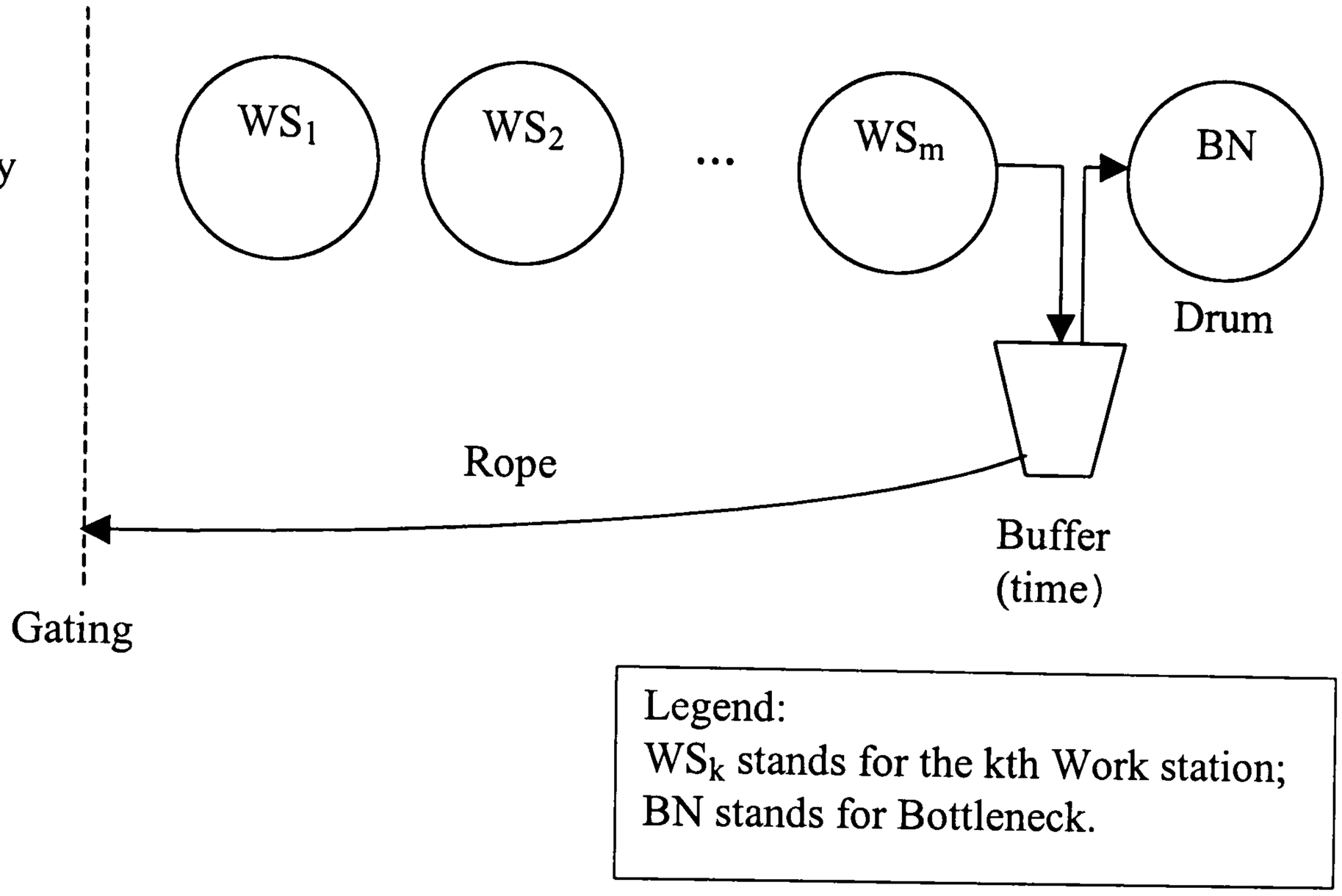


Figure 2.6: The Drum-Buffer-Rope Approach

flexibility to create new product networks, modify old networks, or evaluate modified network layouts.

- In a "Serve" module, described as a "smart" MRP system, a backward schedule (infinite capacity system) of the non-bottleneck resources is established, with time buffers being provided for the bottleneck resources. It verifies all resources data to ensure accuracy, calculates average resource utilization, and provides a load profile for each of the resources.
- In a "Split" module, the network is divided into two parts, i.e., critical and non-critical resources. The critical resource element will incorporate all bottleneck resources and succeeding operations for the parts being processed through the bottlenecks. Non-critical resources are reverse scheduled by the module with an aim to serve the critical resources.
- The OPT brain module employs a finite-capacity forward-scheduling algorithm which details are kept secret. It is to produce what is demanded for the bottleneck resources, taking account of the capacity and priority. It also determines the transfer and process batch sizes at each operation, coordinates the flow of

products, and brings together 'like-batches' in order to save set-up time and maximize throughput.

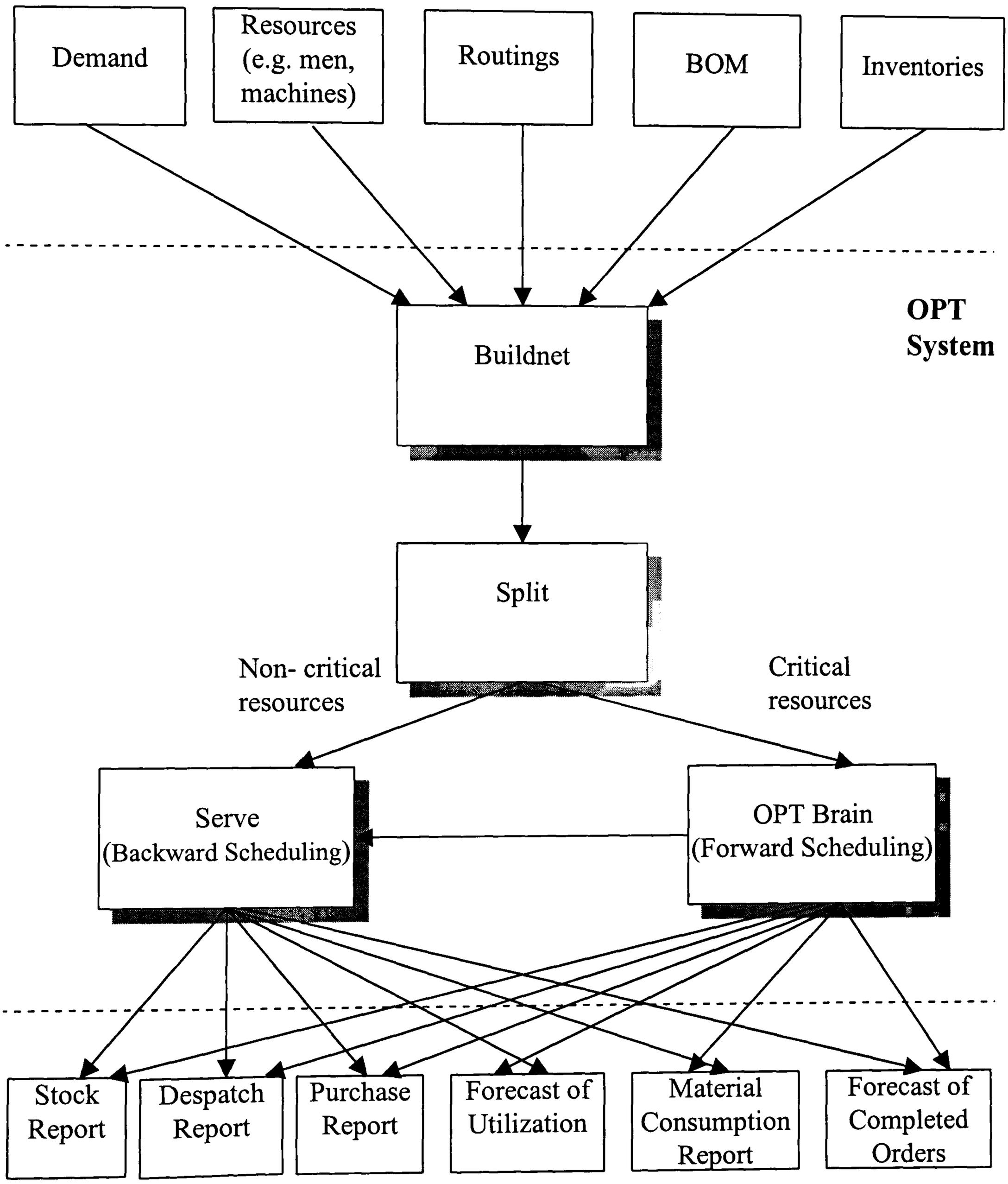


Figure 2.7: The OPT structure

Among the three MPC systems (i.e. JIT, MRP and OPT), OPT is least well known and understood[64,132]. According to two surveys[29,133] carried out in the U.S. in the early 1990s, less than 5% of the manufacturing organizations use OPT. In 1995, another survey[134] shows that the growth in OPT implementation is less than 1%. This may be due to the unwillingness of the developers to reveal the algorithm embedded in OPT and very few reports about the application of TOC in actual business settings[136].

OPT is designed for complex production environments. It has the ability to model an organization's manufacturing environment and produce efficient manufacturing plans. The essential difference between OPT and MRPII is that the realistic delivery times could be obtained by OPT system since it takes into account of the manufacturing system's bottleneck resources.

Unfortunately, there has been a lack of research on the application of OPT[151]. Fry et al.[152] report that the automotive industry is the main user of OPT and that organizations of make-to-order (MTO) production have tried the OPT software more than that engaged in make-to-stock (MTS) production. Other reports[e.g.,153,154] have demonstrated that TOC can be used to reduce WIP inventory and lead time, and improve the delivery performance. Bakke and Hellberg[169] contend that OPT is highly dependent on the time horizon and warn that applying OPT for long-term decisions may be potentially dangerous. One common complaint is its secrecy and complexity.

2.2.2.6 Constant Work-in-Process (CONWIP)

Constant Work-in-process (CONWIP), proposed by Spearman et al.[130], is an alternative form of Kanban. It is focused on the interactions between the planning modules at the different levels in the decision hierarchy[109]. Its aim is to maintain WIP at each routing at a constant level. In this respect, each routing becomes a CONWIP line. It is a closed production management system, as is Kanban, in which a fixed number of containers or cards traverse a circuit that includes the entire production line[149]. Under the CONWIP system, only the actual demands of customers are responded to. The Kanban cards, either in physical or in electronic form, are used to trigger the release decisions immediately when the end items at the output station of the line are consumed. Raw material is

"pulled" into the workstations. This can be interpreted as a pull system. Then the material under processing is "pushed" all the way through from one station to another line until completion (see Figure 2.8). In this way, it is considered to be a push system. Therefore, CONWIP is a hybrid push-pull system. Since the system only feeds back the message of demands immediately to the first workstation without going through the intermediate workstations, it is also called a single-stage Kanban system by some researchers[e.g.,130, 147].

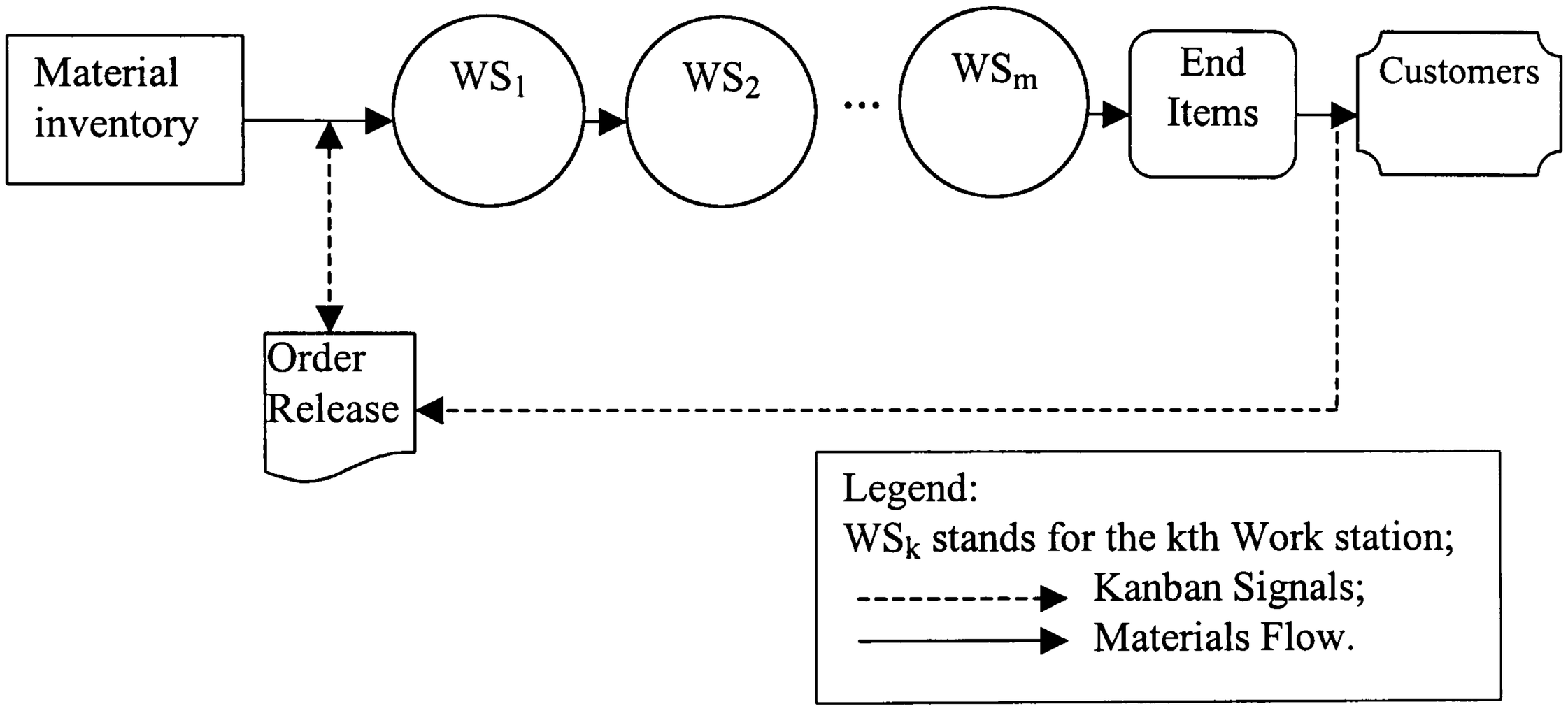


Figure 2.8: CONWIP Models

According to Spearman et al.[130], CONWIP differs from Kanban in 3 major areas: (a) CONWIP uses a backlog to dictate the part number sequence; (b) a card is associated with all parts produced on a CONWIP production line, but Kanban is linked with an individual part only; and (c) the jobs are pushed between workstations in series once they are being authorized to start.

System implementation performance is an important issue associated with CONWIP researches. Papers associated with CONWIP are often discussed about the performance comparison between CONWIP, Kanban and push systems[110,130,147-150]. The approach, similar to other pull systems, is to "set WIP and measure throughput." "Throughput" is one of the common measurements in predicting performance since it permits the computation of a completion time and the establishment of a realistic due date.

Spearman and Zazanis[110] compare CONWIP with a pure Kanban system and find that CONWIP has the following advantages over the Kanban system: (a) it is applicable to a wider variety of manufacturing environments; (b) it is superior in handling changes in the product mix and the introduction of new products; (c) with the same throughput in most cases, WIP level in CONWIP is lower than a Kanban system; (d) it is easier to cope with flow shop operations with large set-up times and permits a large product mix; (e) the system provides a greater throughput; and (f) it provides better customer service, e.g. less tardy jobs than a pure Kanban system. However, they point out that the comparison between CONWIP and Kanban is difficult. CONWIP is a material release policy for production scheduling while JIT-Kanban includes more managerial features than the scheduling activities.

As described by Spearman et al.[110, 130], CONWIP is a closed manufacturing system, it has the following distinct advantages over an open system (i.e. a push system), such as easier control, smaller variances, lower WIP levels, shorter flow time, and a more stable flow rate. In addition, it avoids a problem found commonly in many push systems called "overtime vicious cycle"[130].

Duenyas et al.[150] examine a production system consisting of several fabrication lines feeding an assembly machine based on simulation technique. They demonstrate that the CONWIP release policy is more effective than the Kanban release policy.

A CONWIP-based control system is not without drawbacks. These are: (a) rapid response to customers is difficult since the "safety stock" is relatively low; (b) a uniform materials flow in a production line must be achieved, but in reality it is an almost impossible task when a low "safety stock" position is to be maintained; and (c) CONWIP optimisation depends on the determination of the container size, i.e. the smallest element of WIP in a production line.

2.3 Hybrid System

There has been considerable discussion on the possible combination of MRP, JIT, and OPT. Nevertheless, most of these papers are focused on the conceptual level. Authors such as Belt[155], Cook[156], De Toni et al.[161], Maskell[94], Lee[158], Flapper et al.[157],

Jiang and Li[163], and Sillince and Sykes[159] etc. give detailed descriptions of how JIT-Kanban is embedded into MRP. Foo et al.[160], Weng[164], Sylvain et al.[165], Chin and Rafuse[166], Pun et al.[170], and Betz[181] etc. describe the successful real-life cases in adopting the hybrid JIT/MRP systems in a variety of manufacturing situations. Axäter & Jonsson[171], Meal et al.[172], Meal[91], and Özdamar et al.[182] etc. are in favor of the integration of MRP and HPP in order to achieve manufacturing effectiveness. Cooper and Zmud[173], Swann[174], Vollmann[175], Genders and Van Wassenhove[32,176], and Spencer[177] etc. support the use of the MRP-OPT system. Umble and Srikanth[135] consider the combination of OPT and JIT, while Shivnan et al.[41] promote a hybrid MRP/OPT/JIT system. Olhager and Östlund[178] enhance the push-pull system. Their works are briefly described as below.

Belt[155] suggests that organizations should use MRP as the coordinating mechanism for the manufacturing system with the help of JIT techniques, such as reduction in lead times and lot sizes, and the use of Kanban approach to the integration of processes.

Cook[156] discusses some issues related to the integration of MRP and JIT through software reconfiguration. The elements of the hybrid system include reduced set-up times, quality at source, small lot sizes, demand pull production control, level schedules, group technology, consensus management, employee involvement, and long-term supplier relationships. He argues that the use of computer can greatly enhance the capability of JIT without the loss of the pull system concept.

De Toni et al.[161] strongly address the combination of Kanban and MRP system and assert that it is desirable to apply inventory management with pull logic (MRP), and the priority assignment, picking and moving sub-system with pull logic (Kanban). Maskell[94] agrees that the MRP system can be used to improve manufacturing with other leading production systems such as JIT. Lee[158] also proposed an integrated MRP-JIT hybrid system, in which MRP is used to plan production and accommodate uncertainties, whereas JIT is used to execute and control production and reduce complexity.

Flapper et al.[157] propose a three-step framework for integrating MRP and JIT that captures the strengths of the two systems. The framework makes use of MRP's backflushing and phantom features, which enables JIT principles to be utilized to the fullest extent. They argue that MRP is an ideal mechanism for planning and control

purposes, while JIT is the best tool for reducing cost and lead times. The main concern of this framework is that MRP orders should be issued for the final products only, while the parts and materials required for these orders are pulled from the inventory at the other production areas by using the JIT Kanban control system. The other parts (components) that are manufactured in response to Kanban pull signals are called phantom issues.

Jiang and Li[163] identified three kinds of hybrid system. In the first type of hybrid system, items in the MPS are split into either MRPII or JIT items and are therefore processed according to MRPII or JIT. However, they indicate that this is far too ideal and is virtually non-existent. There is a need for both MRPII and JIT systems to combine together in order to gain the strengths of the other modes, rather than to operate separately. The second type is repetitive manufacturing, where only a few components are produced. The consideration on whether an item is to be processed by JIT mode or MRP mode depends on the nature of supplies. Items are split into either MRPII or JIT items after the explosion result of the BOM. The third type segregates items into common components and special parts that are produced in MRPII and JIT modes respectively. The common items are generated by the MRP mode, while the final assembly scheduling and operations scheduling of the special items are executed and controlled by JIT mode. These three situations represent the coexistence of both MRPII and JIT systems within one facility.

With regard to the application of MRPII-JIT hybrid system in industry, Sillince and Sykes[159] cite successful cases, which include large enterprises such as AT&T, Leviton, Mitel Lucas, Unisys, and Du Pont etc., in order to illustrate that MRPII and JIT can complement to each other.

Foo et al.[160] give an account of the hybrid system at the AT&T Denver Works, in which a three-step initiative is implemented in order to increase the manufacturing competitiveness. The three-step approach consists of: (a) an MRP system; (b) JIT/TQC processes on the shop floor; and (c) integrated pull manufacturing, i.e. the integration of MRP and JIT/Pull Systems. The implementation of MRP-JIT system is successful. The total inventory is reduced by 90%, inventory ratio is increased by a factor of 4, and the quality levels as measured by first pass yields is increased from 55% to greater than 90%. There are several key principles Foo et al.[160] put forth:

- The MPC system should be tailored to match the characteristics of the product design, cost and demand volatility.
- A diverse set of MPC systems can be complementary and can be integrated into a hybrid, unified, flexible manufacturing control system.
- MRP and JIT/Kanban are complementary provided that MRP is used only for planning and JIT/Pull is used for execution.

Several other papers have illustrated the effective implementation of hybrid MRP-JIT systems in a wider variety of manufacturing environments. For examples, Weng[164] reports how JIT, alongside a traditional MRP system, can be applied to a low-technology organization. Sylvain et al.[165] document a medium-sized business which has been successful implementing an integrated MRP-Kanban-Coding system in an environment that is both repetitive and non-repetitive. Chin and Rafuse[166] demonstrate the successful implementation of MRP-JIT systems in a small organization even though it is well known that small manufacturers are likely to face problems of limited resources. Pun et al.[170] describe a successful experience in adopting an integrated JIT/MRP concept in a multinational manufacturing organization that has production in several locations in South-east Asia. Betz[181] called the hybrid JIT/MRP system common-sense-manufacturing (CSM), which is successfully implemented in Lucent Technologies.

Some writers suggest the combination of MRP and HPP approaches as effective MPC practice. Axäter & Jonsson[171] suggest that HPP philosophy can be used to develop systems to support MRP and overcome some of the limitations of MRP, i.e. being unable to deal directly with optimization criteria associated with multilevel production problems. Meal et al.[172] assess the HPP and MRP approaches. They assert that an ideal planning system should incorporate both MRP and HPP concepts and consider that they are complementary rather than competitive. Meal[91] also contends that HPP could provide a mechanism to smooth the load at each manufacturing center while MRP provides an accurate statement of requirements that constrains production scheduling at the shop floor. Without the HPP framework's aggregate planning to provide a context for the detailed planning, the traditional MRP approaches will not be effective. Özdamar et al.[182] develop a decision support system that integrates MRP, aggregate models and HPP

algorithms. They propose that this system represents a higher-level planning tool in dealing with different issues in a manufacturing organization.

Cooper and Zmud[173] suggest that MRP-OPT system could be developed to replace traditional order-based information systems that support MPC. Swann[174] advocates the use of MRP for net requirements and OPT for realistic shop schedules. Vollmann[175] considers OPT as an enhancement to MRPII. Genders and Van Wassenhove[32,176] express similar views and conclude that OPT would come first to plan the bottleneck facilities in the medium time horizon. MRP should be used to generate time-phased requirements while JIT should be used to maximize throughput.

Spencer[177] provides a qualitative description of incorporating OPT concepts in an MRP system. He presents a case study that applies a 5-step process in implementing an MRP-OPT system: (a) identifying the bottleneck operations in the shop; (b) implementing a plan to eliminate the bottleneck; (c) developing a finite schedule for the bottleneck; (d) creating buffers; and (e) assuring that the release of material into the plant is sufficient to support the bottleneck operation.

Umble and Srikanth[135] combine the principles of OPT and JIT to develop a philosophy of synchronous manufacturing. They assert that the new MPC system is an all-encompassing manufacturing management philosophy that could be assessed in terms of the common global goal of the organization.

Shivnan et al.[41] propose a hybrid MRP/OPT/JIT system with OPT developing the schedules, MRP acting as an information system, and JIT controlling production in the short term.

Olhager and Östlund[178] consider the linkage between manufacturing strategy and business strategy by changing the MPC focus. They show that push and pull strategy can be integrated. They suggest that the possible points of integration between push and pull systems can be related to the customer order point, to bottleneck resources and to the product structure. A case study is presented to illustrate a successful integration of a push-pull manufacturing strategy in a MTO production environment.

2.4 Customized System

In Newman and Sridharan's survey[29], about 9% of their responding U.S. corporations claim that they use their "home grown" systems to meet their unique needs. However, the data is not used for their own analysis. Whether some of these organizations create their own MPC systems or write their own software packages or develop their own hybrid systems that integrate several standard software systems, remains unknown. There is no any discussion why some organizations build their "home grown" systems rather than adopting some well-known standard MPC systems such as MRPII, or JIT, or OPT etc.

Some organizations prefer to purchase the standard software, than to write their own software, for the reasons that software development is costly, time-consuming and lack of external support for maintaining the software system.

I have contacted a number of manufacturing organizations over the past ten years and observed that most, if not all, of them feel unsatisfied with the packaged MPC software systems. In this regard, they try to modify the packaged application on their own or to buy the software system that can be customized to meet their specific needs. However, too often they find that the customisation process of the software system still bring about troubles such as surging expenses and the complexity of implementation. Rewriting or changing software may damage a key software link in a program and generate fatally flow data[179].

With the rapid advancement of IT, it seems possible that software makers may soon be able to offer the packaged MPC systems that allow for a certain degree of customisation, user-friendliness and at cheaper modification costs. As a consequence, more and more organizations may adopt customized MPC systems to fit their specific needs. The increasing competitive pressure in the fast-paced e-business era may prompt organizations to incorporate new MPC models that are capable to customize logistics and to align with new business practices. It is expected that the design of reconfigurable manufacturing systems (RMSs)[180] may provide another future research direction that is associated with customized MPC models.

2.5 Comparative Study

The comparative study of various MPC systems has given rise to much controversy for more than two decades. The critical issue is whether these standard MPC systems could contribute to production control and manufacturing thinking, and to what degree and under what conditions these systems would perform effectively. Although there are many MPC approaches/systems available, their uses always need to be evaluated and verified in the large context of the application. The results are mixed. These studies are described in Sections 2.5.1 to 2.5.7.

2.5.1 SIC versus MRP

Fortuin[75] compares two traditional Western MPC approaches, SIC and MRP, based on a simple production-inventory model. He shows that the benefits of using MRP are its resilient feature to cope with fluctuating demand, lower logistic costs, higher customer service level, and less data collection, despite its relatively high investment cost.

2.5.2 JIT versus MRP (or MRPII)

Rice and Yoshikawa[189] are the pioneers of the MRP/JIT comparison. They have discussed the overall differences and similarities of the MRP and JIT production systems. After comparing ROP, MRP and Kanban, Schonberger[42] concludes that ROP is the worst for all types of manufacturing. He further adds that a proper manufacturing environment must be defined for the evaluation of various MPC systems.

Matsuura et al. [190] indicate that MRP implementation is not a top priority among the Japanese organizations since MRP is regarded as a systematic top-down MPC system and it may contradict the Japanese management philosophies such as employees' involvement, and quality control circles etc. They further argue that MRP is a system that cannot be directly compared with JIT as a philosophy. MRP is implemented at the operational level, while the JIT system is achieved by executing the core Japanese philosophy. Therefore, comparison between MRP and JIT-Kanban is a more appropriate approach.

Benton and Shin[114] point out that JIT systems require the right execution, on time delivery; whereas MRP depends on the right signal and on time ordering.

Steele et al.[186] compare the performances of MRP, Kanban and Period Batch Control (PBC) in multi-cell manufacturing by a simulation study. Their results are mixed. It illustrates that: (a) under the mixed conditions and high Master Production Schedule (MPS) variation, PBC produces superior performance; (b) under non-JIT conditions, MRP is more effective; (c) Kanban performs best when manufacturing environment permits small lot sizes.

Im and Schonberger[197] regard JIT-Kanban as an advanced version of ROP approach, that has three major merits over MRP. First, capacity utilization is improved since JIT-Kanban has a shorter production planning horizon, which reduces throughput time of the manufacturing system. Second, the net requirements explosion is simple. Third, it improves the stability and flexibility of a manufacturing system because of the reduction in reaction time and the amount of committed resources.

Karmarkar[62] compares MRP (push) and Kanban (pull) systems in terms of order release, information flow, and batching policies. He concludes that all MPC systems have their strengths and weaknesses but are not mutually exclusive. He proposes that the best solution is a variety of hybrid MPC approaches that takes the benefits of each MPC system in order to fit for different production processes (see Table 2.3).

Lead-time variability	Control Stage: Materials Planning	Control Stage: Order Release	Control Stage: Shop Floor
High Pull: Continuous Flow	JIT	Rate-Based	JIT-Pull
Hybrid Push-Pull: Batch, Repetitive	JIT-MRP	Pull or MRP	Pull
Hybrid Push-Pull: Batch, Dynamic	MRP	MRP	Pull or Order Scheduling
Low Push: Custom Engineering	MRP	Order Scheduling	Operation Scheduling

Table 2.3: Hybrid MPC Approaches, Proposed by Karmarkar[62, p.128]

2.5.3 OPT (or DBR/ TOC) versus MRP (or MRPII)

Based on the simulation of an actual operating production environment, Duclos and Spencer[192] find that the scheduling procedure under TOC produces significantly better results than MRP systems. They also indicate that the constraint buffer used in the TOC approach successfully increases the system output. Contradictory to most of the research (as discussed in Section 2.3), the simulation study shows that hybrid system may not yield a satisfactory result.

Guide and Daniel[193] compares DBR and MRP systems based on a simulation study for a Naval Aviation Depot. They show that DBR is a more robust MPC approach than the MRP system.

Darlington and Moar[98] assert that OPT is a proven means of overcoming the shortcomings of MRPII systems. They identify the major differences between OPT and MRPII, as summarized in Table 2.4.

OPT	MRPII
1. Balance flows, not capacity.	1. Balance capacity, maintain flows.
2. Utilization and activation of a resource are not synonymous.	2. Utilization and activation of a resource are the same.
3. An hour lost at a constraint is an hour lost for the total system.	3. Impact is not realized.
4. Constraints govern both throughput and inventory.	4. Little impact on inventories, temporary impact on throughput.
5. An hour saved at a non-constraint is a mirage.	5. All savings have equal impact.
6. Transfer batches may not and many times should not be equal to process batches.	6. Lot splitting should be discouraged.
7. Process batches should be variable, not fixed.	7. Lot sizes should be fixed.
8. Schedules should be determined by looking at all constraints simultaneously. Lead times are the result of a schedule and cannot be predetermined.	8. Predetermine lot size and lead-time, assign priorities, schedule by longest lead-time first: adjust capacity by above.

Table 2.4: Differences between OPT and MRPII (Source: Darlington and Moar[98])

2.5.4 JIT versus OPT (or DBR/TOC)

Kanban system and TOC have some common features such as finite scheduling, set-up reduction, and no data integrating requirements etc. However, the two systems have some differences. Cohen[131] compares OPT with JIT. Table 2.5 summarizes their differences.

OPT	JIT
1. Focus on constraints, i.e. capacity, market, material, and management policy. 2. Computer software is used. 3. Process batch is a variable. 4. Use DBR as basic elements of synchronized manufacturing.	1. Focus on production flow; there is no capacity constraint since excess capacity is used. 2. Team work is used. 3. Process batch is fixed and pre-determined. 4. Restructure the facilities for synchronized manufacturing.

Table 2.5: Differences between OPT and JIT (Adapted from Cohen[131])

2.5.5 CONWIP versus Kanban

Spearman et al.[130] compare CONWIP with kanban. They argue that CONWIP is more effective than Kanban because of its relatively lower WIP while being applicable to a broader range of manufacturing environments where Kanban is impractical. The differences between CONWIP and Kanban are discussed earlier in Section 2.2.2.6.

2.5.6 Differences among MRP (or MRPII), JIT, and OPT (or DBR/TOC)

Based on a priori experience and qualitative reasoning, Shivnan et al.[41] review the development of the types of manufacturing process with the MPC system. They suggest that JIT is suitable for the repetitive manufacturing while OPT and MRPII is appropriate for the batch-oriented manufacturing.

Plenert and Best[35] reckon that both OPT and JIT are more productive than MRP and therefore they are two impressive options to MRP systems. They suggest that OPT is the best system and it is more complete than the JIT system. However, there is no empirical evidence and formal argument in both of the papers to support the above hypothesis.

Aggarwal[34] offers an assessment of MRP, JIT and OPT. Table 2.6 presents the summary of the points being discussed.

MRP	JIT	OPT
1. Uneven demand.	1. Stable demand.	1. Not available.
Goals:	Goals:	Goals:
2. Zero Stockouts;	2. Stockless production;	2. Maximum profit;
3. Setting priorities.	3. Eliminating wastes.	3. Setting priorities.
4. Extreme discipline.	4. Strict discipline.	4. Moderate discipline.
5. "Informal system" is prohibited.	5. Entrusted workers with responsibility and authority.	5. Not available.
6. Mass production assembly lines.	6. Not available.	6. Few fundamental products of large batch size; a few operations.
7. For planning medium-inventory situations; inflexible planning.	7. For well-structured supply lines and co-operative workers.	7. Adversely affect non-bottleneck areas.

Table 2.6: Comparison of MRP, JIT and OPT (Adapted from Aggarwal[34])

Plenert[194] assesses the success and failures of MRP by studying the system differences between JIT and OPT in the context of design and usage (see Tables 2.7 and 2.8). He asserts that there is a need to adjust the usage errors of MRP to make the system more competitive.

Area	MRP	JIT	OPT/TOC
Product flexibility	High	Narrow range	High
Order tracking	High	None	Fairly high
Data accuracy	High	None	High in limited areas
Computational needs	Lots	Minimal	Some
Scheduling flexibility	High	Poor	Good
Shop layout	Flexible	Restricted	Flexible

Table 2.7: Comparison of MRP, JIT and OPT in the Context of Design Differences (Source: Plenert[194])

Area	MRP	JIT	OPT/TOC
Production lead time	Very long	Very short	Medium
Production batch size	Large	Small	Varying
Resource efficiency focus	Labor	Materials	Bottleneck
Inventory levels	Large	Small	Medium
Set-up time	Averaged	Minimized	Adjusted

Table 2.8: Comparison of MRP, JIT and OPT in the Context of Usage Differences (Source: Plenert[194])

Several studies[e.g.183-185, 187] compared the performances of TOC, JIT and MRP using computer simulations. In Ramsay et al.'s[183] study, OPT appears to be the most useful approach in various circumstances. However, they indicate that since there is a lack of intelligence in the simulation program, the testing results may not be perfectly accurate. Neely and Byrne[184] suggest that the consideration of bottleneck resources when scheduling will favourably affect the system performance. Besides, they contend that the three systems are in fact complementary. Miltenburg[185] compares the performance of the three systems by four measures, i.e. output, inventory, cycle time, and shortages. JIT and TOC are found to out-perform MRP. Unfortunately, the choice of whether to use JIT or TOC is difficult to make. A simulation study undertaken by Cook [187] demonstrates that the traditional "Western" manufacturing system has no advantages

over either TOC or JIT. When comparing TOC with JIT, TOC outperformed JIT on a number of critical measures, including the output and standard deviation of flow time. However, he suggests that neither TOC nor JIT is a panacea to MPC problems. Newman and Sridharan's [29] survey indicates the following points:

- MRP systems accommodate to a wide variety of manufacturing environments;
- ROP systems work best in steady demand and a simpler environment;
- OPT applications are found mostly in process industry subject to a less complicated environment; and
- Kanban applications appear primarily in process industry and repetitive manufacturing conditions.

They address the issue that the performance of various MPC systems or approaches is dependent on the manufacturing environments.

2.5.7 Push System versus Pull System

According to Muckstadt and Tayur[195], a pull system has two distinctive qualities for shop floor management: (a) there is a clear control of the amount of inventory at each location; and (b) the Kanban mechanism reacts dynamically and immediately to a yield loss and other sources of variability. JIT-Kanban is generally agreed to be a pull system. However, to label MRP as a push or pull system is controversial. Aggarwal[34] holds that MRP and JIT are alternative approaches but Rice and Yoshikawa[189] argue that both Kanban and MRP systems are "pull-through" approaches. Pyke and Cohen[196] address the fact that a manufacturing system may contain a certain amount of push or pull components.

The principles to differentiate the nature of a push or pull system are divided. De Toni et al.[161] and Karmarkar[62] distinguish the system based on the order release policy. In a pull system, moving a part or end item prompts order release. On the other hand, a push system releases order in anticipation of future demand.

Olhager and Ostlund[178] use the structure of information flow to label a pull or push system. A pull system uses local information, while a push system makes use of global and centralized information to plan and control material flows.

Spearman and Zazanis[110] define push/pull systems based on a queueing network, which is influenced by the bounded WIP between workstations. A push system is considered as an open queueing network with infinite queue space, while a pull system is a closed queueing network.

Benton and Shin[114] contend that a push system initiates materials flow by the central planning system without controlling WIP level. A pull system withdraws the parts from the preceding process using local information systems to control WIP level.

Grovenevlt[198] considered that a Kanban (pull) system stores less information centrally. Most detailed information is scattered across the factory floor and may not be available in real time for a centralized system. In addition, a pull system sets the time scale for control much shorter than a push system. The pull mechanism transmits the necessary adjustments quickly. He further contends that MRP planners tend to react to uncertainty by increasing the planned lead time between order release and completion, which will create queues of WIP. The Kanban system tends to reduce uncertainty by efforts extending beyond the factory floor area such as high quality targets, high equipment reliability, extensive cross-training, small set-up times, continuous improvement, and extensive preventive maintenance, etc.

2.6 Summary

For decades, the study of the MPC systems or approaches has stimulated a number of research interests. The literature on this area is wide ranging from quantitative methods to system-based approaches, from a few independent research streams to hybrid MPC system studies.

The performance comparison of various MPC systems may provide a clearer picture for practitioners of the business world to select the right choice. Unfortunately, the assessment results are highly divided. The comparative studies have led to a strong debate. Moreover, many of these comparisons are mainly based on qualitative reasoning. Their theoretical basis and results from practical experience are not sufficient. The bulk of the research study is in a simulated environment with a limited scope. Few studies concentrate on the basic difference such as strategic issues, decision support framework,

organization structure, supply chain network etc. under various manufacturing environments.

A few comparative studies on the appropriateness of various MPC systems suited for a certain MPC environment and competitive strategy is based on a more sophisticated method using quantitative models. Simulation studies for this purpose have been carried out by Krajewski et al.[31] , Ritzman et al.[30] , Miltenburg[185] and Steele et al.[186]. The major limitation of this quantitative comparison is that they do not embrace the whole complexity of MPC problems. Besides, the evaluation of the performance among integrated hybrid MPC systems for the variety of real-life situations is relatively few. This remains a possible topic for future research. The general consensus derived from these comparative studies is that the existing MPC systems or approaches are complementary, rather than competitive. It would be better for an organization to integrate these MPC systems in order that the benefits of each system could be exploited.

From the literature studies in this thesis, it is difficult to conclude with a high degree of confidence which MPC system is the best. Each of the MPC systems has its strengths and weaknesses. Its application is highly dependent on a certain kind of manufacturing situations such as process characteristics, product flexibility, demand volume and fluctuations, shop facilities and layout, and order release policy, etc. There is no single perfect MPC system suited for all types of manufacturing situations.

Apparently, organizations in today's highly competitive business world are not satisfied with their existing MPC systems. For example, manufacturing corporations in Western countries endeavour to apply JIT philosophy, while Japanese organizations are interested in bringing the MRP concept into their manufacturing systems[190]. The quest for a "perfect" MPC system and the research for investigating the critical factors in the selection of an appropriate MPC system to cope with specific manufacturing environment continue. In this respect, the relationships among competitive and manufacturing strategies, manufacturing environment, and MPC systems are discussed in Chapters 3 and 4.

Chapter 3 Strategies and MPC System

One of the critiques on the literature review in Chapter Two is that the discussion of the strategic issue associated with various MPC systems is relatively little. According to Chandler[204], strategy is the determination of the basic long-term organizational goals, the adoption of courses of action, and the allocation of resources necessary for carrying out the goals. The MPC system, as part of the organization infrastructure, plays an important role to administer the process of resources allocation. In this respect, this Chapter examines the linkage between organizational strategies and the MPC system. Several types of strategies are reviewed: competitive priorities, focused strategy, process design strategy, product/process matrix, manufacturing system typology, manufacturing strategy typology, best practice strategy, positioning strategy, and supply chain strategy. Then the strategic archetypes are considered. Finally, the relationship between strategies and MPC system is discussed.

3.1 Introduction

Wallace[199] maintains that the Japanese organizations drive for manufacturing flexibility is giving impetus to MRPII system. This is an example to illustrate how the design and implementation of a MPC system is influenced by the manufacturing strategy, i.e. flexibility. In a word, MPC decision variables are related to manufacturing strategy. However, as discussed earlier, it is surprising to envisage that few MPC studies focus on the strategic issues of MPC systems under various manufacturing environments.

MRPII system (refer to Section 2.2.2.2) and HPP approach (refer to Section 2.2.1.4), as part of the manufacturing management process, encompass complex choices among a large number of decisions that affect several organizational echelons. These choices have to be made by trading off conflicting goals subject to organizational constraints such as internal resources, policy, and marketing (refer to Section 2.2.2.5). These two traditional Western MPC models could be typified by the taxonomy developed by Anthony[200], who classifies decisions into three hierarchical groups, i.e. strategic planning, tactical planning and operations control.

Strategic planning is externally oriented and, to a great extent, is used to define the competitive position of an organization, i.e. long-term business plan etc. Tactical planning is focused on the resource utilization process such as capacity, human resources, inventory level, and distribution resources, etc. Operations control includes day-to-day operational and scheduling processes that disaggregates the entire high-level plans into details such as operations sequencing, machines assignment, inventory control, dispatching, vehicle scheduling, and so on. As such, the strategies made at the higher levels must be translated accordingly to tactical planning and operations control at lower organizational levels. For example, MPC system decisions and processes are undertaken at the echelons of tactical planning and operations control after capturing the manufacturing priorities from higher hierarchy strategy.

Operations Management (OM) writers (e.g. Krajewski & Ritzman[201]) often suggest that the corporate strategy of an organization provides a framework of plans for the entire organization. Then the competitive priorities such as cost, quality, time and flexibility, are developed to act as a bridge between corporate strategy and functional strategies (see Figure 3.1).

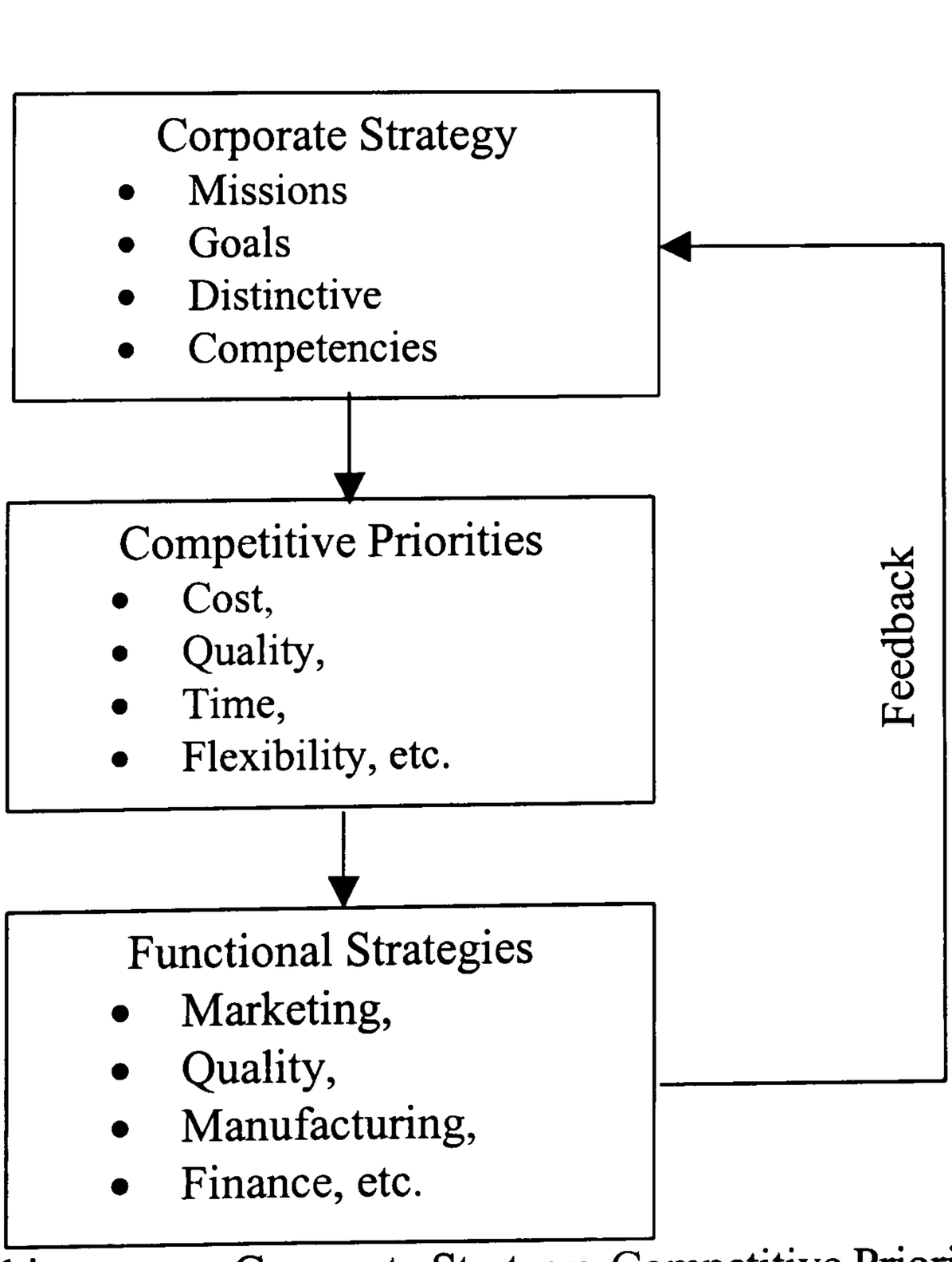


Figure 3.1: Relationships among Corporate Strategy, Competitive Priorities and Functional Strategies

3.2 Competitive Strategy (Priorities)

Much of the thinking on competitive strategy has been influenced by Porter's[205] competitive analysis and the interactions of five competitive forces: (a) the threat of new competitors; (b) the rivalry among existing competitors; (c) the threat of substitute products; (d) the bargaining power of buyers; and (e) the bargaining power of the suppliers.

Hayes and Wheelwright[2] defines competitive priorities as the dimensions on which the organization selects to compete in the marketplace. The establishment of an appropriate set of competitive priorities helps an organization to sustain or grow year after year, in good times and bad. The development of a competitive strategy, in a broader context, is a business unit problem[208], not a functional problem. A business unit problem is considered with the entirety of all functions such as marketing, accounting, finance, design, engineering, production, and distribution etc. It therefore requires an inter-functional approach to bring various sub-systems together.

The dimensions of the competitive priorities have been subject to considerable argument. It is not a universal set of priorities for an organization to compete in the global marketplace. Wheelwright[202] formalizes the concept of competitive priorities into four different priorities, i.e. price, flexibility, quality and dependability. He further segregates manufacturing strategic decisions into two groupings, i.e. structural decisions and infrastructural decisions. The structural decisions are considered to be more strategic, while the infrastructural decisions are more tactical. Of the eight key decisions, the structural grouping includes capacity, facility, technology, and vertical integration decisions. The infrastructural grouping includes workforce, quality, production planning and control, and organization decisions.

Based on the empirical study of 15 Canadian electronics organizations, Richardson et al.[215] identify six distinct corporate missions: technology frontiersman, technology exploiter, technological serviceman, customizer, cost-minimizing customizer, and cost minimizer. These priorities are ranged from those based primarily on innovations skills to those based on low-cost production.

Hayes and Schmenner[203] identifies five different dimensions: price, quality, dependability, product flexibility, and volume flexibility. Skinner[1] recognizes a combined list of competitive priorities, including plant and equipment, production planning and control, labor and staffing, product design and engineering, and organization and management. Hayes and Wheelwright[2] suggest capacity, facilities, equipment and process technologies, vertical integration, vendors, new products, human resources, quality and systems. Based on the systems-oriented decision flow model, Fine and Hax[214] divide the priorities into nine categories: facilities, capacity, vertical integration, processes and technologies, scope and new products, human resources, quality, infrastructure, and vendor relations.

Hill[218] argues that an organization should identify those criteria or priorities that win orders against the competition in the marketplace. His "order-winning" criteria include price, delivery, quality, product design and variety. Hill also considers that "qualifying" criteria (or performance criteria) are also important for an organization to achieve in an industry.

Krajewski and Ritzman[201] put forth a more detailed list by differentiating four different aspects: cost, quality, time and flexibility. Their list then includes low-cost operations, high performance design, consistent quality, fast delivery time, on-time delivery, development speed, customisation, and volume flexibility.

Porter[205] asserts that organizations have three generic strategies to provide a long-run defendable position. They are: (a) overall cost leadership – a business that seeks to be a low cost producer in an industry; (b) differentiation – a business that sees itself as unique in some characteristics valued by buyers; and (c) focus – a business may choose a narrow market or niche, competing on the basis of either a low cost or differentiation strategy. Porter[206] further adds that the generic strategies require different organizational arrangements, control procedure, and incentive system.

Wright et al.[207] indicate that there are two schools of thought on the strategic profile. One school of thought follows Porter's competitive strategies[205], i.e. viable organizations seek either cost efficiency or differentiation. However, this theory has been criticized for being simplistic. Another school of thought has proposed that the low-cost and differentiation strategies can be achieved simultaneously. They

demonstrate that organizations adopting an integrated low-cost and differentiation strategy outperform those organizations that compete mainly with either cost efficiency strategy or differentiation strategy. They assert that a manufacturing organization can compete in several dimensions.

3.3 Manufacturing Strategy

Manufacturing strategy reflects the organizational goals and corporate strategies, acts as the linkage among various decisions in operations management, guides various operating decisions, and develops the manufacturing strengths as a competitive weapon for an organization[209,210]. Hayes & Wheelwright[2] highlight the importance of manufacturing strategy to support an organization competitive success factors. Swamidass and Newell[209] empirically find that organization performance will improve when manufacturing managers are involved more actively in the strategy formulation process.

Two types of manufacturing strategy are reviewed, i.e. product-oriented and process-oriented strategies. Theories in the manufacturing strategy research, such as dominant orientation[205], and competitive priorities[201,210] take into consideration the product-oriented decision as a key element of strategy in the evaluation of the opportunities and threats in the market. Besides, there are theories in manufacturing strategy closely linked to process-oriented decision, such as efficiency versus flexibility[2,211] and economies of scope[212]. Such decision relates to the determination of how efficient an organization can achieve the process requirements and therefore affects the competitive strength of an organization. Hill[46] discusses five generic process types of manufacturing strategy across 25 dimensions in order to capture product and market requirements, manufacturing features, cost considerations, and infrastructure issues.

Williams et al.[262] capture the variables of manufacturing strategy along two dimensions: market orientation and technology orientation. Their research demonstrates that business performance is a result of a concerted effort of all the functional strategies within an organization, in which manufacturing strategy is one of these functional strategies.

Cil and Evren[263] link manufacturing strategy, market requirements and manufacturing attributes using an expert approach for the acquisition of manufacturing technology. They draw attention to the emergence of new technology rather than the conventional emphasis on the manufacturing-marketing coordination. Four types of competitive strategies are reviewed: innovation, customisation, product proliferation, and price reduction.

Most of the manufacturing strategy literature under review is conceptual. For an empirical study between strategy and MPC system such as this thesis, it is crucial that the scope and objective of the study are based on a firm conceptual framework. It is unfortunate that most of the frameworks are conjectures. There is a need to validate and test these conceptual works in order to become a solid research framework.

3.3.1 Focused Manufacturing Strategies

Skinner[212] suggests focused manufacturing strategies, i.e. product-focused or process-focused, that are considered critical to the long-term success. Figure 3.2 shows the focus strategy concept. In the upper left quadrant, a production plant deploying process-focus strategy uses a common set of processes to produce a small number of fairly homogeneous end products. In the bottom right quadrant, a product-focused plant manufactures similar products using several different process technologies. In the top right quadrant, an all-purpose facility produces a large number of products using many different technologies. All-purpose facilities are generally avoided. There are difficulties in achieving any particular competitive advantage for all-purpose facilities that are attempted to deliver "all products" to "all customers".

3.3.2 Process Design Strategy

OM literature generally classifies the manufacturing process types into five generic groups: (a) project, (b) job shop, (c) batch process, (d) assembly line, and (e) continuous flow. The operating dimensions such as facility layout, human factor, materials flow, information flow, and operating controls are considered to be variables, depending on the types of

process. Therefore, an organization should strategically choose a particular manufacturing process type that fits with the product and market requirements[2].

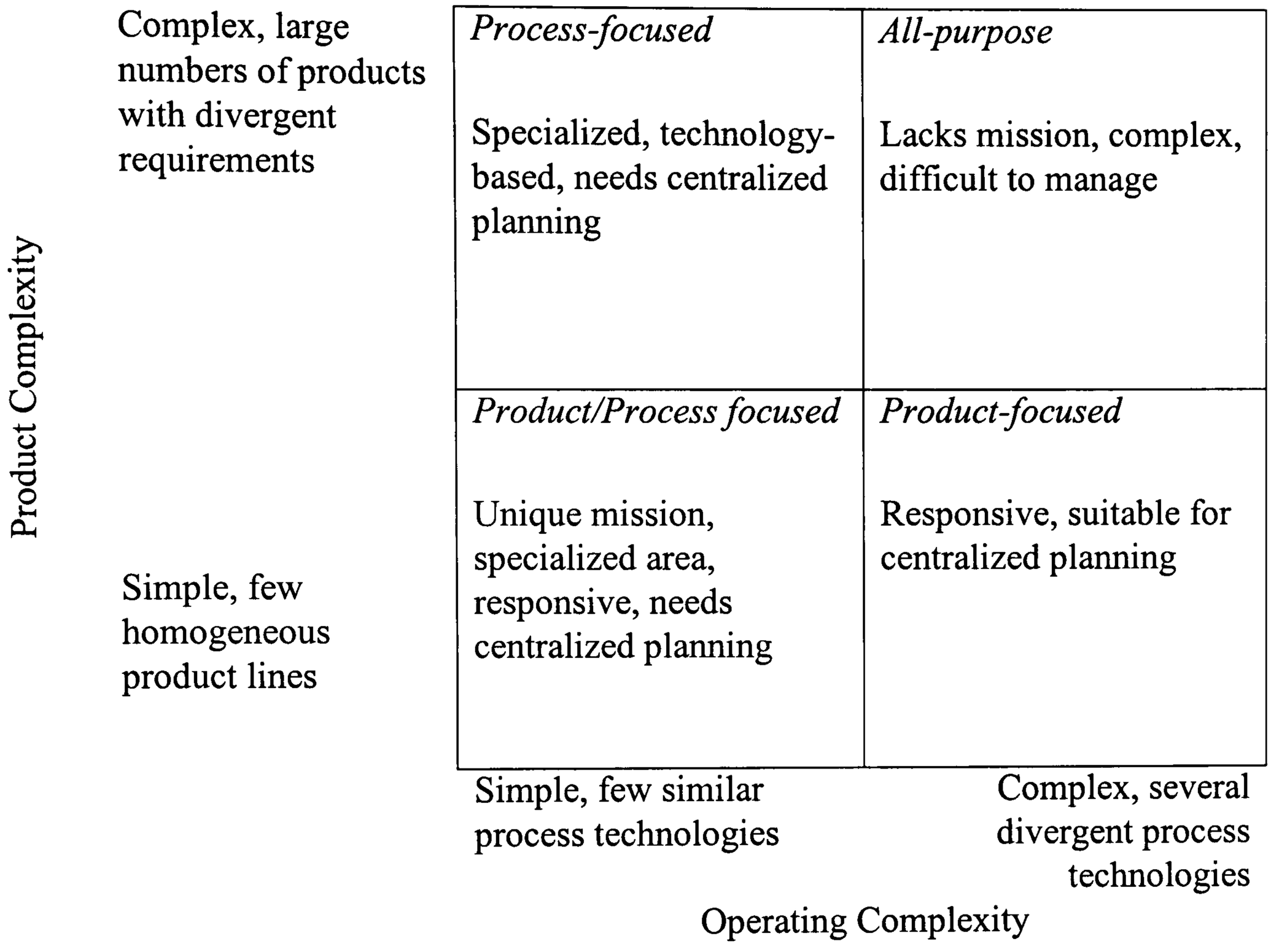


Figure 3.2: An overview of Focused Manufacturing Strategies
(Adapted from Skinner[212])

Krajewski and Ritzman[201] describes four features of process design: (a) degree of capital intensity, (b) resource flexibility, (c) vertical integration, and (d) customer involvement. In each of these features, the process design decision includes the manufacturing choice with reference to the trade-off between efficiency and flexibility. There exists an optimal point on the trade-off curve that decides the appropriate level of these features. As such, higher-level strategies could be effectively achieved.

3.3.3 Product/Process Matrix

The linkage between product and process decisions has also been the subject of many publications[e.g.2,201]. For example, Hayes and Wheelwright[2], based on four process

categories, initiate the concept of the product/process matrix as shown in Figure 3.3. They recognize the dynamic nature of operations process rather than considering the traditional concept of the ever-changing product phases only. Therefore, they recommend that integrating the concept of a process life cycle with the product life cycle can help an organization to determine among its various strategic options from a manufacturing

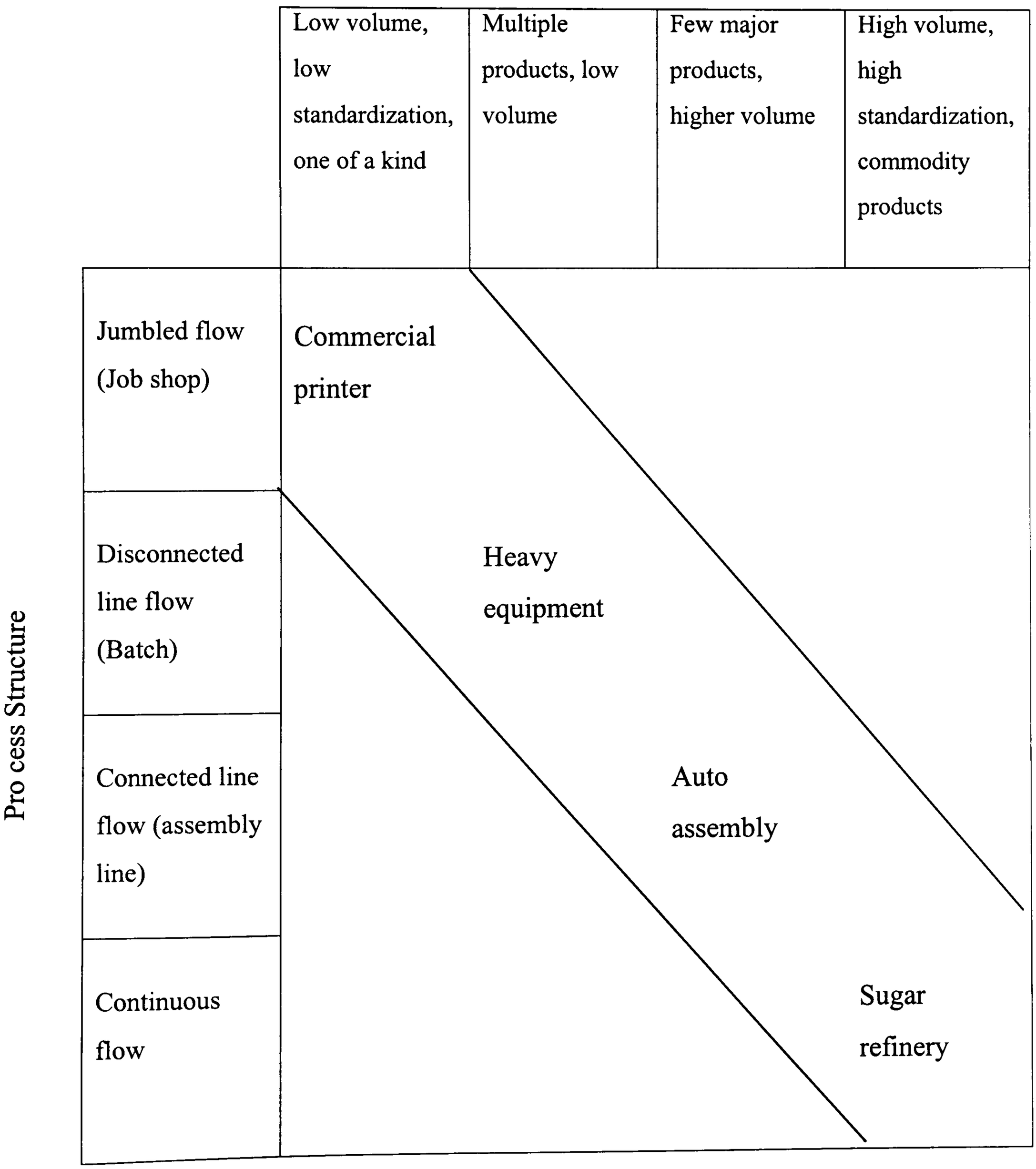


Figure 3.3: A Product/process Matrix (Source: Hayes and Wheelwright[2])

perspective. The best position for a manufacturing organization to compete more effectively in the market is on the diagonal of the matrix, where the product requirements and the process capabilities can be matched.

In addition, they also contend that the product-process matrix can be used as a useful tool to explore various strategic issues, such as distinctive competence, managerial implications, and the organization of focused operating units. They demonstrate that the priorities that govern the manufacturing function should change when products and markets evolve.

3.3.4 Manufacturing System Typology

Kim and Lee[217] proposed a new typology of production systems, based on two dimensions – technical complexity and technical flexibility. Four types of production systems are proposed (see Figure 3.4): (a) a degenerate production system implements the strategies of low technical flexibility and technical complexity; (b) a continuous production system adopts the strategies of low technical flexibility but high technical complexity; (c) an intermittent production system employs the strategies of high technical flexibility but low technical complexity; and (d) a concurrent production system executes the strategies of high technical flexibility and high technical complexity.

Technical Flexibility		
High	Intermittent production system (e.g. job shop, batch production etc.)	Concurrent production system (e.g. FMS, CAM, "factory of the future" etc.)
Low	Degenerate production system (e.g. non-competitive declining manufacturing system, "anachronistic factory etc.)	Continuous production system (e.g. transfer line, assembly line continuous flow process etc.)
	Low	High

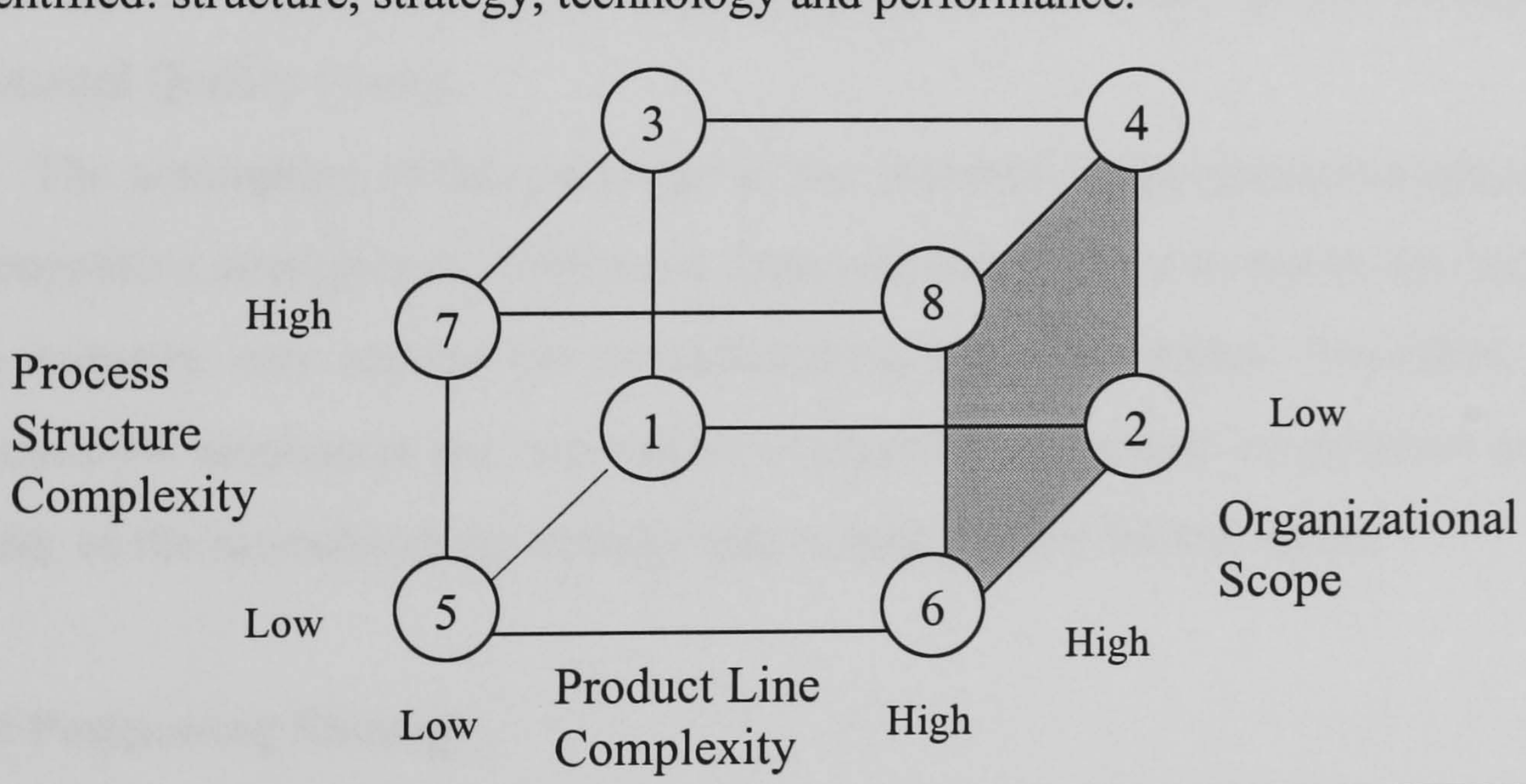
Technical Complexity

Figure 3.4: Kim & Lee's Typology of Production Systems (Source: Kim and Lee[217, p.6])

They provide a conceptual feature that takes into consideration of four decision variables, in which MPC is included. The relationship among MPC decision variables, generic manufacturing strategy and production systems is outlined (see Section 3.7 – Strategies and MPC system).

3.3.5 Manufacturing Strategy Typology

Kotha and Orne[216] provide a conceptual 3-dimensional framework (see Figure 3.5) that links manufacturing structure to business unit strategy at the strategic business unit (SBU) level. The dimensions of manufacturing system are based on the process structure complexity, product line complexity, and organizational scope. Eight manufacturing strategies are proposed (refer to points 1 to 8, Figure 3.5). This approach and conceptual synthesis provides a theoretical base for considering the process of fit and content of fit of a manufacturing organization. Four critical elements in manufacturing competitiveness are identified: structure, strategy, technology and performance.



Legend:
Point 1 denotes Segment, neither cost nor differentiation strategy;
Point 2 denotes Segment, differentiation strategy;
Point 3 denotes Cost leadership strategy;
Point 4 denotes Segment, mixed strategy;
Point 5 denotes Industry-wide, mixed strategy;
Point 6 denotes Industry-wide, differentiation strategy;
Point 7 denotes Industry-wide, cost leadership strategy;
Point 8 denotes Industry-wide, cost and differentiation strategy.

Figure 3.5: A 3-dimensional Manufacturing Strategy Typology
(Source: Kotha and Orne[216, p.225])

3.3.6 Best Practice Strategy

Hayes and Wheelwright[2] are the pioneers of the concept of world class manufacturing (WCM). They present a four-stage development of the strategic role in which, the final stage is the completion of world-class status. Schonberger[13] describes the goal of WCM as continual and rapid improvement with respect to quality, cost, lead-time, customer service, and flexibility. The underlying assumption of WCM practice is that it will lead to superior organizational performance. Since the 1990s, a considerable amount of best practice literature has been published. Examples of these practices are: JIT manufacturing[13], synchronous manufacturing[135], business process re-engineering (BPR)[219], concurrent engineering[221], lean production[222], and learning organization[223].

Voss[224] lists three major reasons for organizations to seek continuously best in class practice. They are: (a) outstanding performance of Japanese manufacturing; (b) the growth of business-process based techniques for improving organizational effectiveness; and (c) the emergence of promotional programmes such as the Malcolm Baldrige National Quality Award.

The assumption of this paradigm is that successful organizations implement the new competitive strategies of continuous improvement. Failure to match the best practice in an industry can reduce the manufacturing competitiveness. Therefore, Hayes and Pisano[243] emphasize the importance of creating operations capabilities, beyond world class, as the manufacturing strategy that is most needed for the future.

3.4 Positioning Strategy

Some researchers[e.g.,225,201] argue that the nature of relationships between the strategic decision variables determines the competitive position of a firm. They suggest the term "positioning strategy" for the choice of how the product and process decisions are linked together. For example, Porter[225] suggests three distinct sources for strategic positioning: (a) from the choice of product or service varieties, i.e. variety-based positioning; (b) from the targeting segment of customers, i.e. needs-based positioning; and (c) from different segments of customers, i.e. access-based positioning.

In addition, Porter reaffirms the crucial significance of strategic positioning in business competition. However, identifying them often requires creativity and insight since they are not obvious. A sustainable strategic position requires trade-offs. In other words, the "trade-off" process in strategic positioning creates the need for choice. In this context, a MPC system/process, as a key element of manufacturing infrastructure of an organization, requires management to determine and to create a unique and valuable position.

Krajewski and Ritzman[201] contend that positioning strategy serves as the linchpin between corporate strategy and manufacturing strategy (see Figure 3.6). They identify three fundamental positioning strategies that are commonly used in manufacturing industry, namely, MTS strategy, ATO strategy, and MTO strategy. On one extreme is the MTS strategy, in which materials requisition and production orders are based on forecasts. This strategy aims to offer a quick-response delivery to the customers at the cost of carrying inventories. The other extreme is the MTO strategy, in which no inventories are kept. Materials requisition and production orders depend on the receipt of a firm customer order. The third strategy, ATO, is a compromise between the above two extremes. In this positioning strategy, some raw materials, components or subassemblies are stocked for final assembly of end products. Production is activated by a firm customer order. Besides, they contend that product-focused manufacturing organizations tend to use an MTS strategy and process-focused organizations tend to use an MTO strategy. Organizations adopt an ATO strategy that addresses two competitive priorities: customization and fast delivery time.

The selection of an appropriate positioning strategy is product and market dependent. Krajewski and Ritzman[201] suggest that if positioning decisions are properly linked to other manufacturing decisions (e.g. strategic choices, design decisions, and operating decisions), the operation of an organization becomes a competitive weapon rather than a burden.

In the context of positioning decisions, Buffa[226] also contends that it is of considerable strategic importance to position the production system to match the market requirements. By positioning the product strategies with the production system, an organization can develop a competitive edge over its competitors. Berry and Hill[227] adopt

the same view. They propose a framework to determine an appropriate MPC system that reflects manufacturing strategy. They illustrate the critical need to link manufacturing strategy with production system by using the MPC system as an example.

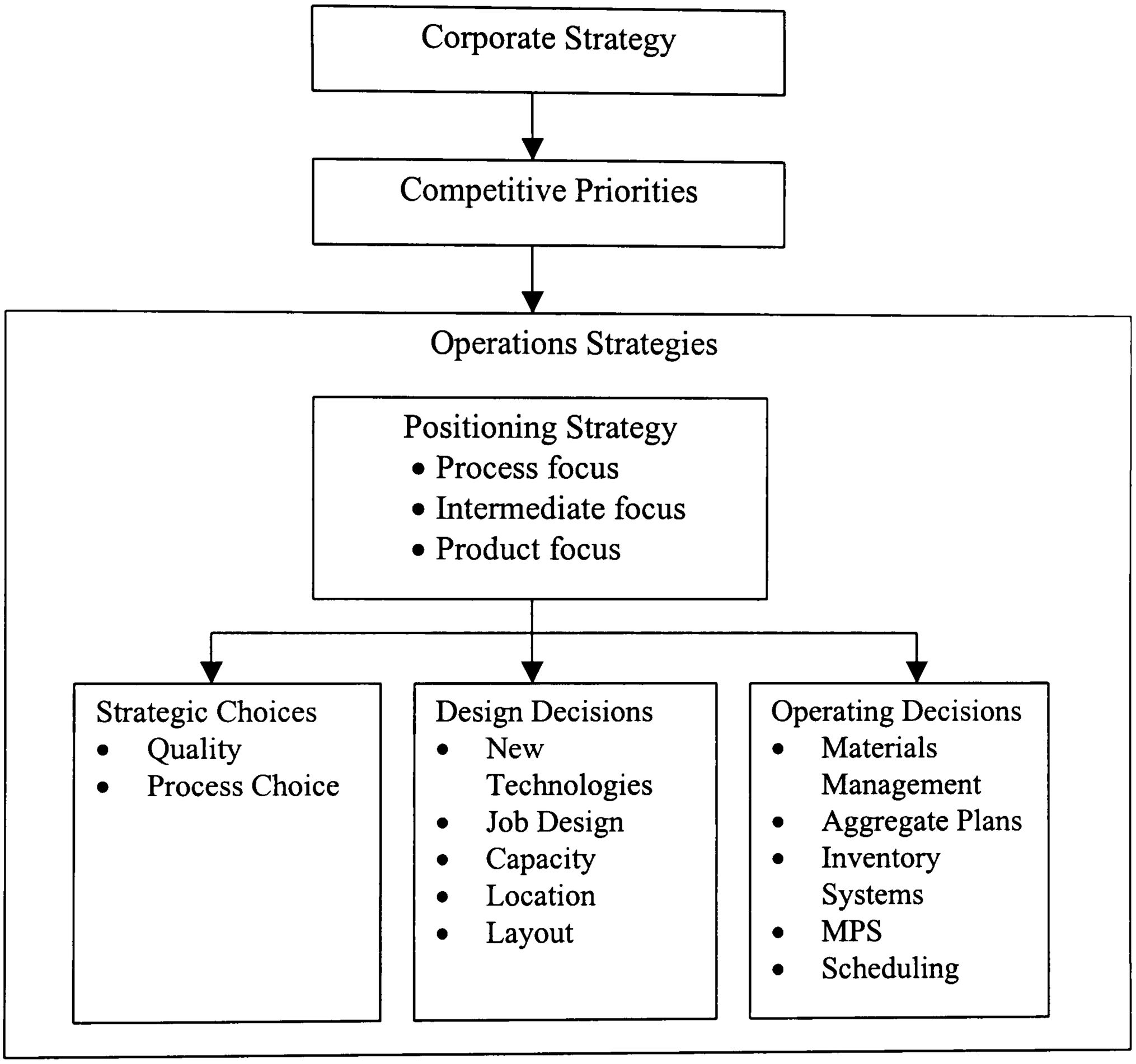


Figure 3.6: Positioning Strategy as a Linchpin between Corporate Strategy and Manufacturing Strategies (Source: Krajewski and Ritzman[201, p.46])

In addition to Krajewski and Ritzman's[201] three fundamental positioning strategies, Sari[228] describes the engineer-to-order (ETO) strategy, where products require unique engineering design or significant customization. Each customer order will result in a unique set of part numbers, BOM, and routings for manufacturing control.

Different manufacturing strategies will need different positions for the decoupling point (DP), a concept that outlines the possible product-market situations for the control of goods flow. Figure 3.7 depicts five DP positions, developed by Hoekstra and Romme[229].

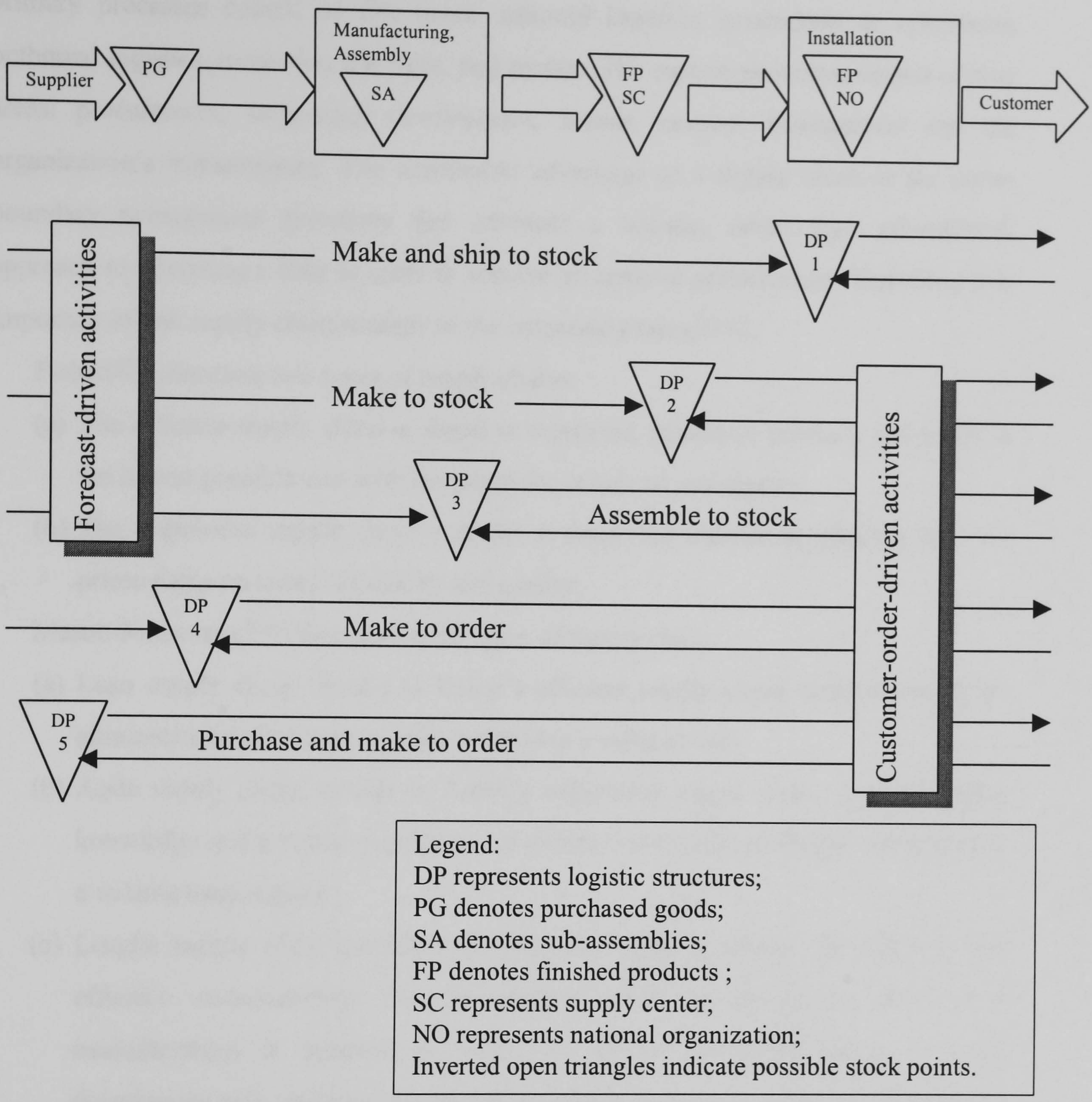


Figure 3.7: Decoupling Point Position for Different Manufacturing Strategies
(Source: Hoekstra and Romme[229, p.7])

3.5 Supply Chain Strategy

A supply chain refers to an integrated and sequentially interrelated value system of suppliers, manufacturers, subcontractors, distributors and retailers, working together with the prime purpose to create value to the output for the ultimate end-users. According to Porter[206], each supply chain has a collection of some nine generic and discrete activities that can be divided into two broad groups: primary processes and support processes. The

primary processes consist of five areas: inbound logistics, production or operations, outbound logistics, marketing and sales, and service. The support processes consist of four areas: procurement, technology development, human resource management and the organization's infrastructure. The sustainable advantage of a supply chain is the cross-boundary management processes that advocate a holistic, rather than sub-optimal, approach to operating a firm in order to achieve an optimal performance. Therefore, it is important to link supply chain strategy to the corporate strategy[232].

Fisher[230] discusses two types of supply chains:

(a) The efficient supply chain is aimed at supplying functional products efficiently at the lowest possible cost with the prime focus on cost and quality.

(b) The responsive supply chain is aimed at supplying innovative products with the prime focus on speed, flexibility and quality.

Mason-Jones et al.[231] discusses three types of supply chain:

(a) Lean supply chain, similar to Fisher's efficient supply chain, emphasizes on the elimination of all wastes in order to develop a value stream.

(b) Agile supply chain, similar to Fisher's responsive supply chain, uses its market knowledge and a virtual organizational structure to exploit profitable new niches in a volatile market place.

(c) Leagile supply chain combines the lean and agile paradigms for effective and efficient manufacturing. On the upstream side of decoupling point, lean manufacturing is adopted in order to achieve cost-effectiveness. On the downstream side, agile manufacturing is applied in order to achieve a high service level for the end-users.

As such, a supply chain strategy is dependent on the nature of the supply chain. A lean (or efficient) supply chain is focused on efficiency, quality and cost leadership. An agile (or responsive) supply chain emphasizes responsiveness, flexibility and quality. A leagile supply chain strategy is a mix-mode with upstream activities focused on efficiency, quality and cost leadership; while downstream activities focused on responsiveness, flexibility and quality.

The advancement of E-commerce and the movement of supply chain reengineering processes mark the trends in organization structural shift. A new organization arrangement

– extended supply chain (see Figure 3.8), has evolved. The increasing outsourcing activities largely manifest it. The core firm of the supply chain develops close relations with partnering firms to form alliances in the following ways: upstream, subcontracting extended logistics, downstream (sales and marketing), and downstream (service) partnerships.

(a) By extending beyond the conventional supplier relationship, an upstream partnership could be established. It is not just to secure the inputs for the core firm but also to make the supply chain to be more responsive to the changing customer demands.

(b) A firm could set up a subcontracting partnership by contracting out partially or fully the customer orders. The major purpose is to expand the capacities of the supply chain and be more flexible to the market demands.

(c) By allying with third-party logistics (3PL) service providers, an extended logistics partnership is formed in order to maintain quality logistics (outbound) services and to achieve the economy of scale for shipment.

(d) When the number of consumers in the market is large or the distribution process in a foreign market place is difficult to carry out, the downstream (sales and marketing) partnership can be developed by allying the core firm with the distribution and retailing firms in a supply chain. Supply chain complexity due to sophisticated consumer market and complicated distribution channel could be reduced.

(e) Downstream (service) partnership could be used to provide a better service to the end-users. For example, the core firm may affiliate with application services provider (ASP) for collaboration in workflow management, or associate with universities or research institutions in research projects, teaching company schemes, etc.

When an MPC system is considered to be a part of an overall supply chain, partnering departments such as marketing and sales can work with operations department to quickly assess the feasibility of demand changes and distribution needs based on realistic capacity constraints. Production plans, which account for broader business objectives, can be generated. As such, a proper integration, both horizontally and vertically, of an

organization based on supply chain strategy will result in better manufacturing planning and execution.

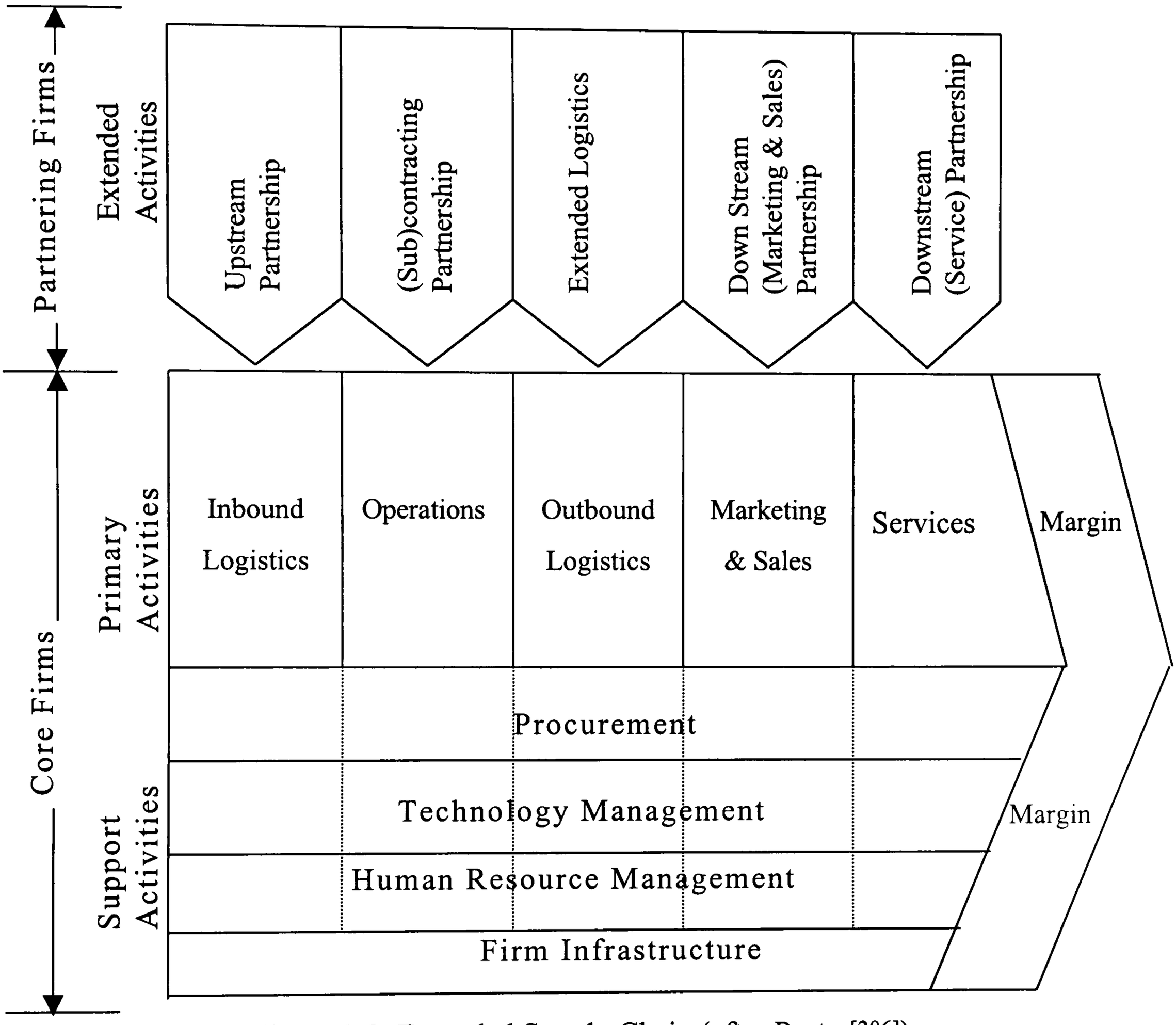


Figure 3.8: Extended Supply Chain (after Porter[206])

The rules of the business game are altering so rapidly for several major reasons: (a) an ever-increasing processing power of information technology (IT); (b) the move towards the more "open" systems that enhance the potential for inter-connectivity of manufacturing systems and disparate business partners; and (c) growing interest in extending system integration beyond the production boundary. As a consequence, the traditional MPC systems lose much of the value. For example, ERP system was previously served only for internal "planning and execution", but it has now been reconfigured into the E-commerce solutions for improving the competitive stance of an organization. Table 3.1 depicts the

effects of E-business on supply chain and logistics[233] during four different stages of business application.

	Market Laggards	Majority	Current Leaders	New Economy
	Stage 0	Stage 1	Stage 2	Stage 3
	Supply Chain Orientation	Advanced Supply Chain Management	E-Commerce	E-Business
Manufacturing Planning & Scheduling	MRP MRPII ERP	ERP – Internal Connectivity	Collaborative Network Planning – Best Asset Utilization	Full Network Business System Optimization Shared Process and Systems
Logistics	Manufacturing Push – Inventory Intensive	Pull System Through Internal/external Providers	Best Constituent Provider – Dual Channel	Total Network, Dual Channel Optimization
IT	Point Solutions Internal Silos	Linked Intranets Corporate Strategy/ Architecture	Intranet-based Extranet Shared Capabilities	Full Network Communication System Shared Architecture Planning

Table 3.1: The Effects of E-business on Supply Chain and Logistics
(Source: Gecowets and Bauer[233])

3.6 Classifications of Organization Strategies

In this Section, three representative typologies of strategy are reviewed, namely, Miles & Snow's[234] strategic archetypes, Miller & Roth's[47] taxonomy of manufacturing strategies, and Ward et al.'s[271] strategic configurations. Miles & Snow's work is applied to both manufacturing and servicing industries, whilst the remaining two taxonomies are associated with manufacturing environment only.

3.6.1 Miles & Snow Strategic Archetypes

On the basis of three problem domains (entrepreneurial, engineering, and administrative), Miles and Snow[234] conclude a conceptual "product-market strategy-structure" typology that could be summarised into four different strategic types:

(a) A "defender" organization tends to create a stable domain. Its target is to produce a limited set of products and maintain a small niche within the industry. It emphasizes technological efficiency by continuous reduction in distribution, production and administration costs.

(b) A "prospector" organization strives to be an innovator in product and market development. The environment of a prospector is neither stable nor predictable because of the new market domains. A strong orientation in technological and administrative flexibility is necessary in response to a rapidly changing environment, but production and distribution efficiency is hardly achieved because of the under-utilization or mis-utilization of physical, financial, and human resources.

(c) An "analyser" organization has good adaptation capabilities endeavouring to minimize risk and maximize opportunities for profit. It tends to imitate the successful prospector products and modifies them for the market. The strategic orientation is a combination of defender and prospector types.

(d) A "reactor" organization has no clear strategic focus. It responds to its organizational environment ineffectively and is forced to adjust its strategy-structure by pressures. There are three main reasons causing the firm's instability: lack of clear articulated strategy; not fully reconfigured structure and process to fit with chosen strategy; and the rigidity of the strategy-structure of the firm despite the changes in environmental conditions.

However, the Miles and Snow study focuses more on innovation and market-product domain but offers relatively few details about manufacturing strategy. Furthermore, the study gives little attention to the processes of change between archetypes.

Carrie et al.[235] combine Miles & Snow strategic archetypes and Ingham company types and develop13 possible situations that a manufacturing organization may have to operate (see Table 3.2).

Ingham Type	Miles & Snow Strategic Archetypes		
	Defender	Prospector	Analyzer
MTS, narrow range of own design products	X		
MTS, narrow range of products designed to customers specification		X	X
MTO, wide range of products		X	
MTO wide range of products, with some standard MTS products		X	X
MTO wide range of products, with some standard components		X	X
MTO wide range of products, with both standard products and standard components			X
Jobbing contractor capital goods		X	X
Jobbing contractor		X	X

Table 3.2: The 13 Possible Combinations of the Ingham and the Miles & Snow Strategic Archetypes (Source: Carrie et al.[235])

3.6.2 Taxonomy of Manufacturing Strategies (Miller & Roth)

Miller and Roth[47] examine the strategic management practices of 188 North American organizations and derive empirically three distinct manufacturing strategic types: caretakers, marketers and innovators. They demonstrate that manufacturing organizations tend to fall into one of these three groups, characterized by a mixture of manufacturing task profiles. The taxonomy of manufacturing strategies is described below.

(a) The "caretaker" organizations rank price as the dominant competitive capability. They tend to place relatively lower emphasis than their competitors on the improvement programmes.

(b) The "marketer" organizations seek to obtain broad distribution and product lines. They tend to be responsive to changing volume requirements. Conformance quality, dependable deliveries, and product performance are their dominant competitive capabilities.

(c) The "innovator" organizations emphasize the ability to make changes in design and to introduce products quickly. Similar to "marketer" organizations, they rank

conformance and performance quality as their dominant competitive capabilities. Besides, dependability is also emphasized.

Their research study supports the concept that a manufacturing strategy is related to product life cycles. The products of "innovator" organizations have a relatively short life cycle. The products of "marketer" organizations are well established and would be in a more mature phase of life cycle. The "caretaker" organizations demonstrate the product characteristics in the declining stages of the life cycle. In the "product-process" context, the "innovator" organizations are at the near end of the job shop continuum, while the "caretaker" organizations are at the opposite end, i.e. continuous process type; and the "marketer" organizations lie in between.

Miller and Roth[47] compare their three distinct manufacturing strategies with Miles and Snow's[234] strategic archetypes and reckon that "innovators", "marketers", and "caretakers" are similar to "prospectors", "differentiators" and "defenders". Nevertheless, their taxonomy yields fewer categories.

3.6.3 Strategic Configurations (Ward and Colleagues)

Ward et al.[271] identify four basic strategic configurations: niche differentiator, broad differentiator, cost leader, and lean competitor. These configurations are conceptual framework linking competitive strategy, organizational structure, environment, and manufacturing strategy. Each configuration is reviewed and summarized as follows:

(a) A "niche differentiator" offers specialized products to a narrow market segment defined by customer, product, technology or locale. It typically operates under a high velocity, high complexity, and low munificence environment. It has a flexible production facility in order to accommodate environmental changes. Strategic emphasis is either on quality or delivery performance.

(b) A "broad differentiator" provides a wide range of products to a variety of markets. It operates under unpredictable, complex and dynamic environment. The skill bases in product development, manufacturing and marketing are essential for a broad differentiator in serving a diverse market. It faces with conflicting objectives between product customisation and cost reduction.

(c) A "cost leader" supplies a range of high-volume and usually mature products to the market under the conditions of stable environment. Manufacturing strategies such as low-cost and quality are extremely important.

(d) A "lean competitor" pursues a broad product-market scope with an aim to accomplish low-cost manufacture and product differentiation. It copes with dynamic, complex and munificent environment. Strategic focuses are: quality, cost, delivery, and flexibility.

Ward et al.[271] propose that the fit between manufacturing strategy and its constellation of competitive strategy, structure, and organizational environment is important.

3.7 Strategies and MPC System

Hill[46] asserts that the organization infrastructure is contingent on the choice of process. Berry and Hill[227] illustrate this in the area of MPC. They demonstrate that the linkage among market, process and MPC system is the key to implement an appropriate system.

Skinner[1] compares the differences between conventional factory and focused factory in the context of production scheduling and control.(see Table 3.3). He observes that MPC approaches would be different under different manufacturing conditions.

	Conventional Factory	Focused Factory
Production scheduling and control	Detailed, frequent sales forecasts; produce for inventory economic lot sizes of finished goods; small, decentralized production scheduling group.	Produce to order special parts and stock of common parts based on semi-annual forecast. Staff production control to closely schedule and centralize parts movement.

Table 3.3: Comparison between Conventional Factory and Focused Factory in the Context of Production Scheduling and Control (Source: Skinner[1,pp.80-81])

Miller[220] identifies eight key design issues for strategic choices such as competitive strategy, key manufacturing task, architecture, priorities, reflexes, focus, technology, and

responsibilities. He reckons that MPC system must be linked with manufacturing policies, organization, and the competitive posture of an organization.

The discussion in Section 3.5 regarding the effect of E-business on a supply chain and logistics is another example to illustrate the possible relationship between strategy and MPC system.

Based on Porter's generic manufacturing strategies and the proposed systems (refer to Figure 3.4), Kim and Lee[217] hypothesize the relationship between MPC variables, manufacturing strategies and manufacturing systems (see Tables 3.4 and 3.5). The relationships, however, are conceptual in nature and requires empirical test to validate these strategic variables. They further recommend that the development of new manufacturing infrastructure is essential for competitive advantage. There is therefore a need to study the MPC variables in new manufacturing environments.

	Pure cost-leadership	Pure differentiation	Cost & differentiation
MPC Variables:			
Inventory size	Large	Small	Small
Set-up time	Large	Small	Very small
Lot size	Large	Small	Small

Table 3.4: Comparison between MPC Variables and Manufacturing Strategies
(Source: Kim and Lee[217, p.11])

	Degenerate Production System	Intermittent Production System	Continuous Production System	Concurrent Production System
MPC Variables:				
Inventory size	Large	Small	Large	Small
Set-up time	Large	Small	Large	Very small
Lot size	Not determined	Small	Large	Small

Table 3.5: Comparison between MPC Variables and Manufacturing Systems
(Source: Kim and Lee[217, p.12])

3.8 Review

A number of studies associated with competitive and manufacturing strategies are reviewed. Several points can be drawn:

- The general consensus of these studies recognizes the dimensions of the competitive strategy that include cost, quality, flexibility, and delivery.
- Most of the writers suggest hierarchical approaches for the strategic management process.
- Manufacturing strategies can be classified into two types: product-focused strategy, and process-focused strategy.
- Strategy, system, product, process, and technology are related.
- Positioning strategy serves as the linchpin between corporate strategy and manufacturing strategy.
- Manufacturing strategy is multi-dimensional.
- Manufacturing infrastructure such as MPC system relates to strategic choices.

Some of the manufacturing strategy literature takes into account the MPC system/approach. Berry and Hill[227] acknowledge the importance of choosing an appropriate MPC system that fit with the manufacturing strategy. Skinner[1] identifies MPC as one of the decision variables for the comparison of two factories with different focused strategies. Miller[220] contends that MPC system must be linked with manufacturing policies and competitive priorities. Kim and Lee[217] propose the possible relationship between MPC variables, manufacturing strategy and system. According to these analyses, manufacturing infrastructure such as MPC system/approach relates to strategic choices.

Some researchers conduct surveys on manufacturing strategies (e.g. Swamidass and Newell[209]). Some other researchers apply more vigorous confirmatory statistical methods in order to clarify and validate the conjectures in manufacturing strategy studies. Examples of these statistical methods are: regression analysis[52,215] and path analysis[209] etc.

Analytical research has been criticized due to their unrealistic assumptions. Given that the problems cannot be defined clearly enough due to unrealistic assumptions, the meaning of optimality for analytic method is particularly weak for solving strategic decision

problems. Therefore, the application of an analytical method in manufacturing strategy research is not popular.

Unfortunately, most of the manufacturing strategy literature is conceptual in nature. Therefore it is essential to carry out more empirical studies in order to validate and test the concepts and propositions in manufacturing strategy.

In this Chapter, the supply chain strategy is also discussed. There are two implications:

- The holistic approach offers a broader perspective for integrating business processes in order to achieve an optimal performance. It indicates the importance to extend the scope of study beyond the MPC boundary.
- The changing business rules (i.e. business environment) often devalue the utility of the traditional MPC system. It indicates that it is worthy to conduct the research inquiry beyond the organizational boundary.

In such regard, the review of the relationship among MPC system, strategy and organizational environment is necessary and it is carried out in Chapter 4.

Chapter 4 Organizational Environment, Strategies and MPC Systems

Further to the study of the relationship between organizational strategies and MPC system in Chapter 3, this Chapter broadens the scope of review beyond the system boundary to organizational environment. The operational measures of general and task environmental attributes are discussed. Then the relationships between organizational environment and a constellation of competitive strategy, manufacturing strategy, supply chain strategy, and MPC system are reviewed. Finally, the environment-strategy (E-S) fit is considered.

4.1 Introduction

Numerous authors[e.g.236,237,238,239,240,241,30,29,242,36,52,209] support the premise that the organizational system interacts with the environment. Organizational survival and performance depend on the implementation of an appropriate system that suits the environment conditions. Examples of organization studies associated with environment are: Lawrence & Lorsch[236], Aldrich & Pfeffer[237], Miles et al.[238], Lenz[239], and Thompson[240]. Examples of MPC studies related to environment are: Klassen & Whybark[241], Ritzman et al.[30], Newman et al.[29,242], Karmarkar et al.[36], Van Dierdonck & Miller's[52] and Swamidass & Newell[209].

Lawrence and Lorsch's[236] study implies that organizations may face multiple specific environments that are not uniformly stable. They argue that there are two types of environment, i.e. internal environment and external environment. Successful organizations should carefully balance the two opposing forces, integration and differentiation, so that each department of an organization should meet with the demands of their sub-environments.

Aldrich and Pfeffer[237] contend that different environments may lead to different organizational forms. Miles et al.[238] has suggested four patterns of organization-environment interaction, namely, domain defenders, reluctant reactors, anxious analysers,

and enthusiastic prospectors. Similar to Miles et al.'s work[238], Aldrich and Pfeffer[237] propose that some types of organizational forms fit the specific environment.

Lenz[239] finds that the organizational performance depends on a set of factors including organizational environment, strategy, and organization structure. A single factor is sufficient to explain the performance differences.

Thompson[240] postulates two dimensions of organizational environment, i.e. homogeneous-heterogeneous environment and stable-unstable environment. He considers environmental uncertainty at different organization levels and asserts that uncertainty is more prevalent at the institutional level than other organizational levels. To cope with uncertainty, an organization must be restructured at the institutional level.

In their survey[241] to identify barriers to the effective management of international manufacturing operations, Klassen and Whybark find that there is a need for international manufacturing organizations to understand international environment and its impact on manufacturing management.

The simulation work done by Ritzman et al.[30] implies that an organization may improve their performance by creating and shaping the manufacturing environments. Newman et al.'s survey results[29,242] also confirms that there are significant performance differences between manufacturing organizations that use different MPC systems under various operating environments.

Karmarkar et al.[36] supports the hypothesis that different MPC systems might suit different manufacturing environments. They claim that it is difficult to measure the variables for statistical analysis because of the complicated nature of the relationships amongst market conditions, production processes, and the systems.

Van Dierdonck and Miller[52] link competitive strategy and MPC system with organization environment. They assert that the complexity and uncertainty of MPC tasks are dependent on the strategy and environment of an organization.

Swamidass and Newell[209] empirically find that environmental uncertainty influences manufacturing strategy variables and, in turn, affects business performance.

It is widely accepted in the literature on organization-environment interactions that environmental variables must be taken into consideration in the design of an effective

organizational system. This premise is also applicable to the development of MPC systems, which interact with manufacturing environment.

4.2 Organizational Environment

Based on both 2-dimensional environment and 2-dimensional strategy, Bourgeous[245] suggests three views of environment for research in organization theory (OT). In this conceptual framework, the environment is categorized into "task" and "general", while the strategy is sub-divided into primary (domain selection) and secondary (competitive approach) levels. The environment encompasses three perspectives. The first perspective is on the external stakeholders such as customers, competitors, and suppliers, etc. The second perspective focuses on the attributes external to an organization, such as complexity, dynamism, and volatility, etc. The third perspective is the managerial perceptions such as perceived environmental uncertainty (PEU). Table 4.1 depicts the three views of environment.

Perspectives	Dimensions	Operational Definitions
External: Objects	General Environment and Task Environment.	Not operationalized (for Organization Theory research).
External: Attributes	Complexity, Heterogeneity and Dynamic-shifting or Volatility.	Number of task environment components and Rate of change or Technological and market volatility.
Internal: Perceptions	Perceived Environmental Uncertainty.	Lack of information; knowledge about decision outcomes; ability to estimate environment's effect on firm's performance.

Table 4.1 Three Views of the Environment (Source: Bourgeous[245,p.35])

Sections 4.2.1 and 4.2.2 review the general environment and environmental attributes respectively.

4.2.1 General Environment

The general environment (or known as macro-environment) approach is to consider the organizational environment in a broader sense. The environmental factors include economic system, economic conditions, governmental agencies, social system, legal system, cultures, educational system, and technology etc. Examples of the classification schemes for characterizing the general environment are: Jurkovich's[258] core typology of environment and Tung's[259] study. Since not all the general environmental factors will affect an individual organization, there is a need to consider the more specific environmental forces, i.e. task environment (see Section 4.2.2), for this research. After reviewing MPC literature, the MPC system measures that relate to general environmental variables are presented in Table 4.2.

Variables	Measures Related to MPC System
General environmental relationships: Market conditions	Frequency of changes; the number of different markets; % output to overseas; % output for local market; product variety, product life cycle; the number of components in the products
Economic conditions	Economic expansion; depression.
Information technology	Rate of technological change; telecommunication infrastructure.
Manufacturing technology	Rate of technological change; choice of software.
Physical conditions	Transportation facilities; physical infrastructure.
Social system	Availability of human resources; culture; educational level.

Table 4.2: Operational Measures for General Environmental Variables Associated with MPC System

4.2.2 Attributes of the Task Environment

Dess and Beard's[239] codification of environmental dimensions is a common approach to measure an organization's task environment. They reduce the conventional environmental attributes from a 6-dimensional to a 3-dimensional task environment, i.e. munificence

(capacity), complexity (homogeneity-heterogeneity, concentration-dispersion), and dynamism (stability-instability, turbulence).

Munificence is the extent to which the availability of environmental resources supports sustained organizational growth (e.g. Starbuck [252]). It also relates to the degree of a firm's capacity to the resources that it requires. Aldrich[244] studies the relations between organization and its environment and he asserts that a firm seeks the environment that has abundance of resources, i.e. high munificence, to permit organizational growth and stability. In the conditions of high environmental munificence, firms have more means and higher flexibility to achieve their goals. However, under the conditions of low environmental munificence, firms would have little strategic options[251], encountering high competitive pressures[239], and requiring changes in their planning and control systems, budgets, facilities and structure[253].

Dynamism is the rate of change in the organization environment due to market instability and environmental turbulence[244]. The more dynamic the environment of an organization, the higher the uncertainty a firm faces and it would be more difficult for it to predict the probabilities of future outcomes. Hence, the knowledge available for making decisions is reduced[254] and some critical criteria for the evaluation of alternatives will go unnoticed. Under such situations, both the strategy-making and the manufacturing planning processes could become ineffective. Firms that are experiencing high dynamism will face more environmental changes such as fluctuating demands, random production volume, varying material prices, disruptions in supplies, changing engineering requirement, and frequent introduction of new products, etc.

The notion of environmental complexity has its origins of difficulty in handling a great number of issues relating to human relationship, inter-organizational relationship, technical matters, operational and administrative processes, etc. It is the degree of heterogeneity and the dispersion of an organization's activities[244,252]. As firms become larger and involve a greater number of interactions, both internal and external, the underlying management processes will be more complicated and the difficulties increase. The larger the interaction a firm handles, the higher is the environmental complexity[255,256]. Complexity naturally increases due to either (a) external factors such as the increases in the number of external stakeholders, or (b) internal factors such as the

increases in the number of product items, inputs, and work-centres. Thus, a firm in a highly competitive environment that requires many inputs or that produces many outputs is operating in a more complex environment than a firm with relatively fewer inputs and outputs[239]. Extant literature asserts that firms operating under high environmental complexity must become more flexible, adaptive and organic for organizational effectiveness[236,257].

A further discussion on the operational measures of Dess and Beard's[239] 3-dimension environmental attributes is presented in Sections 7.5.2 and 7.6 of Chapter 7.

4.2.3 Other Operational Measures of Environmental Variables

Nowadays organizations become more network-like with a number of inter-organizational tasks to be carried out[261]. The task environment attributes could be measured at both intra-organizational and inter-organizational levels. In addition, Harrison[260] suggests a more precise conceptualization of the environmental variables than the general taxonomic studies of organizational environment. An attempt is made to classify the exogenous forces as constraints on MPC systems according to interdepartmental and inter-organizational relationships. The measures for the MPC environmental variables are tabulated in Table 4.3.

4.3 Strategy and Organizational Environment

Organization and strategy theorists have suggested that the environment is a critical determinant of a strategy. The literature on organizational theory views the external environment of an organization as the source of events and a series of changing rules that create opportunities and threats for an individual organization. The purpose of developing a strategy is to identify these external threats and opportunities. Section 4.1 outlines the studies associated with corporate strategy and organizational environment.

Most of the previous research studies on the organization environment have been conducted at the corporate strategy level. The method to capture the complex nature of the

environment has been controversial. Some of the representative studies are described below.

Variables	Measures
Interdepartmental relationships:	
Interactions among MPC, quality, marketing, manufacturing information system, industrial engineering, accounting, human relations, product development.	Interfunctions cohesiveness; harmonization of the goals of interdepartments within a firm: • to solve problems such as returned goods, disposal of obsolete materials, rework etc.; • to capture data, ensure data accuracy and completeness of documents etc.; • to establish the agreeable standards of labor, materials, operations, etc.; • to estimate the production costs; • to control engineering change orders; • to meet with customer orders.
Inter-organizational relationships:	
Customers	
Nature of products	Product introduction rate; commonality of parts; value of items.
Nature of orders	Number of strangers, repeaters, and runners.
Frequency of changes	Number of change orders.
Positioning profile	MTO; ETO; MTS; ATS.
Materials/components suppliers/sub-contractors	Number of suppliers; availability of materials; quality of supplies; supplier relationships.
Software/hardware suppliers	Availability of software and hardware.
Competitors	Competitors' quality, delivery and cost performance.

Table 4.3: Operational Measures for MPC System Environmental Variables

4.3.1 Corporate Strategy and Environment

Aldrich[244] remarks on two major theories on environment perception, i.e. information-oriented approach and resource-oriented approach. The information-oriented approach considers the impact of environmental uncertainty on managerial competence in making decisions and on the consequent restructuring to cope with uncertainty. The resource-oriented approach treats the environment consisting of resources: for which an

organization competes. The level of resources that are available is critical to the organization that copes with environmental changes.

After studying the re-adaptation process in 7 U.S. industries, Lawrence and Dyer[247] propose a two-dimensional environment, which consists of information complexity and resource scarcity. Information complexity is regarded as the extent of variations in an immediate organizational environment that affects the choice of supplies. The information domain includes variations in competitiveness, technical matters, customers, products, and government regulation. Resource scarcity is considered as the extent of difficulties an organization experiences in acquiring the resources for organization survival and growth. The resource domain includes the availability of resources; and the impact of customers, competitors, government, and organized labour. A two-dimensional matrix to capture the information and resource domains is proposed (see Figure 4.1). Lawrence and Dyer[247] then relates the changes of organization structure in different industries based on the information and resource domains.

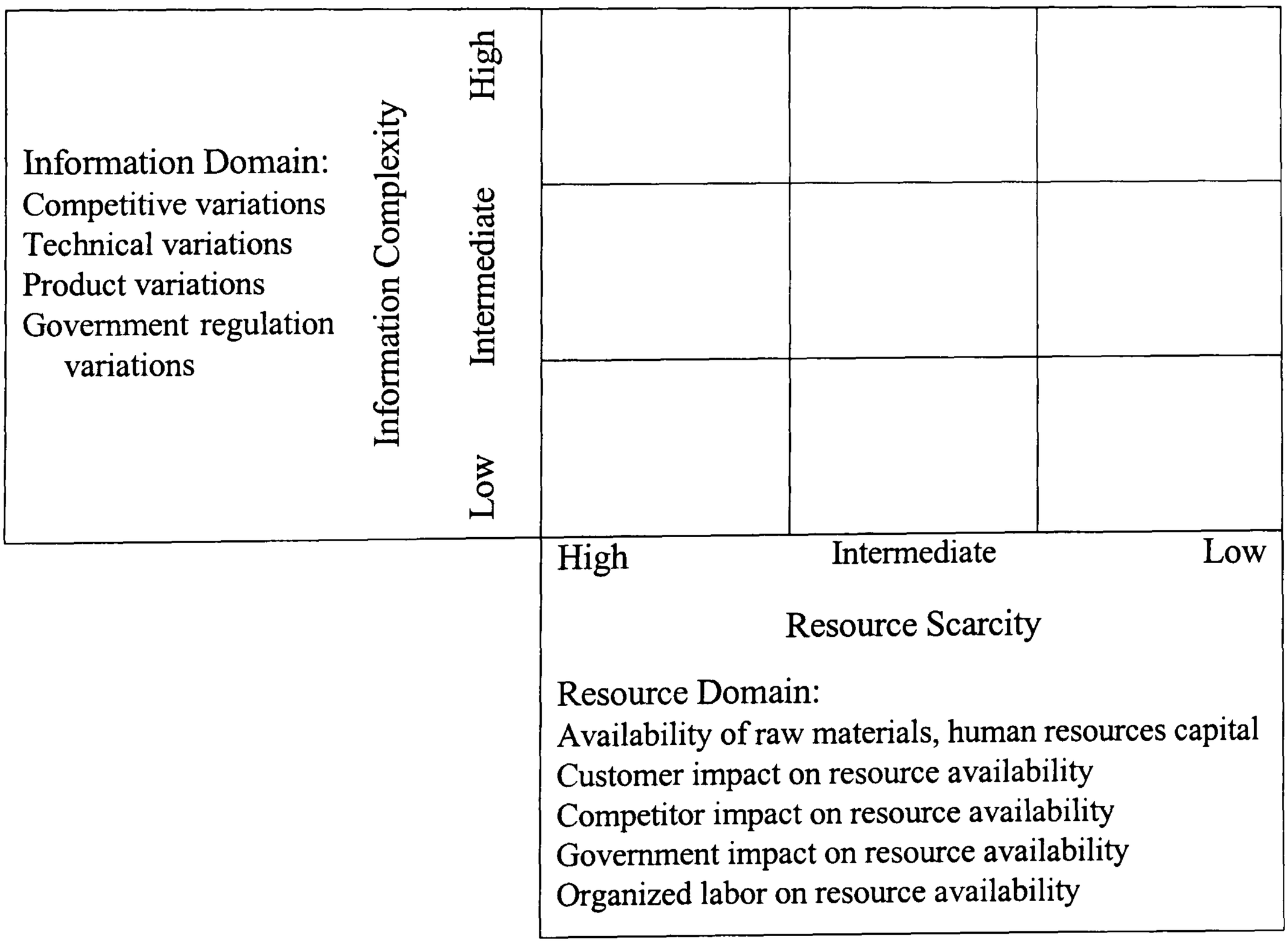


Figure 4.1: Two-dimensional Matrix of Organizational Environment
(Source: Lawrence and Dyer[247, p.6])

Emery and Trist[246] suggest that organizations can be classified by differentiating the types of environment with which an organization interacts. Four types of environments are proposed: (a) placid-randomized environment, in which goals and noxiants ('goods' and 'bads') are relatively unchanging and randomly distributed; (2) placid-clustered environment, in which goals and noxiants are not randomly distributed but hang together in certain ways; (3) disturbed-reactive environment, in which there exist a number of similar organizations subject to high competitive pressures; and (4) turbulent-field environment, in which the dynamic field forces emerge due to interactions of the component organizations and the industry. Although they adopt a more sophisticated view in developing this environmental typology, yet they have made no further suggestion on the types of organization structure that will fit with each environment.

The organization theory (OT) literatures show that the environmental context can be operationalized by the dimensional approach. However, most strategy researchers in the corporate strategy area seem to choose a two-dimensional approach, based on information and resource elements. Information elements include environmental complexity, volatility, and uncertainty etc. Resource elements include availability of materials, competitor impact, and customer impact etc.

4.3.2 Manufacturing Strategy and Environment

In contrast to the corporate strategy field, where abundant OT literature on the environmental dimensions can be found, the manufacturing strategy field has few studies on the environmental aspect. Ward and colleagues[248,249], Dean & Snell[250], and Swamidass & Newell[209] recognize the need for associating the environmental dimensions in their manufacturing strategy study.

Ward and Duray[248] study the relationship among environmental dynamism, competitive strategy, and manufacturing strategy. They observe that the competitive strategy is a mediator between environmental dynamism and manufacturing strategy for high performing organizations. However, their research loses its value as only one environmental attribute is considered which is contrary to the multi-dimensional nature of organizational environment.

Ward et al.[249] identify the strong relationship between environmental factors and operations strategy choices. They focus on two of Dess and Beard's[239] environmental attributes, i.e. munificence and dynamism, whilst environmental complexity is excluded. They show that high performers choose to emphasize different competitive priorities than low performers.

Dean and Snell[250] measure competition in terms of environmental munificence and complexity in their empirical study with respect to the use of integrated manufacturing techniques. They demonstrate that integrated manufacturing and manufacturing strategy are potentially synergistic.

Swamidass and Newell[209] offer another framework of environmental study for manufacturing strategy research. A single dimension, i.e. environmental uncertainty, is used to operationalize the environmental context. By using a path analytic model, they find that: (a) environmental uncertainty is negatively affected by the extent of strategic manufacturing decisions; and (b) under high environmental uncertainty conditions, flexibility is emphasized more in the design process of manufacturing strategy. Yet the study is still primitive in that the factors that operationalize environmental uncertainty are not explicitly recognized. Moreover, similar to Ward and Duray's[248] study, the research loses its value as only one environmental attribute is considered whilst dynamism and complexity are ignored.

Most strategy researchers in the manufacturing strategy area seem to choose either a one-dimensional or two-dimensional approach.

4.3.3 MPC System and Environment

Hall and Vollmann[264] pioneer the consideration of operating environment such as market position in the implementation of MRP system. They use two case examples to contrast the success and failure in MRP system.

Miller[220] identifies two dimensions of manufacturing environment, i.e. complexity and uncertainty, for analysis in the context of "organizational technologies" related to MPC system. He argues that IT seems to be the most useful tool for unstable,

unpredictable and a highly complex manufacturing environment. The limitation of the study is that the sample sizes are too small to substantiate the findings.

Van Dierdonck and Miller[52] propose a model to guide the design of MPC systems under different environments. They divide the environmental context into two dimensions: uncertainty and complexity. Uncertainty is defined as the reliability of information and assumptions, which includes variables such as demand, production, supply, and goal. Complexity is defined as the maximum amount of data for making effective decisions, which includes variables such as volume, diversity, repetitiveness, and the interdependency of manufacturing tasks. They contend that a more integrated MPC system is required to cope with higher task uncertainty, and enhanced information processing systems involvement (IPSI) is indispensable for handling a higher task complexity. The changes in organizational strategies will alter the IPSI and integrativeness of an organization. Their contribution is commendable since it pioneers the study in linking manufacturing environment with the MPC system. Although the main subject area is more closely related to MPC design, the approach to conceptualise the environmental context is applicable to the more strategic decisions and choices.

Barber and Hollier[275] classify production control complexity by using a hierarchical cluster technique, CLASP program. Based on a questionnaire survey to collect the data from the engineering batch-manufacturing sector in UK, a six-fold classification is defined. Their findings illustrate that it is possible to inductively construct a taxonomy of production-control complexity by using numerical taxonomic methods. The taxonomy provides a basis for standardized approach to the design of MPC systems and, therefore, they are sceptical about the claims for organizational uniqueness. The authors assert that organizations can be formed by groupings that exhibit similar characteristics. These operational characteristics can be described by the relative weightings on a discrete set of factors (see Table 4.4), closely related to Constable and New's[276] criteria. However, Barber and Hollier have not labelled these six groups of organizations.

Newman and Sridharan[242] contend that a good fit between MPC system and manufacturing environment can add value to the manufacturing infrastructure of an organization. They map three standard MPC systems with a 2-dimension manufacturing environment (see Figure 4.2). Their empirical study illustrates that there are significant

performance differences amongst organizations that use different MPC systems under various manufacturing environments. However, the limitation of the study is that there is no operationalized measure to appraise demand predictability and demand variability.

Production Control Complexity	Factors
Market/customer environment:	The number of distinct products; The percentage of output manufactured for stock; The percentage of output manufactured to order; The manufacturing lead time.
Product complexity:	The number of components in the products; The number of different live inventory records; The number of operations per batch.
Nature and complexity of manufacturing operations:	The number of live shop orders; The percentage of components made in-house; The number of sub-assembly stages; The number of operations per batch; The number of work centres/stations; The number of live drawings; The manufacturing lead time; The sharing of manufacturing facilities; The organization of manufacturing facilities; The number of machines.
Company structure and manufacturing policies:	The percentage of product cost attributed to overhead; The number of direct workers; The number of indirect workers; The number of new shop orders per week; The value of work in progress; The turnover at factory cost; The percentage of factory cost attributed to direct labour; The method of manufacture (batch, mass or jobbing).

Table 4.4: A Discrete Set of Factors for the Classification of Production Control Complexity (Source: Barber and Hollier[275,pp.206-7])

Demand Predictability	Demand Variability: Low	Demand Variability: High
Low	Kanban	OPT
High	Kanban, OPT, and MRP	MRP

Figure 4.2: Three Standard MPC System and Demand Environment
(Source: Newman and Sridharan[242,p.37]

Van der Linden and Grünwald[43] use a priori method to develop a typology of production situations for MPC system design and selection. The production situations are summarized in Table 4.5. Their study is focused on the short-term control of the flow of goods but capacity planning is not considered. The proposed classification of MPC system is based on the extreme production situations. Three coordination functions are suggested, namely, order generation (on stock versus on order), sequence determination and capacity allocation (fixed conditions versus variable conditions), and requirements planning (statistical versus deterministic). Besides, this typology of MPC is conceptual in nature and it needs testing and validation.

Howard et al.[272] propose a generic reference architecture for MPC system which is tested in four different sites. They demonstrate that the reference architecture has a broad application in different manufacturing environments. However, the linkage between the reference architecture and the manufacturing environment is not described. A further discussion on Howard et al.'s[272] proposed reference architecture for MPC system is presented in Section 8.8.2 of Chapter 8.

By using a gap analysis approach, Kochhar et al.[273] offer a reference model for MPC system based on complexity, uncertainty, flexibility and company culture. The premise of the proposed reference model is that the implementation of an MPC system depends on the characteristics of the manufacturing environment. The authors claim that the model provides a structural approach to the selection and implementation of MPC system as it can be applied in a number of manufacturing environments. According to Kochhar et al.[273], a total of 23 complexity-related, 12 uncertainty-related, and 11 flexibility-related

Production Situations	Characteristics
Market	Specificity (from unique product to mass product); Uncertainty (stochastic components of the demand pattern); Irregularity (deterministic components of the demand pattern); Life cycle.
Technology	Complicacy of the product; Number of processes; Degree of distinguishability of product; Degree of uncertainty of the quality.
Production organization	Co-ordination within organization; Diversity of products; Production volume price added value; Degree of convergence.
A chain of production units (centres) control	Integration of plant departments; Suppliers characteristics such as the length of delivery time and its variance ; Supplier reliability; Supplier lead time; Volume.
Production control	Customer orders (delivery plans) and factory orders; Operations sequencing; Possibilities of requirements planning.

Table 4.5: A typology of Production Situations
(Source: Van der Linden and Grünwald[43])

characteristics are included in the reference model. Unfortunately, the authors have provided no information on these characteristics of manufacturing environments.

Kochhar and McGarrie[274] use a questionnaire to identify the requirements of MPC systems and summarize a number of key characteristics relating to complexity, uncertainty and flexibility aspects. They suggest that there are two broad categories for these key characteristics: external and internal considerations. The influence of the market demand is an example of the external considerations. However, further details about the external parameters affecting MPC system are not discussed.

4.4 Supply Chain and the Environment

As mentioned earlier in Sections 3.5 and 4.2.3, there is an increasing need to consider the manufacturing system based on an integrated approach at an inter-organizational level. In this respect, this section reviews the supply chain and the organizational environment.

Fisher[230] argues that:

(a) The efficient supply chain fits to the environment of predictable market demand, low product variety, long product life cycle, high inventory turnover rate and low profit margin.

(b) The responsive supply chain fits to the environment of unpredictable market demand, high product variety, short product life cycle, high buffer stock level, short lead time and high profit margin.

Mason-Jones et al.[231] extend Fisher's view and maintain that:

(a) Lean supply chain, similar to Fisher's efficient supply chain, emphasizes on the elimination of all wastes in order to develop a value stream.

(b) Agile supply chain, similar to Fisher's responsive supply chain, uses its market knowledge and a virtual organizational structure to exploit profitable new niches in a volatile market place.

(c) Leagile supply chain combines the lean and agile paradigms for effective and efficient manufacturing. On the upstream side of decoupling point, lean manufacturing is adopted in order to achieve cost-effectiveness. On the downstream side, agile manufacturing is applied in order to achieve a high service level for the end-users.

4.5 Environment-Strategy (E-S) Fit

Extant OT literature has significantly demonstrated that a good fit between the manufacturing strategy, system and its environment is crucial. Many organizational theorists assert that organizational efficiency and effectiveness is an outcome of E-S fit (e.g. Miller & Friesen[55]; Pfeffer & Salancik[265]; Venkatraman & Prescott[266]; Kotha & Orne[216]; Miller & Roth[47]). The concept of fit has become an important utility to build and to test theories. Kotha and Orne's[216] and Miller and Roth's[47] research efforts that address the E-S fit for manufacturing organizations are particular examples.

Miller's[270] questionnaire survey of 97 companies in Quebec examines two types of fit: (a) internal fit exists among strategy process and structural variables; and (b) environmental fit exists among structural and external settings. He finds that internal fit is inversely related to environmental fit. Management seems to abandon one type of fit for accomplishing another. This study demonstrates the conflicting demands of multiple fits with different contingencies.

Venkatraman[267] identifies a classificatory scheme of fit: fit as moderation (interaction), fit as mediation, fit as matching, fit as gestalts, fit as profile deviation, and fit as covariation. Each perspective of fit represents different theoretical strategic issues, models and specifications. The use of fit-as-moderation, fit-as-mediation, and fit-as-matching models have been criticized about their values due to the fact that these kinds of fit specify two variables only[269]. As such, these models are not suitable for the multidimensional typologies such as Miles and Snow's[234] archetype and Miller and Roth's[47] taxonomy.

Venkatraman[267] addresses the deficiency of Miles and Snow's[234] strategic archetype that is lack of corresponding scheme on the pattern of fit. In this respect, this research integrates Miles and Snow's[234] strategic archetype with Itami's[268] dynamic strategic fit, which specifies the fit in terms of the external factors (i.e. customers, competition, and technology) and the internal factors (i.e. corporate resources and the group psychology of the organization). The main features of the dynamic strategic fit are:

(a) Customer fit: An organization has three qualities relating to customer desires, i.e. meeting customer needs, adjusting to changes in customer desires, and capitalizing on customer interactions.

(b) Competitive fit: An organization has to create three levels of competitive fit such as deploying competitive weapons, protecting against counterattack, and avoiding direct competition.

(c) Technological fit: An organization anticipates changes in technology and applies the appropriate level of technology to develop new products or new operational processes in order to satisfy its customers and to make profits.

(d) Resource fit: An organization has utilized its existing resources effectively and accumulates resources for the future efficiently.

(e) Organizational fit: An organization must be able to mobilize its personnel, i.e. providing a focus to unify the organization, matching strategy with its psychological features, creating momentum and sustaining forward-looking pressures for continuous improvement.

The pattern of strategic fit may vary from one strategy archetype to another one. A defender organization focuses on operational efficiency and builds its strengths in technological, resource and organizational fit. A prospector organization stresses on product and market effectiveness, and develops strengths in customer, competitive and technological fit. An analyzer organization imitates the most successful innovative products developed by key prospector firms and it depends on competitive, technological and resource fit. A reactor organization is not able to develop a particular strategy and does not place any emphasis on any particular strategic fit. The focus of fit for Miles and Snow strategic archetype is shown in Figure 4.3. It is hypothesized that firms (higher performers) adopt an ideal set of "fit" should achieve higher performance than those firms (lower performers) having their strategies inconsistent to their environmental demands.

	Customer fit	Competitive fit	Technological fit	Resource fit	Organizational fit
Defender			✓	✓	✓
Prospector	✓	✓	✓		
Analyzer		✓	✓	✓	
Reactor					

Figure 4.3: Focus of fit for Miles and Snow Strategic Archetypes

In the context of E-S fit, this research study adopts the theory of autopoiesis[58], i.e. the capacity of self-production through a closed system of relations. The system-

environment interaction is a reflection and part of the system's organization. In this MPC-environment study, the manufacturing environment is regarded as part of the MPC system and its relations with any external settings are internally determined. The concept of autopoiesis places emphasis on the holistic system of interactions that shapes the system's pattern, rather than the separate processes of organization and environmental elements. Therefore, the MPC system's transactions with manufacturing environment are conceived as the transactions within itself. For example, the releases of purchase orders to the suppliers are considered as the internal transactions, rather than regarded as a system interacts with suppliers (external environment). This highlights the key role of management to enact its environment as projections of its own identity[310]. The degree of E-S fit is dependent on how the management interprets the environment and how successful it can specify the pattern of system-environment relations. The conceptual framework (Figure 1.2 of Chapter 1; Figure 5.2 of Chapter 5) and the reference MPC model (Figure 8.6 of Chapter 8) embrace the view of autopoiesis.

4.6 Summary

From the brief review of the studies on the relationships among organizational environment, strategies and MPC system, the following points emerge:

Firstly, the environment consists of numerous factors with complex relationships among them. In order to evaluate the environment's influences on the performance of a MPC system, a representative construct is needed that can be used for this research study. A multi-dimensional approach such as Dess and Beard's[239] 3-dimensional construct and Lawrence and Dyer's[246] 2-dimensional matrix seem appropriate since these approaches would provide a richer analysis of various environmental factors, including the interactions among them.

Secondly, research on organizational environment has been advanced more at the corporate strategy level than at the lower hierarchical levels. The study on environment at the manufacturing system level is relatively few.

Thirdly, it is also observed that the research in operations management has paid little attention to the connection of organizational environment and manufacturing strategy.

Exceptions are the work by Ward and colleagues[248,249], Dean and Snell[250], Swamidass and Newell[209], Kotha and Orne[216]; and Miller and Roth[47]. More research works, particularly the E-S fit analysis, in this area will provide more insights on the design and implementation of an appropriate MPC system.

Fourthly, the central tenet of the environment-strategy-system-performance (E-S-S-P) paradigm is that an organization's performance is primarily a function of the organizational environment in which it competes. A number of researchers suggest that the strategy and manufacturing system are a reflection of the environment and, therefore, the system performance can be explained by environment. In this regard, it is anticipated that the adoption of the E-S-S-P paradigm in MPC studies will naturally shift the research focus from MPC process and mechanisms to Environment-MPC interaction.

Fifthly, as discussed earlier in Section 4.3.3, it appears that a number of studies have taken account of environmental variables in the design and implementation of MPC systems. Some of the studies are conceptual in nature (e.g. Van der Linden & Grünwald[43]). Some of the studies have used a small sample sizes for analysis (e.g. Hall & Vollmann[264], Miller[220], Van Dierdonck & Miller[52], and Howard et al.[272]). MPC research such as Kochhar et al.'s[273] study has offered little information about the operational characteristics of manufacturing environments and thus limited its utility. MPC taxonomy such as Barber and Hollier's[275] classification scheme is limited in the engineering batch-manufacturing situation only, whilst a range of other manufacturing environments have yet to be defined. Besides, Kochhar et al.'s[274] empirical study has not provided clearly the external parameters that would influence the MPC system. Newman & Sridharan's[242] survey study omits the operationalized measures for different environmental conditions. Therefore, despite a number of contributions from various authors as mentioned above, there still exists a great need to examine how the content and the process of MPC system that matches with the environmental context.

All in all, the development of the configurations of MPC systems will provide a useful framework for the selection of a suitable system that can apply in a defined range of manufacturing environments. This issue is discussed in Chapter 5.

Chapter 5 The Appropriateness of a Configuration Approach for Modelling MPC Systems

In this chapter, the literature on organizational configurations is reviewed. Several issues such as contingency research, inductive and deductive approaches, levels consideration, environmental fit, and internal fit are discussed. Two types of approaches for studying configurations in MPC systems, namely elemental configuration and relational configuration are considered. The objectives of the review in configuration approaches are twofold. First, it explores the possibility of studying configurations in MPC systems. Second, it attempts to identify the methodological issues in developing organizational configurations at micro level i.e. MPC systems.

5.1 Organizational Configurations

Organizational configurations are defined as groups of organizations sharing a common profile of organizational characteristics[285]. Configuration researchers have suggested many imperatives such as organizational environment, structure, leadership, and strategy etc. that drive organizational attributes to cluster homogeneously and systematically[279].

The configuration approach is used to describe a multidimensional profile such as organizational strategy, structure, process or system. It is aimed to ascertain the interrelationship of organizational elements that provides a common, holistic, integrated and insightful configurations (or 'gestalts', or 'archetypes').

Examples of some of the commonly adopted configurations are:

- Based on societal conditions, Weber[280] derives three different profiles of authority in a social organizations, i.e. traditional, rational/legal, and charismatic.
- Burns and Stalker[257] identify two types of organizational structures, i.e. mechanistic and organic, in order to cope with the stable and dynamic environments respectively.
- Woodward[281] develops a comprehensive manufacturing classification, based on three taxonomic manufacturing attributes, i.e. product complexity, operational

objectives, and operational characteristics. Eleven production systems were identified. These systems are: production of units to customers' special requirements, production of prototypes, fabrication of large equipments in stages, production of small batches, production of large batches, production of large batches on assembly lines, mass production, intermittent production of chemicals in multipurpose plants, continuous flow production of liquids, gases, and crystalline substances, production of components in large batches subsequently assembled diversely, and production of crystalline substances and subsequent preparation of them for sale as tablets or in packets. Woodward's three basic types of configurations, that is, unit, mass, and process production systems, have been widely quoted.

- Lawrence and Lorsch[50] distinguish two opposing forces, integration and differentiation, such that each department of an organization may face the demands of multiple specific environments that are not uniformly stable.
- On the basis of organizational strategies, structures, and administrative styles, Miles and Snow[234] develop a typology that consists of four different strategic types, i.e. defender, prospector, analyser, and reactor in multiple environmental conditions (refer to Section 3.6.1).
- Mintzberg[283] differentiates five ideal types of organizational structure, namely, simple structure, machine bureaucracy, professional bureaucracy, divisionalized form, and adhocracy.
- Based on the configuration analysis of strategy-structure-performance relationships, Miller and Friesen's[282] categorize empirically four unsuccessful strategic archetypes and six successful strategic archetypes. The unsuccessful strategic archetypes are the impulsive firms, the stagnant bureaucracy, the headless giant, and the aftermath. The successful archetypes are the adaptive firm under moderate challenge, the adaptive firm in a very challenging environment, the dominant firm, the giant under fire, the entrepreneurial conglomerate, and the innovator. Multivariate analysis between organizations is carried out in order to investigate the quantitative relationships among the organizational elements within each configuration.

The above examples firmly demonstrate the existence of configurations at the organizational level. Underlying these researches is an attempt to present a comprehensive view about the nature of organizational diversity in a given business environment through typologies and taxonomies. Its utility is dependent on the power of configurations to generate insight or to advance a predictive task[299]. In addition, Ketchen and colleagues[286] carry out a meta-analysis which demonstrate that organizational configurations are related to performance. Some configurations will fit a specific environment better than other poorly aligned organizational types.

5.1.1 Configuration Approach

Meyer et al.[285] contend that the configuration approach represents an exciting intellectual movement with the potential for revitalizing organization theories and researches.

The specification of configuration approach requires a corresponding set of classificatory concepts. At present, however, there is no generally accepted method of classifying organizations[288-291]. OT researchers use different methodical procedures to study the organization configurations. No wonder that the classification scheme for organizational studies is a complex exercise[291], not only because some of the configuration theories have not yet thoroughly established, but also because there are differences in language, terminology and concepts amongst writers and practitioners. Moreover, Rich[288] points out that most of the empirical configuration studies are lack of generalizability. Their classification schemes incorrectly take the form of "ideal types" (polar extremes) but not the points on a continuum, as originally proposed.

To make the organizational configurations possible, McKelvey and Aldrich[292] suggest that the taxonomic studies must be carried out with adequate description and classification, and take the generalizability of sampled members of the population into account. The probabilistic statements must also be close to universal statements. In such regard, the research findings in organizational configurations could then be more relevant to the specific organizational types.

Below is the summary of the literature that indicates the problems of taxonomic studies for organizational configurations:

- Classification, strictly speaking, is a yes-or-no, an either-or affair. In scientific research, however, some of the objects under study are often found to resist a neatly bounded pigeonholes[293] and will present with the borderline cases.
- Numerous writers[e.g.289,292,296] have criticized for the limited number of dimensions upon which most typologies have used to classify multi-dimensional object, and hence, the classificatory schemas could not match with the real-life, complex, multidimensional organizations.
- There is a need for a less subjective procedure and criteria for assigning all the individual objects under study to particular groups in order to make the classification more reasonable[290]. In organizational studies, however, it is difficult to find the fruitful objective criteria which will determine a purely comparative typological order.
- There is neither a basic agreement nor any coherent body of material to guide the researchers in organizational configurations[288].
- The selection of appropriate criteria with high predictive power is an important feature of the studies in organizational configurations[289]. Various writers[e.g.294,295], however, question the validity of such a procedure since the selection is based on the researchers' intuitive judgements and it is often very difficult for them to decide how to weigh the variables in practice.

Since organizations are complex configurations consisting of many individual sub-units, Pinder and Moore[296] suggest to divide the entire universe of specimens into a manageable taxonomic size for study. McKelvey[290] and McKelvey & Aldrich[292] also contend that empirical taxonomists should start with easy identifiable populations and draw a non-stratified sample of organizations from the population. The study of the configurations in MPC system is coherent with their suggestions.

Drawing from the literature review relating to taxonomic studies[288-296], the general guidelines for configuration researches are summarized as follows:

- Define the broadest possible population of organizations.

- Use multivariate analysis as a basis for classification to meet with the diversity of real-life situation of a polythetic system.
- Use both the phyletic method and the numerical taxonomic approach to ensure the classification system with both quantitative and qualitative strength.
- Use a sampling plan to include organizational samples.
- Define as many organizational attributes as possible.
- Define the typology or the taxonomy with adequate description.
- Provide a clear meaning in a broad social context.
- Define the broadest possible population of observers of organizational attributes.
- Use a sampling plan for selecting observers.
- Use multivariate analysis, or use an iterative analysis procedure, to handle the full sample of organizational attributes.
- Measure each attribute independently.
- Assign equal weighting for each attribute if the assignment of weight is difficult to achieve.
- Consistently applied the criteria for handling unavoidable decisions in the multivariate analysis.
- Optimize parsimony and homogeneity of classificatory groups and the classification must demonstrate a logical and consistent relationship.
- Develop the classification scheme that must replicate reality.

5.1.2 Contingency versus Configuration Approaches

The configuration perspective to organizational study is grounded in structural contingency theory, which is based on the premise that there is no "one best way" to accomplish effectiveness. Some configurations will fit a given organizational environment than others. This approach emphasizes the existence of equally effective configurations, i.e. equifinality, in which an organization can achieve environmental or internal fit.

The utility of organizational configurations depends on their predictive power, and the theoretical (or practical) implications. The configuration perspective envisages that organizations are best to be regarded as a synthesis of multiple characteristics[299].

However, as discussed earlier in Section 4.3.1, most researches in the corporate strategy area seem to choose a two-dimensional approach, basing on information and resource elements, which tend to damage the explanatory power. Linking variables based on bivariate relationships are subject to the criticism of imprecise models since reality is multifaceted. Therefore, the bivariate approach ignores nonlinearity relationship, which reduces the explanatory power of the interdependence of variables.

The traditional contingency research has received criticism for its simplistic nature in determining bivariate relationship between strategy and structure. Apparently, executives in organizations usually pursue several strategies simultaneously and frequently cope with multiple contingencies in the context of environment, technology, system, infrastructure, leadership, and human resources etc. When an organization has to achieve multiple strategies, multiple contingencies and simultaneous fit can occur. The development of hybrid MPC system is an example of using new approach to cope with multiple contingencies (refer to Section 2.3 of Chapter 2).

Meyer et al.[284] compare contingency approach and configuration approach on several aspects such as the mode of research inquiry, interrelationship among attributes, and effectiveness assumptions. Their differences are tabulated in Table 5.1.

	Contingency Approach	Configuration Approach
Mode of research inquiry	Reductionistic analysis	Holistic synthesis
Interrelationship among attributes	Unidirectional and linear	Reciprocal and nonlinear
Effectiveness assumptions	Situational context	Equifinality

Table 5.1: Comparison of Contingency and Configuration Approaches
(Adapted from Meyer et al.[284])

5.1.3 Inductive versus Deductive Approaches

Miller[279] suggests classifying the organizations according to the imperatives before testing the predictions of the relationships among organizational attributes. There are two common methods for classifying the organizations, namely, deductive approach and

inductive approach. In an inductive approach, configurations are generated from empirical procedures, whilst in the deductive inquiries, organizations are divided into configurations which are then evaluated subject to the theory-based predictions. Different approaches affect the number, type, and consistency of configurations over time. In this regard, Ketchen et al.[287] examine these two approaches by studying the configuration-performance relationship in the organization level. They recommend that the deductively defined configurations explained performance better than the inductively defined configurations. In light of their recommendation, this thesis will use the deductive approach.

5.1.4 Levels Issues in Configuration Approach

Since organizations are multi-level, greater attention must be paid to levels issues in configuration research. Klein et al.[298] highlight the importance of matching the data collection, statistical analysis, measurement, and organizational level in research. Otherwise, erroneous conclusion could be drawn. Miller and Friesen[282] contend that configurations can be derived at different levels of the organization, i.e. departments, divisions, organizations, or networks etc.

The configuration researches that concentrate on the macro organizational level (see some of these examples in Section 5.1) are enormous. However, the discussion of the configuration research at the micro level is relatively few. To my best knowledge, there are two configuration studies at this level. One is Duberley and Burn's departmental configurations for human resource management[297], and the other is Barber and Hollier's study at functional level for production control[275].

Duberley and Burn[297] argue that the focus on organizational configurations can result in impressive strategic plans but bears no relation to the reality, whereas the emphasis of configurations at the micro level can lead to sub-optimization if it does not fit with the organization level. Therefore, configurations at different level must be complementary to each other in the organization. The importance of fit for organizational and the functional configurations should not be ignored.

The configurations in MPC system can be regarded as the study at the micro level and it is reviewed in the Section 5.2.

5.1.5 Fit Issues in Configuration Approach

The concept of fit serves as an important construct for developing theories for both configuration and contingency researches[267,270]. It is commonly held that organizational performance is the consequence of the fit between two or more organizational elements. Therefore, the measure of the fit among organizational elements could be used to assess the degree of configuration. For example, Miller[270] test the degree to which organizational strategy, structure and systems are complement to each other based on environmental fit and internal fit.

Doty et al.[287] develop a set of internal fit models to validate both Mintzberg's[283] and Miles & Snow's[234] configuration theories. Their study is based on the concept that fit must be consistent among contextual, structural, and strategic factors and is positively related to organizational effectiveness. Founded on Venkatraman's[267] definition of fit, the degree of fit is evaluated by computing the difference between the scores of the organizational attributes and those of ideal or hybrid type. The research result demonstrates that Miles & Snow's strategic configurations are more powerful than Mintzberg's typology.

Miller[270] examines the contradictory demands on organizational structure based on two competing fits in the organization. He considers internal fit as the development of organizational structures and processes that are "internal complementarities", whilst environmental fit is the degree of match between organization structures and processes to the external settings. He illustrates the conflicting demands between internal fit and environment fit when multiple contingencies are germane. That is, the focus on environmental fit will obliterate the internal complementarities, whereas the stress on internal fit will undermine the efforts to sustain environmental fit. As such, multiple fit problems may exist among configurations. A literature review on the environmental and internal fits has been carried out earlier in Section 4.5 of Chapter 4. Customer fit,

competitive fit and technological fit are related to external settings. Resource fit and organizational fit are considered as internal complementarities.

5.2 Configuration Research in MPC System

In the past, conventional MPC practices have focused on the optimisation of resources. However, the emphasis today is not only on cost, but also on speed. The environment is constantly changing that requires the design of new system to achieve a number of goals such as cost, quality, flexibility and responsiveness. Organization strives to redesign their supply-chain processes in order to respond to demands rapidly. The build-up of the core competence in responsiveness becomes a major source of competitive advantage. In Chapter 2, the literature review has shown that a few MPC research studies take the supply chain, strategic and environmental issues into account. In this regard, there is a need to revitalize the research in MPC systems that consider the strategic and environmental issues such as speed, supply-chain process, IT, and globalization of manufacturing etc.

As discussed in Chapter 4, the development of MPC configurations will offer penetrating insights into effective MPC systems that can apply in a defined range of manufacturing environments. A well-defined theoretical or empirical classification scheme of MPC systems will greatly enhance both OM researchers and practitioners an understanding of the environment-MPC system paradigm. The contribution of the configuration research in MPC systems is paramount since the classification scheme can act as:

- a basis for researches[288,289,290], specially in studying the interrelationship among manufacturing system, strategy and organizational environment;
- a logical framework for describing and understanding the object under study[289,290];
- an effective model to replicate the reality[288].

Therefore, the configuration study of MPC systems will probably renew the research paradigm in MPC systems, bearing in mind that the traditional MPC models developed

so far do not accurately represent real-life situations and have received significant negative comments (refer to Section 1.1 of Chapter 1).

Barber and Hollier's taxonomic study[275] is an example. They produce six-fold cluster of production control complexity of the engineering batch-manufacturing sector in U.K (refer to Section 4.3.3 of Chapter 4). Such configurations may act as a basis for the standardized approach of MPC systems so that any organizations in this sector may compare their manufacturing profile with each of the clusters. This procedure will aid them to position their MPC systems and to predict the probable benefits. The system effectiveness by using the classification scheme is measured, based on New's eleven subsystems[276]. Their findings indicate that the implementation orders of subsystems and the mode of operations will have a considerable effect on the efficiency of a system[277]. This also demonstrates that configurations of MPC system exist.

5.2.1 Elemental Configurations

According to Miller and Friesen[282], elemental configurations comprise a consistent constellation of organizational elements. For example, based on elements such as situational authority, lateral communications among managers, advice focus and continual redefinition of tasks etc., Burns and Stalker[257] develop a structural configuration – organic form. By using another set of elements such as task specialization, hierarchical-based authority, formal rules, and vertical communication etc., they identify another configuration – mechanical form.

The elemental configurations of MPC systems in this research are based on three different constellations of elements. They are:

(a) Configurations defined on the basis of Miles and Snow's[234] theoretical framework (refer to Sections 3.6.1 and 4.5). There are four configurations, namely, defender, prospector, analyser and reactor.

(b) Configurations emerged from supply chain strategies (refer to Sections 3.5 and 4.4). There are three configurations, namely, lean supply chain, agile supply chain and leagile supply chain.

(c) Configurations derived from environmental influences: Dess and Beard's[239] 3-dimensional of organizational task environments, i.e. dynamism, complexity, munificence. There are 27 elemental configurations if the scores for all environmental elements are classified as high, medium, and low influences. Table 5.2 summarizes these configurations.

	Dynamism	Complexity	Munificence
Configuration 1	High	High	High
Configuration 2	High	High	Medium
Configuration 3	High	High	Low
Configuration 4	High	Medium	High
Configuration 5	High	Medium	Medium
Configuration 6	High	Medium	Low
Configuration 7	High	Low	High
Configuration 8	High	Low	Medium
Configuration 9	High	Low	Low
Configuration 10	Medium	High	High
Configuration 11	Medium	High	Medium
Configuration 12	Medium	High	Low
Configuration 13	Medium	Medium	High
Configuration 14	Medium	Medium	Medium
Configuration 15	Medium	Medium	Low
Configuration 16	Medium	Low	High
Configuration 17	Medium	Low	Medium
Configuration 18	Medium	Low	Low
Configuration 19	Low	High	High
Configuration 20	Low	High	Medium
Configuration 21	Low	High	Low
Configuration 22	Low	Medium	High
Configuration 23	Low	Medium	Medium
Configuration 24	Low	Medium	Low
Configuration 25	Low	Low	High
Configuration 26	Low	Low	Medium
Configuration 27	Low	Low	Low

Table 5.2: Configurations Derived from 3-Dimensional Organization Environments

Not all of the configurations described in (c) above can be evaluated in this study since only some of the sample organizations, influenced by a limited range of environments, are available for study. The elements of MPC system for evaluation are elucidated in Section 5.3.

5.2.2 Relational Configurations

Miller and Friesen[282] define the relational configurations in terms of alignment between organizational elements (or variables). The organizational elements have the characteristics that vary in intensity from "low" to "high". They could be positively related or negatively related. For example, Ward and Duray[54] study the relationship among environment, competitive strategy, manufacturing strategy and organizational performance, based on the path analytic methods. Three different models are developed, namely, higher performer model, direct environmental effects model, and direct competitive strategy effects model. In these models, organizational elements related with the intensity of alignment between elements are illustrated by the path coefficients. Figure 5.1 shows one of the models (High Performer) tested by Ward and Duray[54].

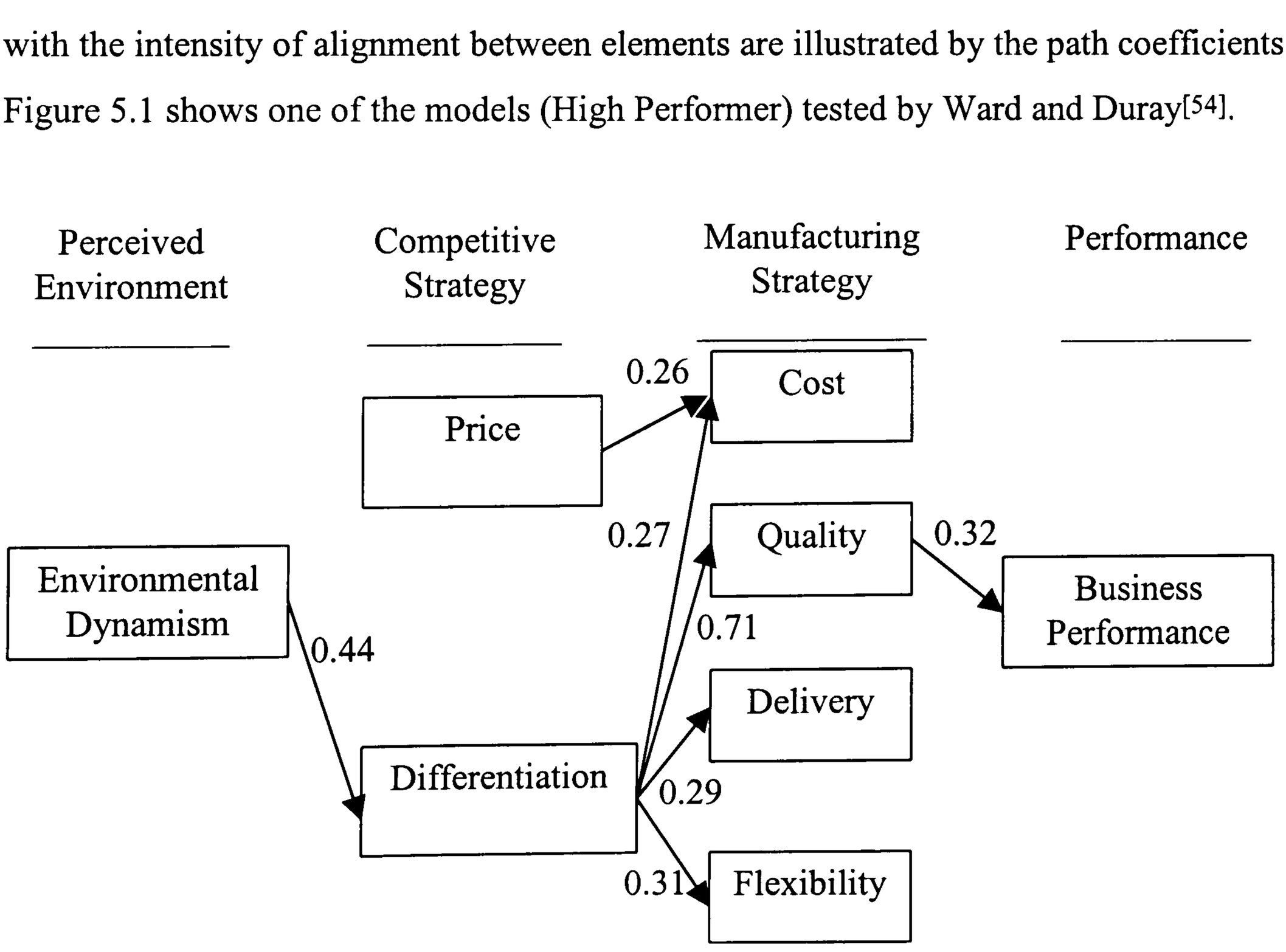


Figure 5.1: An Example of Relational Configuration (Source: Ward and Duray[54,p.131])

Figure 5.2 shows the relational configuration in MPC system, based on the concept of aligning among organizational environment, competitive strategy, manufacturing strategy, MPC system and organizational performance (refer to Section 1.2 and Figure 1.2 of Chapter 1). The variables of the relational configuration are taken from the literature review and the major concepts of the framework will be further discussed in Sections 6.2 and 6.3 of Chapter 6.

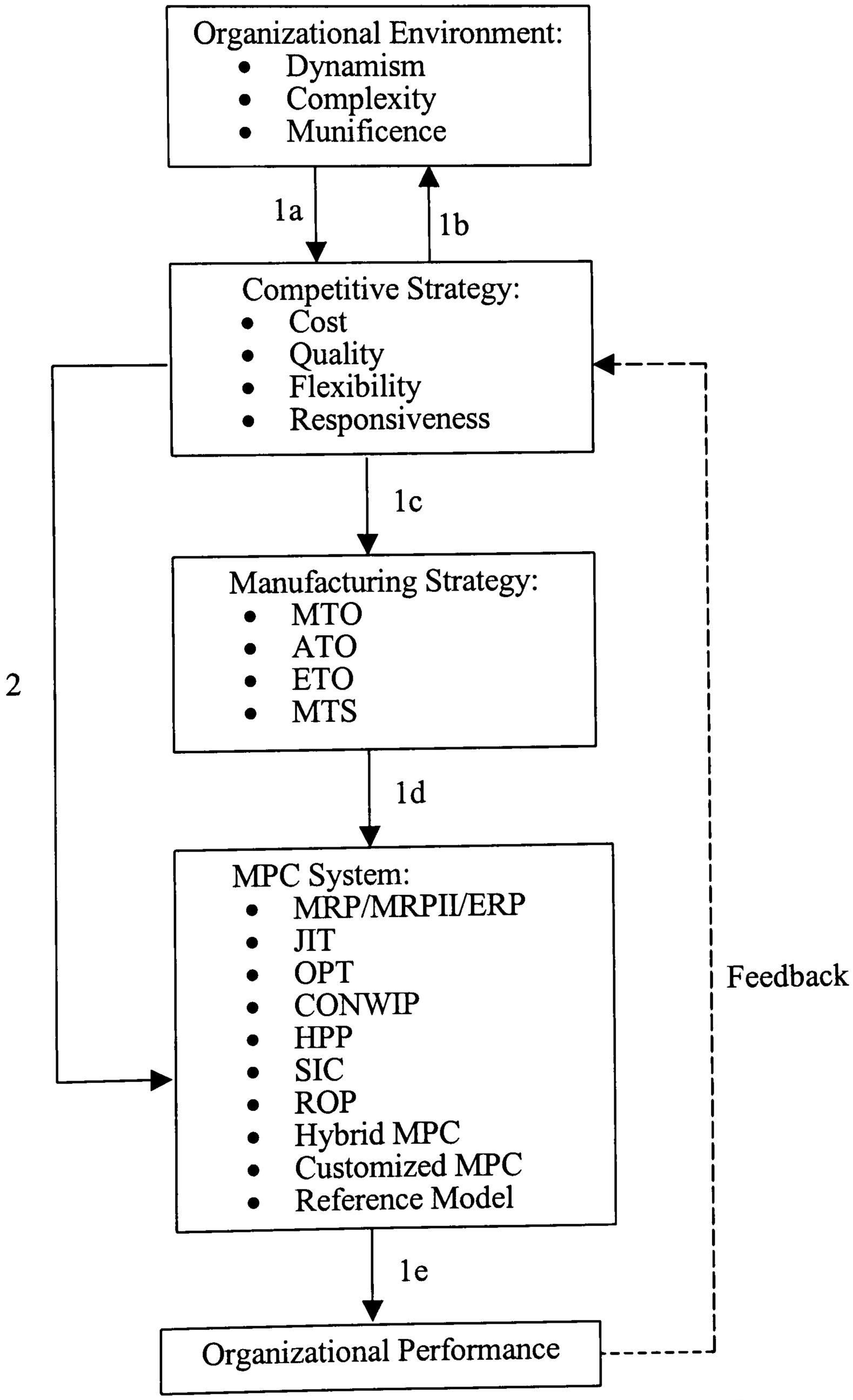


Figure 5.2: A Relational Configuration Model of MPC System and Its Context

5.3 Summary

The theoretical powers of configurations are evidenced by a number of typological and taxonomic examples (refer to Section 5.1) that predominantly focus on the macro organizational level. Although some configuration writers contend that configurations can be derived at different levels of the organization, the discussion of the configuration research at the micro level is relatively few. The development of MPC configurations will greatly enhance both OM researchers and practitioners an understanding of the environment-MPC system paradigm. In this respect, various issues that are associated with configuration approaches are reviewed. Therefore, configurations are possible in MPC functional level.

Two different types of configurations in MPC system are identified in this research study. They are elemental configuration and relational configuration,. Firstly, a relational configuration model of MPC system (Figure 5.2) is constructed. It takes into account of organizational environment, corporate strategy, manufacturing strategy, MPC system and organizational performance. Secondly, several theoretical frameworks are suggested for the elemental configuration research of MPC systems. Configurations could be defined on the basis of Miles and Snow's typology, supply chain strategies, or a set of 27 elemental configurations in Dess and Beard's 3-dimensional task environments of organizations. However, the amount of effort, resources and experimental time for the 27 elemental configurations are considerable and would require a collective effort of organizational research teams to examine them.

The review of both elemental and relational configuration approaches in MPC systems acknowledges the need of developing a reference MPC model that will be discussed in Chapter 8.

This Chapter presents several organization configurations for studying the configuration-performance relationship at the functional level. It is anticipated that the configuration study in MPC systems provides a new research paradigm that can generate insight and advance to a predictive task for MPC practices. The research hypotheses will be discussed in the following Chapter.

Chapter 6 Research Hypotheses

In this Chapter, a conceptual framework (see Figure 5.2, Chapter 5) used in this study is described. The five major constructs are discussed. The paths of the proposed framework and the elemental configurations (see Section 5.2.1, Chapter 5) are referred. They lead to the development of the hypotheses that associate with organizational environment, strategy, and MPC system with performance implication. The rationale for making each hypothesis is stated.

6.1 Introduction

The literature review in Chapters 2, 3 and 4 shows several research gaps on MPC study. These gaps are reiterated as follows:

(a) The literature on the MPC discipline has often not treated the Environment-Strategy-MPS paradigm with appropriate attention. The studies have focused more on the operation of various MPC practices. Little research has been taken to investigate the content of MPC systems, i.e. which MPC system will best suit for a particular environmental condition.

(b) Few studies in MPC research concentrate on the issues such as decision support framework, organization structure, and supply chain network etc.

(c) Many of the comparative studies on various MPC systems are based on qualitative reasoning. The empirical findings are relatively little.

(d) Some studies used quantitative models to evaluate the performance of MPC systems in varying environmental situations. However, they are solved in a piece-meal manner while ignoring the whole complexity of MPC problems. A better understanding of a comprehensive scheme of variables that influence the MPC performance is important for the successful implementation of MPC systems.

(e) The studies on organizational environment have been progressed more at the corporate strategy level, while those studies on the organization configurations at

micro level are little. No studies have addressed the configurations in MPC systems.

In order to fill the aforementioned research gaps, the present research intends to explore the importance of environment-strategy-MPC paradigm, based on configuration approach. The major premise of the thesis is that successful implementation of MPC systems requires a precise research study that inquires into the content of MPC system subject to a defined range of environmental conditions.

6.2 Conceptual Framework

The conceptual framework in Figure 5.2 (Chapter 5) is a hypothesized relationship among the variables of manufacturing environment, strategy and MPC system. The boxes in the framework signify the constructs, and the arrows represent the paths between constructs.

This figure depicts organizational environment, competitive strategy, manufacturing strategy, and MPC system as dependent and independent variables; and organizational performance as a dependent variable. The conceptual framework postulates that environmental conditions affect the MPC system and organizational performance, whilst competitive strategy and manufacturing are cast in a mediating relationship between organization environment and MPC system. The framework implies that manufacturing strategy also affects MPC system. Contrary to previous studies[e.g.53,54,55], this framework suggests an alternative view of environment-strategy relationship. Mutual causality exists between organization and its environment. The environment affects the competitive strategy (path 1a), whilst the management of an organization tends to shape and trade in an environment that matches its strategy (path 1b).

According to the conceptual framework the following propositions are made:

(1) Organizational environment will have a direct influence on competitive strategy (path 1a).

(2) The management of an organization will interpret the organizational environment and develops the competitive strategy that shape the environment (path 1b);

(3) Competitive strategy will directly influence the operation effectiveness of MPC system (path 2).

(4) Manufacturing strategy will have a direct effect on the operation effectiveness of MPC system (path 1d).

(5) MPC system will directly enhance the organizational performance (path 1e).

6.3 Major Constructs of the Conceptual Framework

The constructs of the conceptual framework are made up of five major components. They are described in Sections 6.3.1 to 6.3.5. Table 6.1 presents the summary of the major variables that used to test hypotheses.

Variables	Role in Study
Organizational Environment: – Dynamism – Complexity – Munificence	Independent/Dependent Variable
Competitive Strategy: – Cost – Quality – Flexibility – Responsiveness	Independent/Dependent Variable
Manufacturing Strategy: – MTO – ATO – ETO – MTS	Independent/Dependent Variable
MPC System: – Standard Systems such as MRP, MRPII, ERP, JIT, OPT, HPP, CONWIP, hybrid systems, SIC, APP, ROP – Customized System – Reference Model	Independent/Dependent Variable
Organizational Performance: – Financial – Growth – Inventory	Dependent Variable

Table 6.1: Major Variables Used to Test Hypotheses

6.3.1 Organizational Environment

There are two conflicting research goals in defining the organization environment. On one hand, environment should be captured as comprehensively as possible since it consists of numerous variables. Missing variables in a study may lead to inaccurate result. On the other hand, too many variables included in a research study will render the analysis being extremely complex. The literature reviewed in Chapter 4 suggests that organization environment, in the holistic sense, is multidimensional. It recommends the use of a multiple dimensional approach to evaluate the environment's influences on the performance of a MPC system. This can provide comprehensive findings and reduce the complexity of an analysis by clustering variables into different dimensions of the organization environment. The problem of conflicting goals can be solved partially.

In this study, the objective assessment of organization environment is based on Dess and Beard's[239] generalised characteristics of task environmental conditions, i.e. munificence, complexity and dynamism (see the description in Section 4.22 (Chapter 4) and measurement in Section 7.4.1 (Chapter 7). These three dimensions are widely considered as important constructs for studying the relations amongst business environment, organizational strategy and structure, and the performance implications. For example, Hrebiniak and Joyce's[251] choice-determinism typology is based on these three distinctive dimensions and their findings support the adequacy of operationalizing the environmental constructs for organization study. The subjective assessment of organizational environment is based on the questionnaire survey, in which complexity and dynamism are measured.

6.3.2 Competitive Strategy

As discussed earlier in Section 3.2 (Chapter 3), there is no universal set of competitive strategy. The general consensus of the literature under review considers four dimensions of the competitive strategy: cost, quality, flexibility, and responsiveness. Therefore, in this study, competitive strategy is operationalized as these four dimensions.

6.3.3 Manufacturing Strategy

The literature review in Section 3.3 (Chapter 3) considers manufacturing strategies to be either product-focused or process-focused. Positioning strategy is identified for the choice of the product and process decisions (see Section 3.4, Chapter 3). MTO, MTS, ATO, and ETO are the four fundamental positioning strategies commonly used in manufacturing industry. They affect the cost of carrying inventory, goods delivery, ordering profile, operating decisions, and decoupling point position etc. Hence, they are chosen as measures of manufacturing strategy in this study.

6.3.4 MPC System

The literature review in Chapter 2 shows that MPC systems are diverse and extensive. The commonly used MPC systems/approaches include: MRP, MRPII, JIT, OPT, HPP, CONWIP, hybrid system, SIC, APP, ROP, and customized MPC systems. These systems together with the reference MPC model developed in Chapter 8 will be considered as the elements in the MPC construct.

6.3.5 Organizational Performance

Traditionally, organizational performance is a consequence of the fit between environment, strategy and system (refer to Chapter 3). Since different performance measures might imply different strategies and systems, the selection of performance measures is therefore important.

Performance measurement is a multidimensional construct and it has been a major challenge for researchers. Barker[311] criticizes that the measurement of performance will fail if it is done on the basis of isolated areas of an organization only. A single index will not be sufficient to provide a comprehensive understanding of the performance implication related to the total impact on the entire organization. In order to avoid the measurements of "isolated island of efficiency", Gregory[312] identifies an "integrated performance measurement" that integrates external demands with the internal performance of the organization. However, the total measure of the organizational

performance has become tremendously complex and costly as organizations nowadays evolve into a part of integrated business systems comprised of many stakeholders.

In this study, the dependent variable, i.e. organizational performance, has 3 components: financial performance, growth performance and inventory performance.

6.4 Hypotheses Development

The following hypotheses are based on the conceptual framework (refer to Figure 5.2, Chapter 5) and the literature review (Chapters 2 to 5). These hypotheses are derived from: (a) the paths, representing how some variables of the framework are regressed onto others; (b) the elemental configurations (refer to Section 5.2.1, Chapter 5).

6.4.1 Hypothesis 1

The research question that guides the study is:

How is the MPC system related to manufacturing strategy with performance implication? (Refer to Section 1.2, Chapter 1.)

Krajewski and Ritzman[201] contend that the product-focused manufacturing organizations tend to use an MTS strategy, while the process-focused organizations tend to use an MTO strategy (refer to Section 3.4, Chapter 3). According to Skinner[213], a production plant deploying process-focused strategy uses a common set of processes to produce a small number of fairly homogeneous end products. However, a product-focused plant manufactures similar products using several different process technologies (refer to Section 3.3.1, Chapter 3). Since Skinner[1] recognizes that production planning and control function is one of the elements to achieve the focus, an organization should therefore strategically choose a particular MPC system that fits both the product- or process-requirements. Berry and Hill[227] also demonstrate the importance of the linkage among market, process and MPC system (refer to Section 3.7, Chapter 3).

Therefore, it is posited that:

Hypothesis 1: Manufacturing strategy will have a direct effect on the MPC system effectiveness.

Hypothesis 1a: Manufacturing strategy will have a direct effect on the MPS performance.

Hypothesis 1b: Manufacturing strategy will have a direct effect on the CRP performance.

Hypothesis 1c: Manufacturing strategy will have a direct effect on the MRP performance.

Hypothesis 1d: Manufacturing strategy will have a direct effect on the purchasing performance.

6.4.2 Hypothesis 2

The research question that guides the study is:

How do MPC system, manufacturing strategy and competitive strategy affect the organizational performance? (Refer to Section 1.2, Chapter 1.)

As discussed earlier in Section 1.2 (Chapter 1), it is expected that: (a) competitive strategy will have both direct and indirect effect on MPC system; and (b) the configurations of MPC systems depend on the choice of manufacturing and competitive strategies. The former will be dealt in this section and the latter will be considered in Section 6.4.5. The effect of competitive strategy on MPC system and its modules are posited as follows:

Hypothesis 2: Competitive strategy will have a direct effect on the MPC system effectiveness.

Hypothesis 2a: Competitive strategy will have a direct effect on the MPS performance.

Hypothesis 2b: Competitive strategy will have a direct effect on the CRP performance.

Hypothesis 2c: Competitive strategy will have a direct effect on the MRP performance.

Hypothesis 2d: Competitive strategy will have a direct effect on the purchasing performance.

According to Kim and Lee[217], the inventory level for pure-cost strategy will be large when compared with pure-differentiation or cost-differentiation strategy (refer to Section 3.7). It is further posited that:

Hypothesis 2e: Defender organizations, which adopt a pure-cost strategy, will tend to keep a higher inventory level than analyzer organizations which adopt pure-differentiation or cost-differentiation strategy.

6.4.3 Hypothesis 3

The research question that guides the study is:

How is the relationship between MPC systems and organizational environments defined?

As discussed earlier in Section 6.2, this study adopts an alternative view of environment-strategy relationship. Two different paths are proposed under opposing views: (a) the traditional organization theories (OT) considers that organizational environment affects strategy (path 1a) and it restricts the choice of management; (b) the theory of autopoiesis (refer to Section 4.5) considers that an organization tends to shape and transact an environment that fits the strategy (path 1b). Gopalakrishnan and Dugal[314] assert that both domains, i.e. environmental determinism (path 1a) and strategic choice (path 1b), operate well in an organization. In light of this point, this research study considers that the reciprocal relationship exists between organizational environment and competitive strategy.

The concept of autopoiesis also suggests that the way an organization acts is a product of how it comprehends the environment and enacts relationship with the environment[58,313]. The operational environment, as a result of strategic choice, is established, which will be different from the organizational environment. Figure 6.1 is the submodel of the conceptual framework (Figure 5.2, Chapter 5), in which the relationships among organizational environment, strategy, operational environment, and MPC system are graphically presented. A circular relation is therefore derived. The operational

environment is developed as a result of the management's actions in shaping the organizational environment. It will influence both manufacturing strategy (path 3) and MPC system (path 4). The performance evaluation process is used to provide feedback to the management in redefining the competitive strategy, if necessary.

Three propositions according to the submodel are derived:

(1) The management of an organization will shape the organizational environment from time to time and develop the operational environment (new path 1b).

(2) Operational environment will have a direct influence on manufacturing strategy (path 3).

(3) Operational environment will have a direct influence on MPC system (path 4).

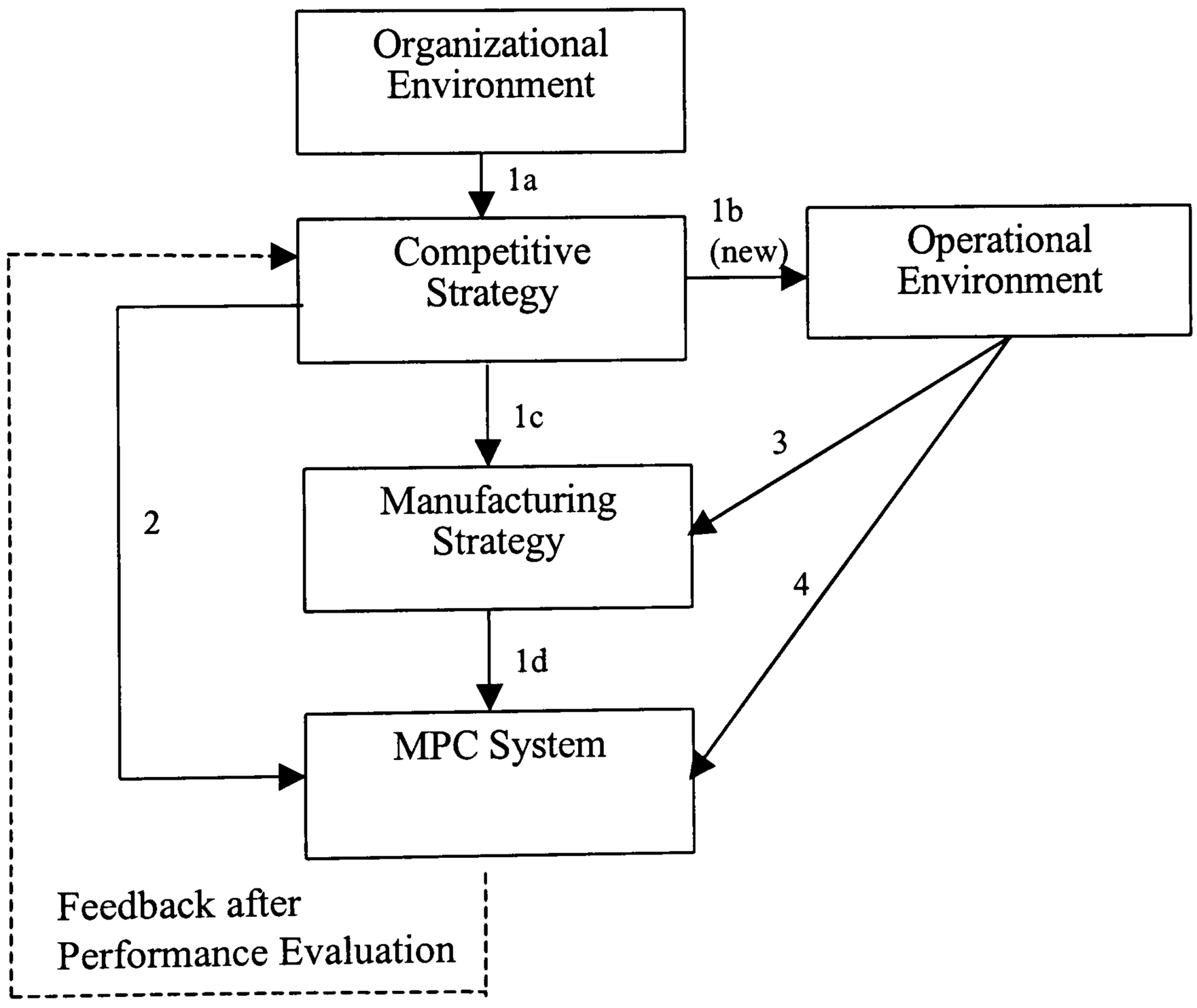


Figure 6.1: A Submodel of the Circular Relations between Operational Environment, Strategy, and MPC System

Based on the concept of autopoiesis and enacted environment, this study view an environment subjectively as:

(a) product development element – the organizations are continuously seeking for new products to meet with the sophisticated customer demands;

(b) external relationship element – the three types of relationships are considered: customer, supplier, and subcontractor in fostering a cooperative environment;

(c) internal relationship (between departments) element – MPC management requires inter-functional cooperation since most of the information flows are provided by other functions;

(d) supply chain strategy – the organizations aim to integrate a number of external stakeholders such as suppliers, manufacturers, subcontractors, distributors and retailers, working together (refer to Section 3.5, Chapter 3);

It is posited that:

Hypothesis 3: Operational environment will have direct effect on the MPC system effectiveness.

Hypothesis 3a: Product development is positively associated with the MPC system effectiveness.

Hypothesis 3b: External relationship is positively associated with the MPC system effectiveness.

Hypothesis 3c: Internal relationship is positively associated with the MPC system effectiveness.

It is also hypothesized that the supply chain strategy is positively associated with the MPC system effectiveness and this is discussed in Section 6.4.5.

6.4.4 Hypothesis 4

Recently the study on supply chain has gained currency. A supply chain includes the management of information systems, sourcing, inventory management, production scheduling, and customer service etc. The study may provide insights for the Environment-Strategy-MPC research paradigm. Therefore, it is interesting to consider the circular relationship between organizational environment, supply chain strategy (as operational environment) and MPC system with performance implication. Figure 6.2 depicts the submodel in the supply chain context. It is proposed that the supply chain

strategy under different operational environment conditions will have direct effect on the MPC system effectiveness.

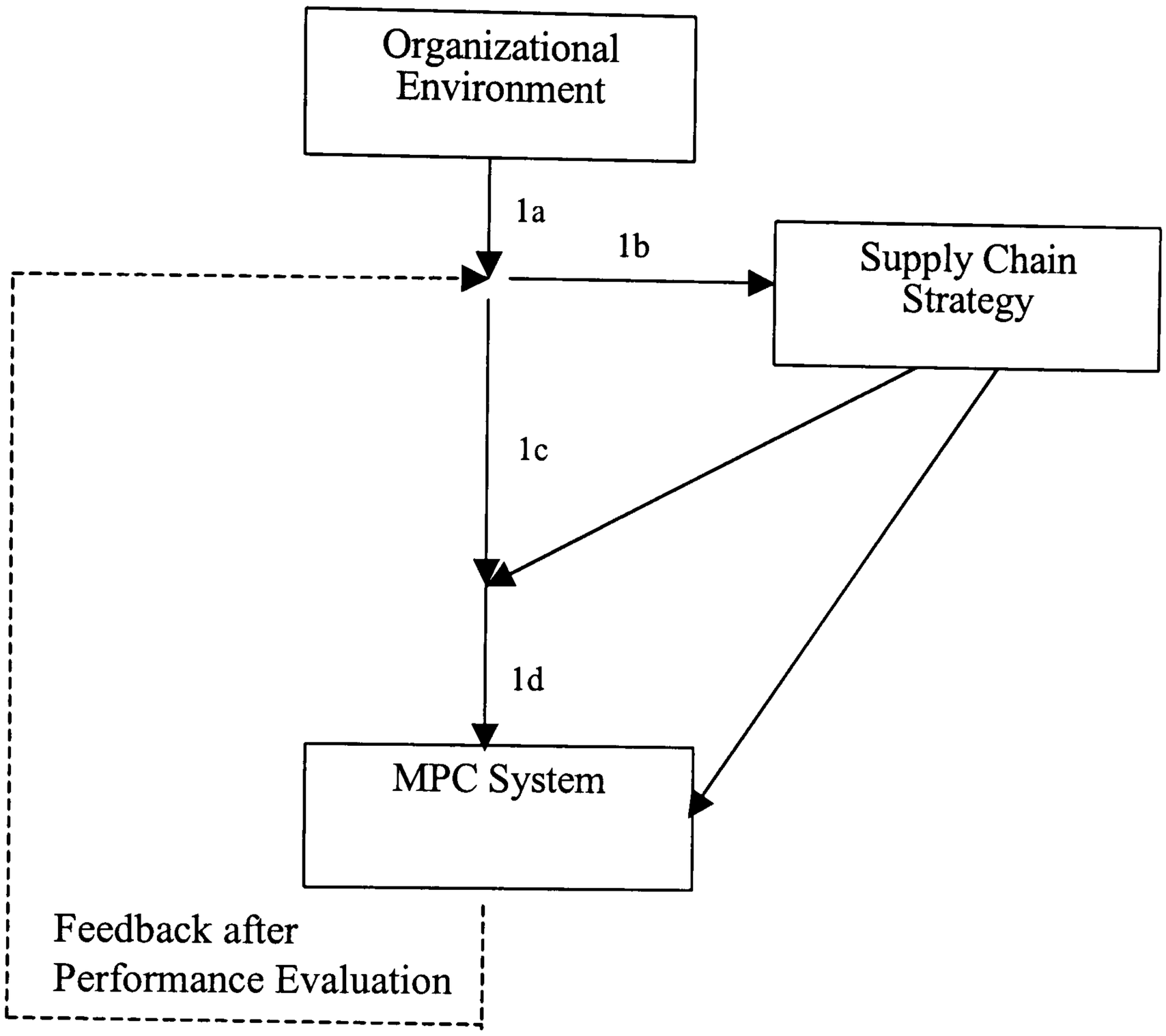


Figure 6.2: A Submodel of the Circular Relations between Organizational Environment, Supply Chain Strategy, and MPC System

In coping with the intensified competitive pressures and environmental changes, organizations continuously employ innovative techniques to revolutionize their operations and logistics activities. Stainer[315] addresses the fact that the most prominent approach for Japanese long-term productivity thinking is hinged on a variety of continuous improvement programmes. For example, Total Quality Management (TQM) programme is widely reported as one of the techniques that can increase organization productivity, raise product quality, and lower production cost[316]. In addition, inventory reduction programme has been identified as one of the continuous improvement activities since inventory represents a major part of total assets for most manufacturing organizations. The research is based on the premise that high-performing organizations have excelled in their continuous improvement capabilities under the

constantly changing environment. The improved inventory performance is one of the outcomes. The following hypotheses are postulated:

Hypothesis 4a: Inventory performance has been continuously improving over time for high performing manufacturing organizations.

Hypothesis 4b: In the context of inventory performance, high performing manufacturing organizations out-perform low performers.

Two separate research studies were carried out by Loar[317] and Vergin[318] to analyze the trends in the inventory turnover ratio for Fortune 500 largest industrial corporations in the United States. Their studies illustrated that there was a significant reduction in inventory level from 1971 to 1995. Both studies, however, did not take the environment influences and the types of supply chains into consideration. In addition, their empirical studies made no conclusion on the relationship between financial performance and inventory performance. One of the aims of this study is intended to fill this gap.

As noted earlier, the prime focus on a lean supply chain is different from that on an agile supply chain. Under unstable market conditions, an agile supply chain tends to build up large inventory, either as inputs, assemblies, or outputs, in order to hedge against uncertain demand and to reduce the risk of shortages. Nevertheless, the minimization of inventory level is not of much concern. On the contrary, a lean supply chain tends to continuously reduce the inventory level when operating under predictable supply and demand situations.

Driven by the need to respond quickly to customer orders and at the lowest possible cost, an extended supply chain is evolved. This new supply chain movement supports the core organization in the following ways: (a) to establish a more closely integrated relationship with partnering organizations; (b) to manage better the increasing scope of outputs and the complexity of processes; (c) to cut down the operating costs by assigning non-core activities to partnering organizations that could achieve both economy of scale and cost efficiency; and (d) to reduce the capital such as warehouse buildings and equipment. Hence, this extended supply chain is designed to accomplish both market-responsiveness and cost-effectiveness.

Some organizations in an extended supply chain tend to outsource their manufacturing through (sub)contracting partnership. There are four major aims for such

outsourcing practice: (a) to expand the supply chain's capacity in order that it can be more responsive to market demands; (b) to reduce environmental complexity by increasing the flexibility of capacity planning; (c) to minimize the risk of demand fluctuations by distributing the orders to (sub)contract manufacturers; (d) to ameliorate capital investment by transferring the storage responsibilities to (sub)contract manufacturers. Berry et al.'s[319] analysis of electronic product supply chain in Britain maintained that inventory was generally held by the organizations with less power at the low value-added end of the supply chain. As such, core organizations of an extended chain may reduce the inventory level via (sub)contracting partnership, but small manufacturers would most likely hold excess inventory to cover for demand fluctuations.

From the above discussions, the inventory performance is dependent on the types of supply chains. As such, it is postulated that:

Hypothesis 4c: The inventory performance for a lean supply chain is better than an agile supply chain.

Hypothesis 4d: For organizations adopting extended supply chain, the inventory performance is better than their previous undertaking that operated as either an agile or a lean supply chain.

Hypothesis 4e: For organizations employing (sub)contractors to execute a large proportion of manufacturing orders, the inventory performance would be better than the organizations undertaking most of the manufacturing themselves.

The logic of relating manufacturing environment to various supply chains and in turn to organizational performance is compelling. It helps to define an appropriate supply chain in responding to its environmental supplies and demands. In this regard, we identify 6 hypotheses with the purpose to investigate the relationship between supply chain and inventory performance subject to three different environmental dimensions, namely, munificence, dynamism and complexity.

Under the condition of high environmental munificence, organizations generally possess adequate funds to uphold investments for both physical and market mediation functions in responding to uncertain environmental demands. The management tends to

deploy a higher level of inventories to mitigate the risk of shortages. The effects of uncertainty and instability would be reduced. Hence, it is postulated:

Hypothesis 4f: The inventory level is positively related to the level of environmental munificence, i.e. the inventory investment is high under high environmental munificence, or otherwise.

While under the condition of low environmental munificence, an agile supply chain is the most vulnerable for two major reasons: (a) the supply is insufficient to cope with the demand as the variety of output is high; and (b) the shortage of funds is not enough to support larger inventory investment as a hedge against uncertain demands. On the contrary, lean supply chain is less vulnerable in the condition of low environmental munificence because of higher physical efficiency, lower operating cost and lower product variety. A lean supply chain is therefore more suitable to low environmental munificence situation. Deduced from this, it is postulated that:

Hypothesis 4g: In the condition of low environmental munificence, organizations operating as lean supply chain will have better inventory performance than organizations operating as agile supply chain, or otherwise.

Under increasing level of environmental dynamism wherein changes and developments take place rapidly and randomly, organizations may face with a greater degree of uncertainty. As such, planning for changes becomes increasingly difficult and demand forecast would be highly inaccurate since information is insufficient for making precise prediction. The inventory or excess capacity can be used as a buffer to hedge against uncertainty arisen from environmental dynamism. According to Williamson (1996), there are two possible means for the organizations to improve economic performance when operating in such environment. First, they should be able to adapt to environmental changes by responding to price signals in the market, i.e. autonomous adaptations. Second, they must change their governance structures (e.g. supply chain mechanism) to align with the market that will produce organization efficiencies, i.e. cooperative adaptations. In this regard, across a continuum of environmental dynamism, there would be differences in the adaptive capabilities of

various supply chains, and such differences would have performance implications. Thus, it is postulated:

Hypothesis 4h: The inventory level is positively related to the level of environmental dynamism, i.e. the inventory investment is high under high environmental dynamism, or otherwise.

As noted earlier, a lean supply chain suits the environment of predictable market demand and low product variety, while an agile supply chain fits to the environment of volatile market situation and high product variety. Thus, it is postulated:

Hypothesis 4i: In the condition of high environmental dynamism, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.

In high environmental complexity condition, i.e. the increase in the heterogeneity of inter-organization interactions, a supply chain will become more sophisticated. The conflicts between organizations within the supply chain will be larger and the risk of inefficiency increases. Thus, it is postulated:

Hypothesis 4j: The inventory level is positively related to the level of environmental complexity, i.e. the inventory investment is high under high environmental complexity, or otherwise.

According to Thompson[240], an organization in high heterogeneous environment would likely require an organic system to achieve organizational effectiveness. Conversely, an organization operating in both homogeneous and stable environment would best operate in a highly mechanistic system. As a result, in a high complexity condition, an organization is better to adopt an agile supply chain for the reason that it is probably more capable to deal with a greater number of external stakeholders in the environment of high outputs and volatile market situation. Otherwise, they will function inefficiently. It is therefore postulated:

Hypothesis 4k: In the condition of high environmental complexity, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.

A supply chain is associated with the physical flow and information flow amongst member organizations. An information processing system is one of the fundamental mechanisms for effective supply chain management since it supports internal transactions and external communication. With the advancement of IT, it brings a number of benefits to the organizations such as better responsiveness to customers, greater capability to handle a large number of transactions and voluminous data, improved coordination and increased integration of a supply chain. This helps to ensure that the output could be delivered to the end-users at the right time, at the right place, and with the right attributes. Expectedly, the inventory performance could also improve as a result. For instance, Brua et al.[320] trace the causal supply chain and study the effect of IT on five intermediate variables, i.e. capacity utilization, inventory turnover, quality, relative price and new product introduction. They find that IT is partially positively related to inventory turnover.

Since an increasing level of environmental dynamism and complexity will lead to a greater environmental uncertainty[321,322], there is a need for an effective information-processing mechanism to elicit more information for maintaining a competent MPC system and reducing that uncertainty[323]. IT investment is expected to bolster the effectiveness of an organization in a dynamic and complex environment. Hence, it is posited:

Hypothesis 4l: Organizations adopting IT have their improvement rates in inventory performance faster than organizations not adopting IT.

Hypothesis 4m: In condition of high environmental dynamism or high complexity, organizations adopting IT have the faster rates of improvement in inventory performance than organizations not adopting IT.

Figure 6.3 shows the environmental influences on supply chain performance for hypotheses 4a to 4m.

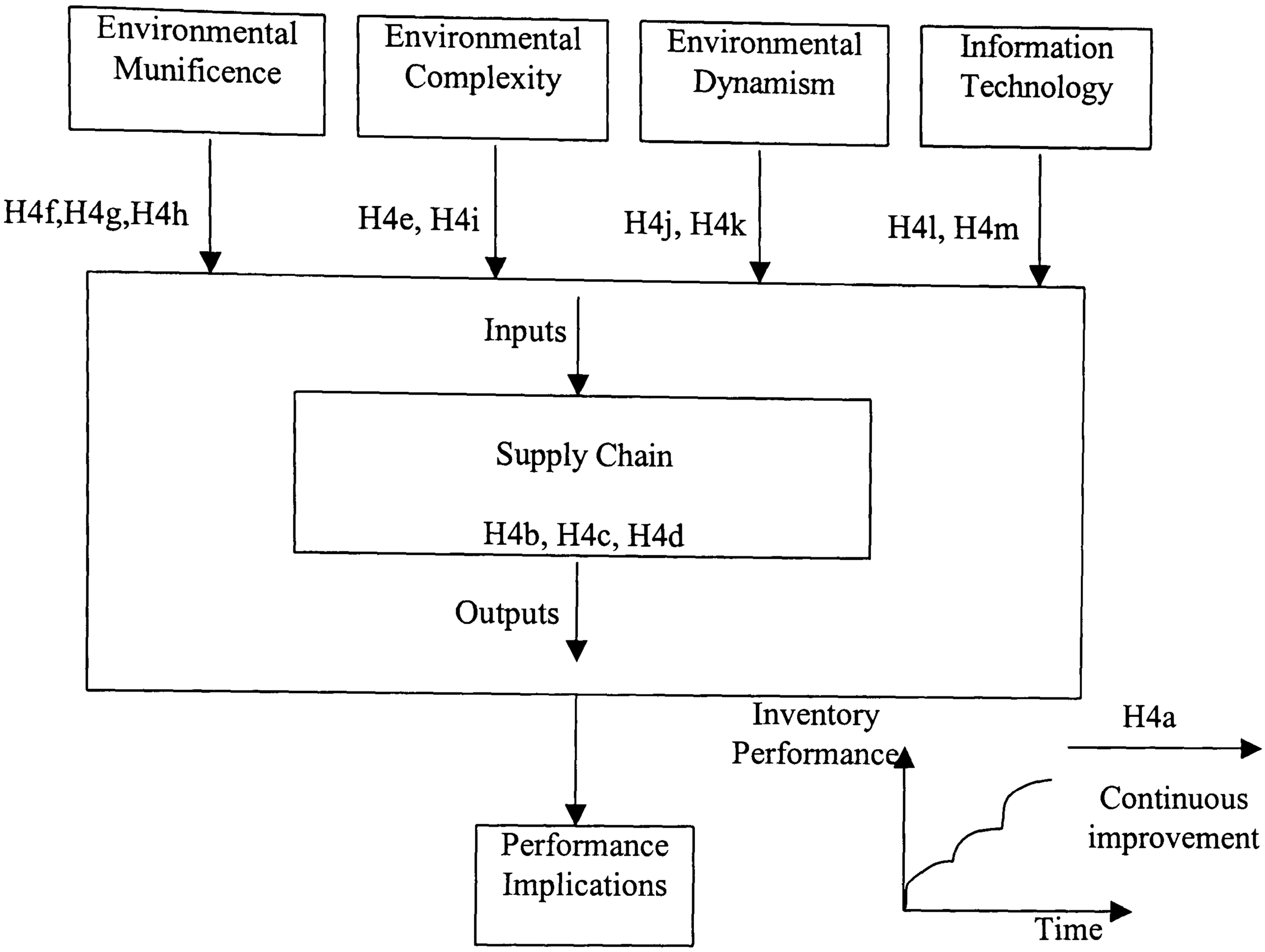


Figure 6.3: Environmental Influences on Supply Chain Performance
[Note: H denotes hypothesis.]

6.4.5 Hypothesis 5

The problem addressed in this research issue is:

How can the relationship of organizational environment, competitive strategy, manufacturing strategy and MPC system be aligned in order to achieve high performance?

In Section 5.2.2 of Chapter 5, three elemental configurations are proposed:

(a) Configurations defined on the basis of Miles and Snow's[234] theoretical framework, namely, defender, prospector, analyser, and reactor.

(b) Configurations emerged from supply chain strategies, namely, lean supply chain, agile supply chain and leagile supply chain.

(c) 27 elemental configurations derived from Dess and Beard's[239] 3-dimensional of organizational task environments (see Table 5.2, Chapter 5).

It will be useful to compare the characteristics of each of the aforementioned configurations. Therefore, the development of MPC configurations will provide a rational, comprehensive classification, and empirical patterns for MPC system. However, given the complexity of the research domain, it is expected that the 27 configurations described in (c) can only be evaluated partially in this study.

It is posited that:

Hypothesis 5a: The manufacturing and competitive strategies have a moderating effect between organizational and operational environments.

Hypothesis 5b: The configurations in MPC systems are related to a particular organizational and operational environment.

Figures 6.4 and 6.5 show the path models for the testing of hypotheses 5a and 5b respectively.

There are 6 paths in the causal model (see Figure 6.4) that connects organizational environment, operational environment, competitive strategy, manufacturing strategy and MPC system performance. The link between operational environment and competitive strategy is recursive in nature that takes into account the theory of autopoiesis.

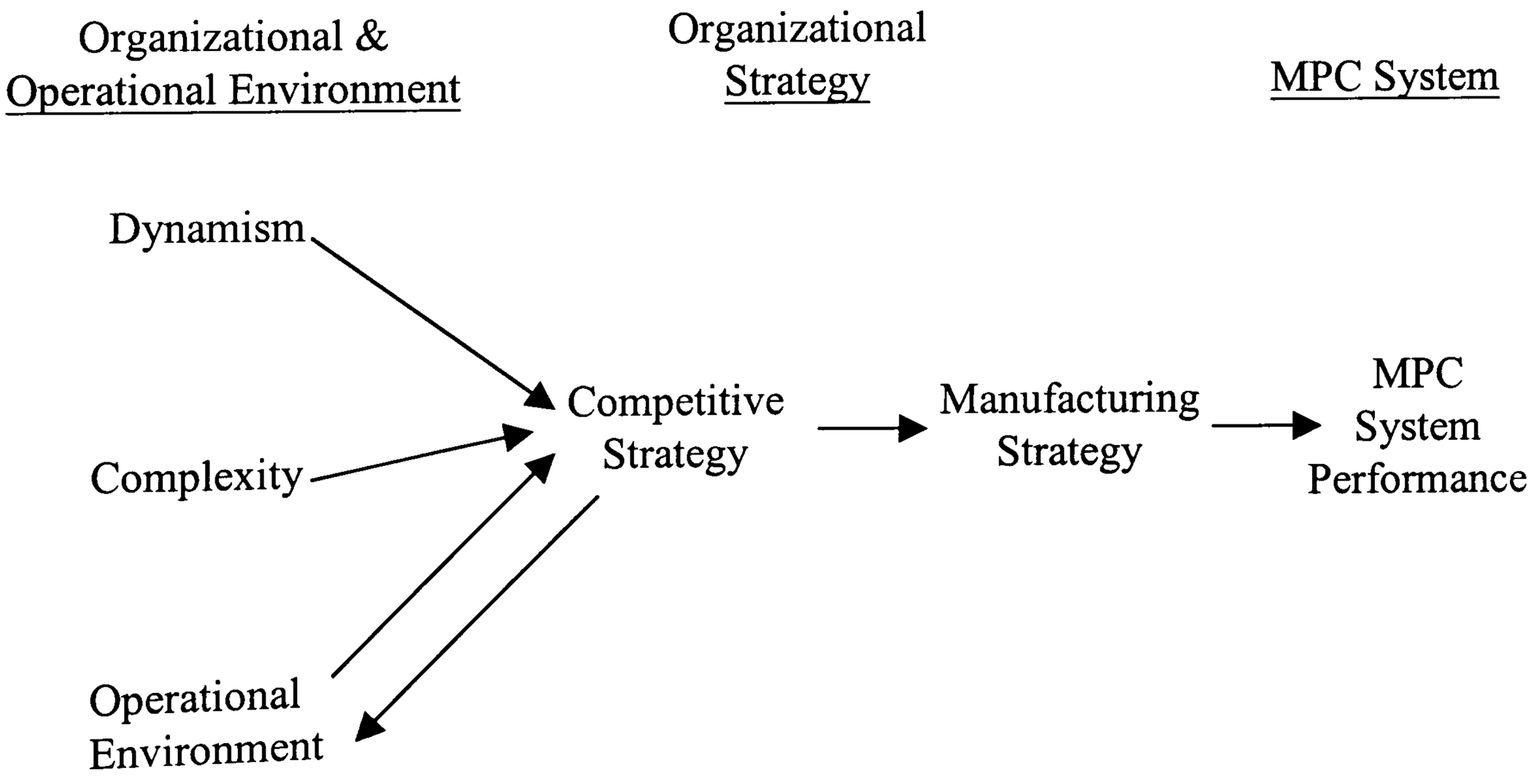


Figure 6.4: Path Model for Testing the Hypothesis 5a

The causal model that links the organizational and operational environment with MPC system (see Figure 6.5) consists of 24 paths. The outcome is the MPC system performance. The MPC system of the model includes functions such as master production schedule (MPS), capacity requirements planning (CRP), material requirements planning (MRP), purchasing, inventory and forecasting for analysis.

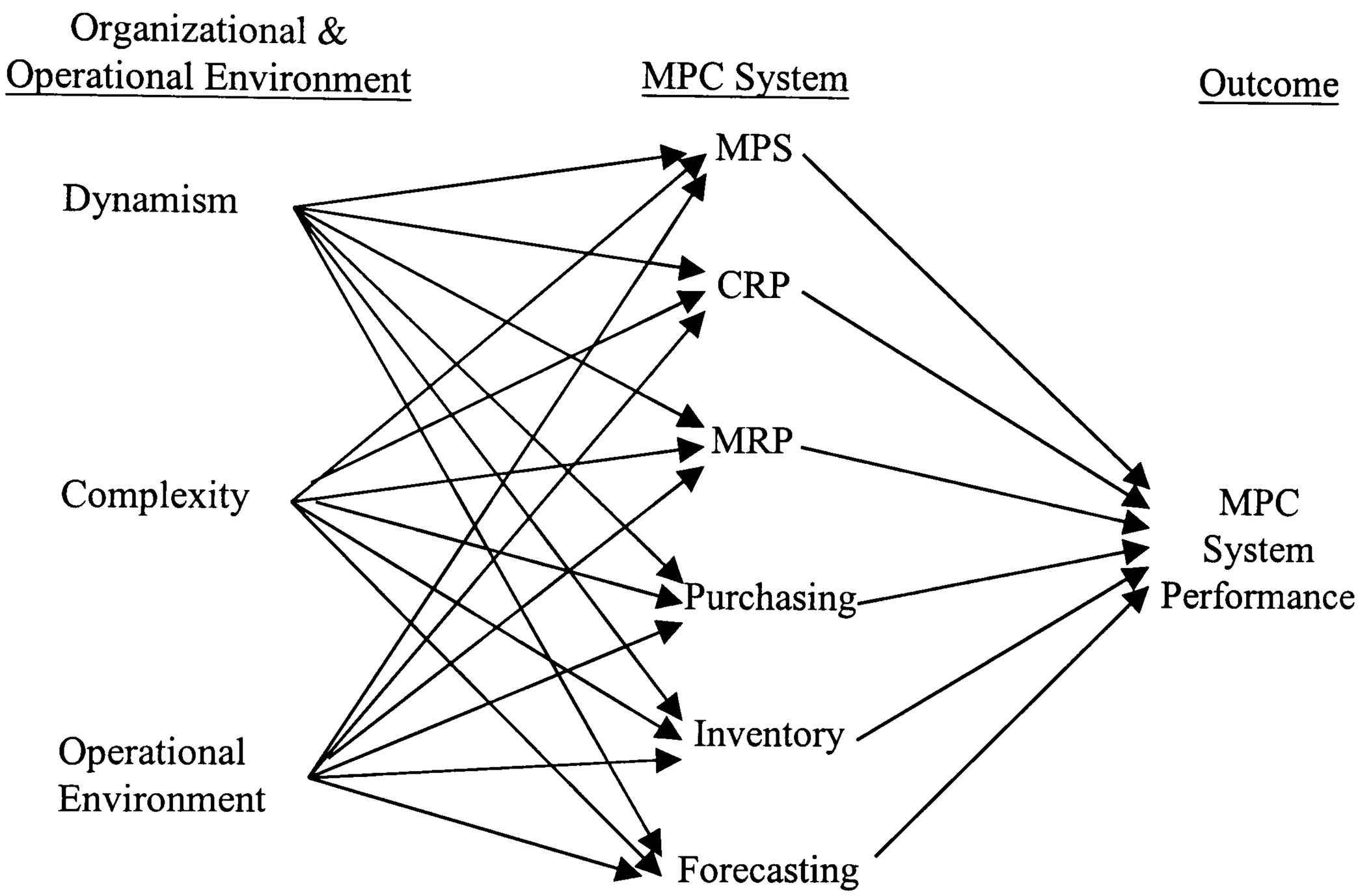


Figure 6.5: Path Model for Testing the Hypothesis 5b

6.5 Summary

A total of 30 hypotheses are proposed in this Chapter. The first 5 hypothesized relationships (Hypotheses 1, 1a, 1b, 1c, 1d) are associated with manufacturing strategy, the MPC system and its related functions. The manufacturing strategic variables are based on the 4 positions and 3 decoupling points an organization may choose, i.e. make-to-order (MTO), make-to-stock (MTS), assemble-to-stock (MTS), engineer-to-order (ETO), decoupling point (end-item), decoupling point (sub-assembly) and

decoupling point (component). Next, 6 hypothesized relationships (Hypotheses 2, 2a, 2b, 2c, 2d, 2e) are proposed that correlate competitive strategy with the MPC system and its related functions. This Chapter also reviews the relationships between operational environment and the MPC system. In this regard, 4 hypotheses (Hypotheses 3, 3a, 3b, 3c) are suggested. Further, 13 hypothesized relationships are put forth in order to test the linkages between supply chain, 3-dimensional task environment, MPC and inventory performance. The last two hypotheses intend to verify the configurations in MPC systems.

Chapter 7 Research Methodology

This Chapter describes the methods used in this research study. It is divided into the following sections: research sample, the design of the study, description of the instrument development, measurement, data collection, and methods of data analysis.

7.1 Introduction

The overall objective of this study is to formalize the configurations in system characteristics and the relationship between MPC systems and their environments. The specific aims of the study includes: (a) the development of instrument such as survey questionnaire for the Environment-Strategy-MPC research paradigm (refer to Section 7.4); (b) the development of environmental constructs (refer to Sections 7.5.1 to 7.5.3 for measurement and Chapter 9 for the result); (c) the description of performance measurement for the study (refer to Sections 7.5.4 to 7.5.7); (d) the determination of reference model for MPC systems (refer to 7.6 for description and Chapter 8 for the development of the model); (e) the test of the five major hypotheses (refer to Chapter 6) including the development of configurations in MPC systems.

7.2 Research Sample

The sample units for analysis in this study are the Hong Kong manufacturing companies. Hong Kong has been a major centre for light industries. Over the past two decades Hong Kong manufacturing has undergone a structural transformation. Changes in manufacturing have been accompanied by the transformation of business practices that includes redistributing production, upgrading front-end activities, establishing subcontractors, transferring manufacturing technology, strengthening logistics operations, and moving into retailing operations. Many manufacturers have diversified their labour-intensive manufacturing processes to low-cost countries across China and the Southeast Asian region. Hong Kong has remarkably transformed itself to a regional control centre for mixing manufacturing capabilities with financial, marketing, transport

and logistics skills. Hong Kong companies are strategically acting as packagers and integrators for both local and global markets[324]. An unofficial estimated figure about the Hong Kong business circle is that around 5 million workers in South China region are working for the Hong Kong manufacturing companies, which is five times the Hong Kong workforce at its peak as a manufacturing economy.

The process of change is dramatically altering the skills required for Hong Kong manufacturing companies. Many manufacturing companies have developed a capability to produce high-end, sophisticated products by either designing their own products or making products on behalf of prestigious international brand names. A wide range of high value-added manufacturing support services, such as product design and development, prototyping, marketing, procurement, trade, finance, quality system auditing and logistics, have been preserved and strengthened in Hong Kong manufacturing industries. As a consequence, technical knowledge of manufacturing processes is no longer sufficient. Hong Kong companies must become more proficient in manufacturing-related services that are knowledge-intensive and information-intensive.

The emerging trend of globalisation of production today has altered the manufacturing structure of a company. A network of manufacturing is built up. It requires the logistics activities of a value chain distributed across two or more countries. The high concentration of manufacturing activities dispersed geographically manifests a low proportion of production processes in Hong Kong. As reported, around 60% of Hong Kong firms have developed extensive manufacturing activities in China and another 30% deploy their manufacturing in the third world countries or South East Asia[325]. Therefore, the use of Hong Kong manufacturing industry as the research sample for the study of supply chain management and logistics system is adequate.

The manufacturing industry in Hong Kong has been strengthened by a number of factors: free port policy, ideal geographic location in the Asia region, a well-versed transportation service, an advanced telecommunication infrastructure, excellent supporting services (e.g. financial and legal), the availability of professionals with good managerial and technical skills, and a well-educated and efficient workforce.

Small- and medium-sized enterprises (SMEs) form the backbone of Hong Kong's manufacturing. Hong Kong has 300,000 SMEs, of which more than 40% are strongly

transnational and have operations outside Hong Kong. As of September 1997, over 96% of Hong Kong's domestic manufacturers employed less than 100 people while an amazing 99% of Hong Kong's trading companies have fewer than 50 employees[325]. It is known that SMEs in Hong Kong have difficulties in developing and using IT due to insufficient resources. For example, the penetration level of e-commerce within the business community in Hong Kong is relatively low due to an extremely large number of SMEs[326].

In this study, the financial data for analysis are collected from a variety of sources with tremendous efforts for two reasons. First, most of the managers keep such data as confidential and refuse to disclose them for research study. Second, statistics database such as COMPUSTAT is presently not available in Hong Kong.

Five databases were gathered to test the hypotheses. The first data source was obtained from Hong Kong Special Administrative Region (HKSAR) government's trade census and industrial production statistics for the period between 1993 and 1998. Twenty major manufacturing industries were chosen for the evaluation of environmental variables. The second source was drawn from a sample of 116 public firms in Hong Kong. The annual reports (1993 - 1998) of public firms were used to collect information on the following variables: (a) sales turnover, (b) end-of-year inventories, (c) total assets, (d) products, and (e) the business perspectives. The third sample consisted of 6 companies chosen for testing a reference MPC model, based on a field study between November 1997 and January 1998 (refer to Chapter 8). The fourth sample was based on a survey of 125 senior managers working in Hong Kong manufacturing organizations, in which 116 replies were considered as useful. The data collection process was conducted by personal interviews and a questionnaire survey taken during two executive development programmes between January 1999 and May 2000. The fifth database were acquired from Hong Kong Trade Development Council's[325] report and Hong Kong Government Industry Department's 1996 survey[328] for content analysis. Table 7.1 summarizes the research samples for this thesis based on archival approach and questionnaire survey.

Sample Industry	Research Sample	
	Number of Public Organizations (Archival approach)	Number of Respondents (Questionnaire Survey)
Food	12	-
Beverages	4	-
Wearing apparel	11	-
Leather and Leather products	4	
Printing & publishing	9	-
Plastic products	4	16
Fabricated metal products	3	16
Radio, TV & communication equipment	14	10
Electrical & electronic products	27	27
Electronic parts & components	14	33
Electrical appliances & houseware	2	10
Machinery, equipment & apparatus	5	13
Containers, paper boxes & paperboard	7	-
Total:	116	125

Table 7.1: A Summary of Research Samples

The Western and Japanese manufacturing practices, cited in the questionnaire, would be familiar to Hong Kong industrialists and their employees. First, Hong Kong has been subjected to the influence of Western culture for more than 150 years. Both the business and technical managers understand well the Western manufacturing and management practices. Second, Hong Kong is also geographically close to Japan and hence there is no barrier for Hong Kong organizations to learn from Japanese manufacturers. Consequently, Hong Kong manufacturing organizations are not completely Western or Eastern but can be considered as a cultural mix with its own ethos and practices[331]. The analysis of the data is proceeded with this in mind. The limitation has already been described in Section 1.6 (Chapter 1).

7.3 Design of the Study

Except for the archival data collected from published reports of public firms and HKSAR's trade statistics, the design of the study for the reference MPC model and questionnaire survey is cross-sectional. Contrary to longitudinal study, which collects data over time, data on both independent and dependent variables are collected at one time period. Babbie[327] indicates that cross-sectional study is not suitable for the determination of causal direction. Cross-sectional design is limited to the study of correlation relationships. Because of this statistical limitation, this study is designed to test the bivariate relationships for the hypotheses 1 to 3c. The archival data collected from published reports and production statistics are used for longitudinal study about the trend between 1993 and 1998. These longitudinal data is used for the evaluation of hypothesis 4a to 4m. Causal models are applied for the test of hypotheses 5a and 5b.

As described earlier in Section 1.4 (Chapter 1), the study contains three phases. The first phase is to carry out a comprehensive literature review. They are presented from Chapter 1 to Chapter 5 of this thesis. The second phase is to design the instrument for the study of Environment-Strategy-MPC relationships. There are several activities in this phase:

- The design of a MPC reference model (see Section 8.8.3, Chapter 8);
- The design of a questionnaire used to collect data (see Section 7.4, Chapter 7) for the test of hypotheses;
- The completion of the questionnaire via field-based interviews and the executive development programmes;
- The validation of MPC reference model by using a field study (see Section 8.9, Chapter 8);
- The development of environmental constructs (see Chapter 9) that includes the collection of production statistical data and the archival data of Hong Kong public firms;

The next phase is to generalise the data by using SPSS 10.0 and SEPATH of STATISTICA 6.0 for Windows. The elemental configurations, relational configurations, and reference architecture of MPC systems are tested.

7.4 Questionnaire Design

The variables of the questionnaire have been revised several times. The initial design of the questionnaire was followed from a thorough literature study in MPC system, organizational environment, and strategy. A piloted survey (by field visits) was conducted between the Winter 1997 and the Spring 1998. The purposes of the pilot test were: (a) to collect data for the test by using SPSS 7.0 for Windows (SPSS 10.0 for Windows was not available until 1999); (b) to obtain the opinions from the practitioners in the field in order to determine the ambiguities and areas of difficulty; (c) to carry out a number of "face-validity" checks for the validation of a MPC reference model. This phase of study uncovered several problems: (a) the time for answering the questionnaire was between 30 to 60 minutes and the respondents complained that it was "too long"; (b) most of the respondents required the explanation of decoupling point, frozen interval, modularized items, the differences between MRP, MRPII, and ERP etc.

The questionnaire was then revised which was a 60-item, closed and open ended questionnaire. It contains the following sections: company profile, positioning strategy, perceived manufacturing environment, competitive strategy, information technology, interdepartmental relationship, inter-site communication, customer profile, performance rating, and various MPC functions (see Appendix 1).

Given the fact that in the previous mail survey for other research studies the respondent rates were low (see Section 1.6, Chapter 1), it was decided that the survey for this study was carried out via field interviews and the executive development programme (part-time Master Degree in Engineering Management). It was expected that face-to-face explanation of some of the questions (but discussion was avoided) would alleviate the problem of mis-interpretations. Besides, for several cases, some respondents were given the time to consult their colleagues if the problem areas were not in their control. They then mailed the questionnaires to me for analysis.

7.5 Measurement

This section describes the design of variable measures, measurement of 3-dimensional organizational environment (munificence, complexity and dynamism), performance, growth, financial and inventory performance.

7.5.1 Design of Variable Measures

The questionnaire (see Appendix 1) is designed to collect data for both dependent variables and independent variables. These variables with their related questions (the name inside the bracket is the variable name that is entered into the SPSS data document) are described as follows:

(a) Five questions numbered 14 to 18 are used to collect the perceptual changes in organizational environment (dynamism): customer demands (envicus), new products introduced (enviprod), product getting obsolete (enviobs), marketing practices (envimar), and production methods (enviop).

(b) The competitive strategy (comstrg) is identified by:

Cost – manufacturing cost (comcost) in question number 58(a);

Quality – product quality (comproq) in question number 58(c);

Flexibility – product design and development (comprod) in question number 19(b);

Responsiveness – goods delivery (compdel) in question number 58(d), and information flow (cominfo) in question number 58(g).

(c) Question number 13 elicits four types of manufacturing (positioning) strategies: make-to-order (mto), make-to-stock (mts), assemble-to-stock (ats), and assemble-to-order (ato).

(d) The data of various MPC modules are collected. They include forecasting (question number 21), MPS (question numbers 23-26), CRP (question numbers 27-32), materials planning (question numbers 33-37, 41), purchasing (question numbers 38-40, 42), and inventory control (question numbers 43-45).

(e) Question number 59 (a, b, c, d, e, f, g, h) elicits the responses on organizational performance (perform). There are eight items: manufacturing cost (perfcost), product development (perfpro), product quality (perfproq), goods delivery

(perfdel), sales revenues (perfsale), sales growth rate (perfsalg), information flow (perfinf), and gross profit margin (perfmarg).

(f) In question number 60, the perceptual performance scores of various MPC modules and the overall MPC performance are dealt with.

(g) The extent of forecasting errors (err) is addressed in question number 22 (a, b, c).

(h) The extent of computerization (comput) is addressed in question numbers 47, 52, and 57. Question number 47 deals with the use of computer(s) for different functions (itarea), question numbers 52 (interenc) and 57 (custenc) deal with inter-site and customer communication via computers.

(i) External relations (extrel) are considered. Questions related to "extrel" are: question number 31 that asks about the subcontractor relationships (subcorel), and question number 40 which elicits the supplier relationships (supprel).

(j) Data concerning internal relations (intersh) is addressed in question number 51.

(k) Question number 20 elicits responses on the risk-taking behaviour of senior executive (risk).

The relationship of the variables and the questions in the questionnaire is summarised in Table 7.2. The variables with code name, sorted by question numbers, are presented in Table 7.3.

7.5.2 Measurement of Environmental Variables

The second approach for the measurement of organizational environment in this study is determined by archival-based method. Unlike the perceptual score measures for 2-dimensional environment as mentioned in Section 7.5.1, this approach collected scores for 3 dimensions, i.e. munificence, complexity and dynamism. They are described as follows:

(a) Environmental munificence. According to Dess and Beard[239], the rate of growth could be used as a proxy measure for scarcity or abundance of resources (environmental munificence). In this study, six industry variables are used to operationalize the environmental construct. They are: growth in sales (or in total export values if the industry is export-orientated), growth in price-cost margin,

Variable	Question Number(s)
Organizational environment (dynamism):	
• customer demands (envicus);	14
• new products introduced (enviprod);	15
• product getting obsolete (enviobs);	16
• marketing practices (envimar);	17
• production methods (enviop);	18
Competitive strategy (comstrg):	
• cost (comcost);	58(a)
• quality (comproq);	58(c)
• flexibility (comprod);	19(b)
• responsiveness by goods delivery (compdel) and information flow (cominfo).	58(d), 58(g)
Manufacturing (positioning) strategy:	
make-to-order (mto); make-to-stock (mts); assemble-to-stock (ats); and assemble-to-order (ato).	13
MPC modules:	
• Forecasting;	21;
• MPS;	23, 24, 25, 26
• CRP;	27, 28, 29, 30, 31, 32
• materials planning;	33, 34, 35, 36, 37, 41
• purchasing;	38, 39, 40, 42
• inventory control;	43, 44, 45
• perceptual performance scores.	60(a), (b), (c), (d), (e), (f)
Organizational performance (perform):	
• manufacturing cost (perfcost);	59(a)
• product development (perfpro);	59(b)
• product quality (perfproq);	59(c)
• goods delivery (perfdel);	59(d)
• sales revenues (perfsale);	59(e)
• sales growth rate (perfsalg);	59(f)
• information flow (perfinf); and	59(g)
• gross profit margin (perfmarg)	59(h)
Extent of forecasting errors (err)	22(a), 22(b), 22(c)
Extent of computerization (comput):	
• use of computers for different functions (itarea);	47
• use of computers between office and plants (interenc);	52
• use of computers between company and customers (custenc).	57
External relations (extrel):	
• subcontractor relationships (crpsub);	31
• supplier relationships (supprel).	40
Complexity	
• (compexp), (compexcu), (compexsu), (compexsp)	12, 31(b), 40(b), 53(b)
Internal relations (intersh)	51

Table 7.2: Relationship of Measured Variables and Questionnaire

Question Number	Variable	
	Type	Code Name
3	Continuous	employ
4	Continuous	age
5	Class	buss
6	Binary	market1, market2
9	Continuous	revenue
10	Continuous	oem, odm
12	Discrete	mainprod, rangprod, matrls, compo, itemlev, newprod
	Binary	family
	Triplet	common
13	Quadruplet	posit1, posit2, posit3, posit4
14, 15, 16, 17, 18	Likert	envicus, enviprod, enviobs, envimar, enviop
19a, b, c, d, e	Likert	commar, comprod, commfg, comqul, comfin
20	Likert	risk
21a, b, c	Binary	forefg, foremod, foremat
22a, b, c	Likert	errfin, errmod, errmat
23	Binary	mps
24	Triplet	mpsitem1, mpsitem2, mpsitem3
25	Continuous	mpstime, mpsrpl, mpsfroz
27	Binary	crp
29	Triplet	crpsub
31a, b	Likert	subcorel, compexsu
33	Binary	mrp
34	Triplet	mrpord
35	Class	mrpsys
39	Binary	suppl
40a, b	Likert	supprel, compexsp
41	Triplet	capsub
42	Binary	purctl
43	Triplet	invdp1, invdp2, invdp3
44a, b	Class/Likert	invctl, invlevel
46	Binary	itis
47	Class	itarea
50	Binary	interel
51	Likert	intersh
52, 55, 57	Class	interenc, custper, custenc
58a, b, c, d, e, f, g, h	Likert	comcost, compro, comproq, compdel, comsale, comsalg, cominfo, commarg
59a, b, c, d, e, f, g, h	Likert	perfcost, perfpro, perfproq, perfpdel, perfsale, perfsalg, perfinfo, perfmarg
60a, b, c, d, e	Likert	mpsperfo, crpperfo, mrpperfo, purperfo, invnperfo, mpcperfo

Table 7.3: Questions Related to Measured Variables

growth in value added, growth in gross output, growth in manufacturing establishments, and sales concentration. The data sources for the industry variables were obtained from the HKSAR government's trade census and industrial production statistics for the period between 1993 and 1998. The measurement scale, being consistent with Dess and Beard's[239] conceptualization and measurement of the extent of dispersion about a trend line, was based on the following formula:

$$M(K) = \frac{\beta(j)}{\overline{y(j)}} \qquad \text{for industry } K$$

where $\beta(j)$ is the slope of regression and is determined by

$$\beta(j) = \frac{\sum_{i=1}^{n} x_i y(j)_i - n\bar{x} \cdot \overline{y(j)}}{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}$$

and $x_1 = 1$ for the year 1993 , $x_2 = 2$ for the year 1994, ……and n = 6;

$y(j)_i$ is the variable to operationalize the environmental munificence $M(K)$ in the ith year:

j	Variables $y(j)$ to be considered
1	Growth in annual sales (or in total annual exports)
2	Growth in annual value added
3	Growth in annual gross output
4	Growth in annual price-cost margin
5	Growth in the number of manufacturing establishments per year
6	Growth in concentration of annual sales

(b) Environmental complexity. Five industry variables were used to operationalize the environmental complexity, i.e. concentration of total sales, purchases, value added, gross output, and geographical dispersion of manufacturing. The first four variables, with data drawn from HKSAR government's trade census and statistics, were adopted as proxy measures for complexity that arose from the intensity of interactions with external stakeholders. Similar to Dess and Beard's[239] approach,

they were computed on the proportion of the values of sales, purchases, value added and gross output accounted for by the eight largest firms. The difficulty of this measure was that trade census and industrial production statistics were not available for the measurement of some variables, as suggested by Dess and Beard [239], such as the diversity of products, specialization ratio, geographical concentration of industry sales, value added by manufacture, employment and establishment. Thus, the geographical dispersion of manufacturing, $S(K)$, was included in the measurement to operationalize the extent of internal logistics linkages and interactions emerged from offshore production. The data was obtained from a survey conducted by Hong Kong Government's Industry Department[328]. The environmental complexity score $C(K)$was determined by the following formula:

$$C(K) = \sum_{j=1}^{4}\left(1 - \frac{1}{n}\sum_{i=1}^{n}\left(\frac{A_{ij}}{T_{ij}}\right)\right) + S(K)$$

where A_{ij} is the amount of the variable j accounted for the 8 largest firms in industry K;

T_{ij} is the total amount of the variable j in industry K;

$S(K)$ is the score of geographical dispersion of manufacturing

and i = 1,2, …., n, is the number of years for measurement starting from 1993;

n = 6 for the present study;

j =1 ,2, 3, 4 represents the following variables:

j	Variables to be considered
1	Annual purchases
2	Annual sales
3	Annual gross output
4	Annual value added

(c) Environmental dynamism. Seven industry variables were used to operationalize the environmental construct. The first six variables were: instability of growth in sales (or in total export values if the sample industry was export-orientated), growth in

price-cost margin, growth in value added, growth in gross output, growth in manufacturing establishments, and sales concentration. The measurement scale was again based on Dess and Beard's[239] study. Environmental dynamism of the first six variables was measured by the variability from the trend line, i.e. on the dispersion about the regression line obtained when each variable was regressed against time for the period between 1993 and 1998. The data were sourced from the census and industrial production statistics and the adjustment was made by dividing the standard error of the regression coefficient by the average value of the industry variable. The data of the seventh variable, manufacturing uncertainty factor, was drawn from Industry Department's[328] survey. Based on the following formula, the score of environmental dynamism $D(K)$ was made:

$$D(K) = \sum_{j=1}^{n} \sqrt{\frac{S_{y(j)}{}^2 - S_{xy(j)}}{S_x{}^2 (n-1)}} \times \frac{1}{\overline{y(j)}} + V(K)$$

where $S_x{}^2 = \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2$;

$$S_{y(j)}{}^2 = \sum_{i=1}^{n} \left(y(j)_i - \overline{y(j)}\right)^2$$

$$S_{xy(j)} = \sum_{i=1}^{n} x_i y(j)_i - n\bar{x} \cdot \overline{y(j)}$$

and $y(j)$ is the industry variable to operationalize the dynamism (refer to section 7.5.2 item a);

$V(K)$ is the score of manufacturing uncertainty factor.

7.5.3 Performance

It is virtually impossible to collect the precise performance data from the industries as most of the firms, if not all, have kept their financial data as confidential and they are not willing to release the data for researchers. In this regard, this study used the published data to measure the performance of various industries.

Three types of performance measurements are used, namely, financial performance, growth performance and inventory performance. They are described as follows:

(a) Financial performance indicator was used to divide sample firms into high performers and low performers. High performers were the firms who performed well in both ROA (returns of total assets) and profit margin when compared with other firms in the same industry. Low performers were the firms performed poorly according to these two criteria. Pareto's 20/80 rule was applied, that is, no more than twenty percent of sample firms in a sample industry will be considered as high performers.

(b) Growth performance indicator was computed for the purpose of segregating sample firms into "high growth" and "low growth" groupings. Firms achieved more than 15 percent increase in annual sales turnover were classified as "high growth" grouping, or otherwise.

(c) Inventory performance indicator was based on the turnover ratio for two major reasons. First, inventory level was used by some scholars as one of the measures to determine the system performance (e.g. Loar[317]; Vergin[318]; Edelman[329]). Second, according to Lee and Billington[330], operational efficiency of a supply chain could be achieved by focusing on the inventory of a complex network composed of suppliers, manufacturers, and distributors. Computation of the ratio is set as below:

$$\text{Inventory Turnover} = \frac{\text{Annual Sales of Goods}}{\text{Year - end Aggregate Inventory}}$$

The evaluation of the inventory performance was based on the slope of regression line of inventory level against time. If the slope of regression is larger, the inventory performance is better. Conversely, the smaller the slope of regression, the larger the inventory investment a firm holds.

7.6 Data Analysis

Many researchers have asserted that environmental complexity and dynamism could be assessed by objective measures (e.g. Dess & Beard[239]) and subjective methods (e.g.

Starbuck, 1973). For instance, Starbuck[252] observed that environmental complexity and uncertainty could be considered as a matter of perception. He asserted that the same environment one organization perceived as unpredictable, complex, and evanescent, another organization might see it as static and easily understood. In order to test the reliability of the scores based on archival-based assessment, a survey was carried out between January 1999 and May 2000 to measure the perceptual scores of complexity and dynamism. The replies were collected from 125 senior managers in 7 manufacturing industries (see Table 7.1).

Question numbers 12, 30, 38, and 53 of the questionnaire (refer to Appendix 1) were used to measure the score of perceptual complexity, X_k, based on the following formula:

$$X(K) = \frac{1}{3N_K} \sum_{j=1}^{N_K} \sum_{i=1}^{3} x_{ij} \qquad \text{for } i = 1, 2, 3$$

where $x_{ij} \in \{1, 2, 3\}$ is an assigned value from the entry y_{ij} of the jth respondent in industry K with the sample size N_k, according to the following conditions:

$$x_{1j} = \begin{cases} 1 \text{ for } & 0 \le y_{1j} \le 3{,}000 \\ 2 \text{ for } & 3{,}001 \le y_{1j} \le 30{,}000 \\ 3 \text{ for } & y_{1j} \ge 30{,}001 \end{cases}$$

$$x_{2j} = \begin{cases} 1 \text{ for } & 0 \le y_{2j} \le 200 \\ 2 \text{ for } & 201 \le y_{2j} \le 2{,}000 \\ 3 \text{ for } & y_{2j} \ge 2{,}001 \end{cases}$$

$$x_{3j} = \begin{cases} 1 \text{ for } & 0 \le y_{3j} \le 100 \\ 2 \text{ for } & 101 \le y_{3j} \le 1{,}000 \\ 3 \text{ for } & y_{3j} \ge 1{,}001 \end{cases}$$

and y_{1j} is the entry related to product characteristics;

y_{2j} is the entry related to supplies; and

y_{3j} is the entry related to customer contacts.

The above conditions for x_{1j}, $x_{2j,}$, x_{3j} were based on personal interviews with 20 senior managers in food, electronics, fabricated metal and wearing apparel industries between November 1997 and the first half of 1998. The replies were converted to a scale between 1 and 3 and assigned in the following way:

Low complexity	Medium complexity	High complexity
$X(K) < 1\frac{2}{3}$	$1\frac{2}{3} \le X(K) < 2\frac{1}{3}$	$X(K) \ge 2\frac{1}{3}$

Question numbers 14, 15, 16, 17, and 18 of the questionnaire (refer to Appendix 1) were used to measure the score of perceptual dynamism, $R(K)$, which was computed by the following formula:

$$R(K) = \frac{1}{5N_K} \sum_{j=1}^{N_K} \sum_{i=1}^{5} r_{ij}$$

where r_{ij} is the score given by the jth respondent in industry K for the ith question and

$$r_{ij} \in \{1, 2, \ldots\ldots, 7\}$$

The score was aligned to a scale between 1 and 7 and assigned in the following way:

Low dynamism	Medium dynamism	High dynamism
$R(K) < 3$	$3 \le R(K) < 5$	$R(K) \ge 5$

7.7 Validity and Reliability Testing

In this Section, the random characteristic and the internal consistency reliability are considered.

(a) Random characteristic of survey sample.

Since most of the survey samples were taken during two executive development programmes, there would be a potential problem about the randomness of the data for analysis. Siegel and Castellan[332] indicate that the sample for statistical analysis must be random in order to enhance the validity of the conclusions drawn. In such regard, I used SPSS 10.0 for Windows to conduct three nonparametric tests to evaluate the randomness issue of the survey sample.

First, the SPSS one-sample runs test was carried out. The result (refer to Appendices 2 and 3) shows that three variables out of eighty-six, i.e. oem, odm, crppl were departed from randomness based on 95% confidence level.

Second, the Mann-Whitney Wilcoxon test for comparing two independent samples was used. The characteristics of the sample for this research study was tested by another set of sample consisting of thirty-nine respondents drawn randomly from a mail survey in middle 1997. There was a total of fourteen variables overlapped between these two independent samples including the demographical data of respondents and sample firms, positioning strategies, MRP system, MPS planning horizon and some product characteristics. It was demonstrated that there were no significant differences between the two independent samples, based on 95% confidence level, in terms of the variables mentioned above. The results are put in Appendix 4.

Third, the Kolmogorov-Smirnov test was employed to investigate the significance of the differences between two samples, based on sample distributions. According to Siegel and Castellan[332], the test is regarded as the most powerful method to study the differences between two sample populations in many aspects such as central tendency, dispersion, and skewness etc.; whilst the Mann-Whitney Wilcoxon test is concerned with the differences in central tendency only. Of the fourteen variables being tested, the results showed that there were no significant differences between the two samples with respect to thirteen variables (refer to Appendix 5). However, the test could not perform for the variable of engineering-to-order (ETO) strategy. It is therefore concluded that, based on the Kolmogorov-Smirnov two-sample test, the two independent samples appear to be similar.

In summary, the abovementioned statistical tests demonstrated that the sample for this study holds random characteristics. In other words, although the sample for this study was drawn mainly from two groups of executives who attended the executive development programme, it was found to be identical to the randomly drawn survey subjects. Therefore, it is appropriate to apply parametric statistical tests for the sample.

(b) Internal consistency reliability.

The SPSS 10.0 statistical package was used to generate the Cronbach's alpha coefficients. The inter-item correlations were evaluated in order to obtain a conservative estimate of scale reliability. Cortina[333] reports that Cronhach's alpha coefficient is the popular reliability estimates and it has been cited approximately

60 times per year in a total of 278 different journals. Cortina further describes that "if a test has a large alpha, then it can be concluded that a large portion of the variance in the test is attributable to general and group factors (333, p.103)." According to Nunnally and Bernstein [334], an alpha coefficient greater than 0.7 indicates an acceptable scale for study. However, there is no standard range of alpha coefficient. For example, Murphy and Davidshofer[335] recommend that when alpha coefficient is below 0.6, the scale of the study is not acceptable. As previously mentioned, the variables were added to the scales conceptually for analysis. Table 7.4 lists all the alpha coefficients for the scales of the study for all the sample organizations. The test shows that other than "dynamism" and "comput", which have the values of 0.55 and 0.51 respectively, the coefficients of the remaining six scales suggest an acceptable level of internal consistency for the scales of the study.

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.83
Organizational complexity (complex)	4	0.55
Change in organizational environment (dynamism)	4	0.54
Competitive strategy (comstrg)	4	0.68
Forecast error (err)	3	0.81
MPS	3	0.67
External relations (exterel)	2	0.76
Extent of computerization (comput)	2	0.51

Table 7.4: Scale Reliability Coefficients for All Sample Organizations

The sample organizations were then classified according to Miles & Snow's strategic archetypes and supply chain strategies. Seven groups were identified. It was observed that the alpha coefficients for the same set of scales were different for various groups.

Unlike the test results for all sample organizations, the coefficients of "complex" and "comput" for defender organizations were 0.43 and 0.48 respectively. These values were at an unacceptable level of internal consistency for the study (refer to Table 7.5).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.71
Organizational complexity (complex)	4	0.43
Change in organizational environment (dynamism)	4	0.65
Competitive strategy (comstrg)	4	0.66
Forecast error (err)	3	0.86
MPS	3	0.65
External relations (exterel)	2	0.88
Extent of computerization (comput)	2	0.48

Table 7.5: Scale Reliability Coefficients for Defender Organizations

For the prospector organization group, the coefficients of MPS and "comput" were 0.56 and 0.25 respectively, below Murphy and Davidshofer's[335] suggested minimum level (see Table 7.6).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.82
Organizational Complexity (complex)	4	0.60
Change in organizational environment (dynamism)	4	0.71
Competitive strategy (comstrg)	4	0.62
Forecast error (err)	3	0.91
MPS	3	0.56
External relations (exterel)	2	0.75
Extent of computerization (comput)	2	0.25

Table 7.6: Scale Reliability Coefficients for Prospector Organizations

Contrary to the above three groupings, the test for analyser organizations shows that all the scales have the value above the minimum standard, i.e. 0.60 (see Table 7.7).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.75
Organizational complexity (complex)	4	0.71
Change in organizational environment (dynamism)	5	0.67
Competitive strategy (comstrg)	5	0.72
Forecast error (err)	3	0.70
MPS	3	0.73
External relations (exterel)	2	0.68
Extent of computerization (comput)	2	0.66

Table 7.7: Scale Reliability Coefficients for Analyzer Organizations

Again, the test result for reactor organizations was different. The coefficients of "complex" and MPS were at below the acceptable level (see Table 7.8).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.72
Organizational complexity (complex)	4	0.59
Change in organizational environment (dynamism)	5	0.71
Competitive strategy (comstrg)	8	0.69
Forecast error (err)	3	0.84
MPS	3	0.56
External relations (exterel)	2	0.64
Extent of computerization (comput)	2	0.65

Table 7.8: Scale Reliability Coefficients for Reactor Organizations

As previously discussed, there are three types of supply chain strategy for study. All the 116 sample organizations were divided into lean, agile and leagile chains accordingly.

In the lean chain grouping, the scales for "complex" and "comput" were far below the minimum level of internal consistency (see Table 7.9).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.76
Organizational complexity (complex)	4	0.45
Change in organizational environment (dynamism)	5	0.63
Competitive strategy (comstrg)	8	0.68
Forecast error (err)	3	0.89
MPS	3	0.73
External relations (exterel)	2	0.78
Extent of computerization (comput)	2	0.45

Table 7.9: Scale Reliability Coefficients for Lean Supply Chain

In the agile chain grouping, the coefficients for four different scales, i.e. "complex", "dynamism", MPS and "comput", were failed to meet with the minimum level of internal consistency (see Table 7.10).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.92
Organizational complexity (complex)	4	0.59
Change in organizational environment (dynamism)	5	0.46
Competitive strategy (comstrg)	8	0.81
Forecast error (err)	3	0.87
MPS	3	0.53
External relations (exterel)	2	0.71
Extent of computerization (comput)	2	0.56

Table 7.10: Scale Reliability Coefficients for Agile Supply Chain

In the leagile chain grouping, the scale coefficients of MPS and "comput" were lower than the minimum level of internal consistency (see Table 7.11).

Scales	Number of Items	Cronbach Alpha
Organizational Performance (perform)	16	0.79
Organizational complexity (complex)	4	0.71
Change in organizational environment (dynamism)	5	0.69
Competitive strategy (comstrg)	8	0.69
Forecast error (err)	3	0.60
MPS	3	0.58
External relations (exterel)	2	0.76
Extent of computerization (comput)	2	0.57

Table 7.11: Scale Reliability Coefficients for Leagile Supply Chain

Table 7.12 summarizes the tests results of alpha coefficients for various sample grouping. The following conclusions are thereafter drawn:

(a) The perceptual scales of organizational complexity (complex), MPS function and the extent of computerization (comput) are not suitable for the study in the context of supply chain strategy. Therefore, the tests of hypotheses with respect to supply chain would better be based on the archival data (refer to Section 7.5.2).

(b) The results for Miles & Snow's archetypes were mixed. The uses of perceptual scales of organizational complexity (complex), MPS function and the extent of computerization (comput) are dependent on the nature of the archetypes.

(c) The alpha coefficients for "perform", "err" and "exterel" were at an acceptable level of internal consistency for all types of sample organizations in this study.

	All Sample Organizations	Defender Organizations	Prospector Organizations	Analyzer Organizations	Reactor Organizations	Lean Supply Chain	Agile Supply Chain	Leagile Supply Chain
Scales with Alpha Coefficients Less Than 0.6	dynamism; comput.	complex; comput.	MPS; comput.		complex; MPS.	complex; comput.	complex ; dynamism; MPS; comput.	MPS; comput.
Scales with Alpha Coefficients Equal to or Larger Than 0.6	perform; complex; err; MPS; exterel.	perform; dynamism; err; MPS; exterel.	perform; complex; dynamism; err; exterel.	perform; complex; dynamism; err; MPS; exterel; comput.	perform; dynamism; err; exterel; comput.	perform; dynamism; err; MPS; exterel.	perform; err; exterel.	perform; complex; dynamism; err; exterel.

Table 7.12: A Summary of the Test Results of Alpha Coefficients for Various Sample Groupings

7.8 Summary

This Chapter presents the research methodology for the thesis. The samples and the databases for the study are described. Two different types of data were collected: archival and perceptual. The measurement of the former is designed for the purpose of the development of the 3-dimensional environmental constructs. The core of the measurement for the latter is the design of the questionnaire. The questionnaire survey was carried out via the face-to-face field interviews and the executive development course. Three nonparametric tests were conducted to validate the random characteristics of the "non-random survey sample." The sample was considered suitable to be applied with the parametric statistical tests for the testing of hypotheses. The scale reliability of the questionnaire variables was also assessed. It was observed that in general different organizational configurations would exhibit different questionnaire responses. As a result, the alpha coefficients, as a measure of scale reliability for different configurations, behave differently. The suitability of using the perceptual scores of various scales in the questionnaire is noted. Having designed the methodology for the study, the development of reference MPC model is undertaken in Chapter 8 and the data analyses are enumerated in Chapter 9, which includes the examination of each hypothesis.

Chapter 8 The Reference MPC Model

On the basis of the literature survey of MPC approaches, 30 propositions are identified and an MPC framework is constructed. A reference MPC model is then proposed for the research in elemental configurations. Two other models are presented, namely, Biemans's reference models of MPC systems, and Howard et al.'s MPC system reference architecture. A field study is carried out to validate the reference model.

8.1 Introduction

A literature survey of scientific, managerial, and professional journal papers in the context of MPC systems and practices has been carried out, in which a total of 255 articles are reviewed. Of which 55 articles related to the topic are chosen for analysis. The data collection for the study is based on the following samples:

12 articles of empirical nature;

30 articles of theoretical nature;

8 articles of case experience nature;

5 articles using simulation model.

The information collected provides the conceptual data, the empirical data, and a comprehensive list of elements relating to MPC practices and their environmental influences. Key elements in implementing an effective MPC system are identified. They are applied to the specific manufacturing environment. As a result, a set of 30 propositions is postulated for building up a MPC framework that takes into consideration the manufacturing environment.

8.2 Operational Measures for MPC System Elements

The primary objective of the MPC system is to ensure that manufacturing resources are optimally used in the manufacturing process according to customer requirements. MPC system elements can be grouped into three broad categories: planning, control and execution. The planning methodology is to establish the resource and capacity plans for

manufacturing planning and control. It includes demand management, master scheduling, capacity planning, materials planning, purchasing, and shop orders planning. The control methodology is to ensure and to determine the effectiveness of the system according to resource and capacity plans. It includes capacity balance and control, purchasing control, inventory control, control of data accuracy, shop floor control, and change control. The execution methodology concerns with detailed scheduling and control of shop and purchase orders. It includes configuration control, order release, supplier partnership monitoring, and performance measurement. Table 8.1 summarizes the measures for MPC system elements.

8.3 Interacting Environmental Variables for Constructing MPC Framework

As discussed earlier, the choice of a suitable MPC system is a challenge to an organization since there are a large number of MPC-environment relations that implicitly exist for consideration. In order to decide on a MPC framework that will suit a particular situation, an MPC-environment relational matrix is identified as shown in Table 8.2. The numbers inside the table are the references of the corresponding interactions. The details of MPC environment elements can be referred in Section 4.23 of Chapter 4.

The analyses of 30 propositions with respect to the relations between MPC systems and their environments are presented in the following Sections.

8.4 Planning Methodology

From Sections 8.4.1 to 8.4.6, modules such as demand management, master scheduling, capacity planning, materials planning, purchasing, and shop order planning are considered. Eighteen propositions are drawn.

MPC Elements	Measures
Planning Methodology:	
Demand Management	
Forecasting	Actual quantities to forecast; forecasting horizon.
Orders taking	Number of customer orders received.
Master production scheduling (MPS)	Number of products; product mix; MPS stability; frozen intervals; frequency of replanning.
Capacity planning	Plan capacity to be provided; input/output planning.
Materials planning	Number of requisition orders; number of move tickets issued; value of raw materials/components; scrap factors.
Purchasing	Number of items to be bought; number of suppliers; value of purchases.
Shop orders planning	Number of work orders placed; number of operations sequencing.
Control Methdology:	
Capacity balance & control	Capacity levels; capacity utilization ratio.
Purchasing control	Suppliers' delivery, quality, price and service performances.
Inventory control	Inventory size to revenues; number of stockouts.
Shop order control (SFC)	Availability of materials and labour; order processing time; throughput time; sizes of queues; lead times.
Control of data accuracy	Forecasting accuracy; accuracy of Bill of Material (BOM), routing accuracy; capacity data accuracy.
Change control	Number of engineering change orders; number of schedule changes.
Execution Methdology:	
Configuration control such as inventory records, engineering change documents, purchasing orders, input materials and goods outgoing records etc.	Number of records; number of transactions; adequacy of reports.
Order release	Number of order releases; on-time release of orders; frequency of expediting.
Supplier partnership monitoring	Proportion of certified suppliers to total number of suppliers; supplier ratings; number of long-term agreements; cooperative working relationships etc.
Production activity control (PAC)	Reduction in lead times; database accuracy and integrity of production activity control; number of feedbacks and warnings.
Performance control	Inventory turns; delivery performance; MPS execution; order book performance; number of problems identified; corrective actions taken etc.

Table 8.1: Operational Measures for MPC System Elements

MPC System Elements	Manufacturing Environment Elements: *Interdepartmental relationships:* Interactions of MPC/Production/ Quality/IE/Marketing/MIS/ Accounting/Engineering/Product development	*Interorganizational relationships:* Customer Nature of products Nature of orders Frequency of changes Ordering profile Materials/components supplier/ Subcontractors Software/hardware supplier Competitors	*General environmental relationships:* Market conditions Economic conditions Information technology Manufacturing technology Social System Nature of work force Management skills
Planning Methodology:			
Demand Management			
Forecasting		1 2	
Order taking			
Master scheduling		3 4	5
Capacity planning	6	7 8 9 10	11
Materials planning			
Purchasing		12	13
Shop order planning			
Control Methodology:			
Capacity control		14	
Purchasing control		15	
Inventory control		16	17 18 19
Shop order control		20	
Data accuracy Control	21		
Change control		22	
Execution Methodology:			
Configuration control		22	
Order release			
Supplier partnership		15	
Production Activity Control (PAC)			
Performance Measurement			
MPC system			23 24

Table 8.2: MPC-Environment Relational Matrix

8.4.1 Demand Management

At the extreme end of demand management in which a firm adopts, after receiving the customer order, the planning data such as production specifications, product mix,

manufacturing volume and processes are deterministic and certain. Manufacturing planning in this environment is MTO or ETO. Forecasting is unnecessary.

At the other extreme, stocks are built up to anticipate customer orders. Manufacturing planning is based on forecasting and the planning data is stochastic. The manufacturing in this environment is MTS or ATS where prediction is possible with a medium degree of uncertainty.

Proposition 1 (Interaction 2): The needs of forecasting function for MPC system depends on the degree of environmental uncertainty. Forecasting is required under a medium degree of uncertainty, i.e. MTS and ATS environments. Forecasting is unnecessary for manufacturing situations with certainty and absolute uncertainty, i.e. MTO and ETO environments.

Demand forecasts will be unstable if there is a large number of strangers (rarely ordered customers) and thus a small number of repeaters (occasionally ordered customers) and runners (regularly ordered customers). It will produce irregular patterns (nervousness) of demands and hence causes larger forecast errors.

Proposition 2 (Interaction 1): The nature of orders will directly influence the MPC system nervousness and its forecast errors.

When forecasting errors increase, more buffer capacity and stocks are required in order to maintain a satisfactory level of customer services. The MPC performance deteriorates. Hence, the effort to improve demand forecasts is essential to the corresponding improvements in manufacturing performance.

Proposition 3: The extent of forecast errors is inversely proportional to the MPC performance.

8.4.2 Master Scheduling

The Master Production Schedule (MPS) reflects a firm's competitive strategy. Its purpose is to meet with the market demand by taking into consideration the factors such as customer orders and forecasts, backlog, availability of materials and components,

capacity limits, and production economics. MPS is vital for the MPC system to attain the firm's competitive strategies in allocating resources effectively. The design of the MPS level for different positioning strategies is set in Figure 8.1. It indicates that the shorter the competitive delivery times to the customers, the closer the MPS level is towards the end product.

Positioning Strategy	MPS Level: End Product ⟵ Raw Material	MPS Item	Delivery Lead Time
MTS	⇧	End product	Short
ATS	⇧	Modularized BOM	Medium
MTO	⇧	Customer orders	Long
ETO	⇧	Customer orders	Long

Figure 8.1: MPS Level under Different Positioning Strategy

Proposition 4 (Interaction 4): Competitive delivery strategy of a firm affects the choice of ordering profile for MPS.

By setting up a longer frozen interval and applying frequent replanning activities, MPS could be used to stabilize the fluctuating marketing conditions.

Proposition 5 (Interaction 5): The more fluctuating the demand profile, the more frequent replanning and longer frozen interval the MPS must adapt.

The more complicated the product structure, the more the MPS changes and hence causes more system nervousness and MPS change costs. Thus, in order to improve forecasting and to reduce MPS change cost, the number of MPS items must be as low as possible.

Proposition 6 (interaction 3): The complexity of the product is inversely related to the MPS performance.

8.4.3 Capacity Planning

Capacity requirements planning (CRP) is affected by a number of external factors such as nature of products, nature of orders, product introduction rate, ordering profile, manufacturing technology, and subcontracting arrangement.

For MTS and ATS environments, detailed CRP is undesirable since capacity could be adjusted by building up buffer stocks against uncertain fluctuating requirements. On the other hand, MPC systems in uncertain MTO and ETO environments, then detailed CRP is necessary.

Proposition 7 (interaction 9): The needs of a capacity planning unit in a firm depend on the ordering profile.

In order to operate the CRP effectively, the resource and capacity checks must be satisfactorily completed. Timely, reliable and accurate data flow should also be performed. This requires an effective integration between production, MPC, and marketing.

Proposition 8 (Interaction 6): CRP of a firm requires the close cooperation of the production, MPC and marketing functions.

For firms with a low level of common parts and unable to form product families, capacity planning will become more complex and capacity problems will be increased.

Proposition 9 (Interaction 7): The degree of complexity of CRP is inversely related to the level of common parts in a firm.

The need for a sophisticated CRP in a firm depends on the nature of customer orders. A large number of strangers increase the shop floor and capacity problems within a firm and thus a sophisticated CRP function is required[274].

Proposition 10 (Interaction 8): The degree of sophistication for the CRP function is directly related to the number of new orders.

The product introduction rate affects the choice of capacity planning and scheduling. When the rate is high, there is a need for a sophisticated CRP function.

Proposition 11 (Interaction 8): The degree of sophistication for the CRP function is directly related to the product introduction rate.

It is less effective for a firm to adjust the changing demands by varying frequently the capacity of a plant. In this respect, some firms today keep their capacity to a minimum level. They are keen to employ subcontractors to absorb the demand fluctuations. The work assignment to the subcontractors will reduce the pressure on the CRP system.

Proposition 12 (Interaction 10): The number of subcontracting tasks to be assigned is inversely related to the complexity and difficulty of CRP.

The use of advanced manufacturing technology (AMT) reduces the number of manufacturing operations and therefore simplifies the capacity planning problems.

Proposition 13 (Interaction 11): The more advanced the application of manufacturing technology, the more simple will be the capacity planning function.

8.4.4 Materials Planning

The use of integrated computer system is an important part of MRP particularly for those firms that process a large amount of data. There are two major issues to be considered. (a) Many firms lack technical expertise to convert their systems into fully or partially automated systems. The selection of suitable software and software vendor support are important for the successful implementation of MRP. (b) Smaller firms have more difficulties installing computerized MRP because of insufficient financial and human resources. Current computer programs do not meet the needs of small firms.

Proposition 14 (Interaction 14): The advancement of information technology helps to improve the performance of a computerized MPC system.

Proposition 15 (Interaction 13): The selection of suitable software and the support from the software vendor are important factors for the successful implementation of computerized MRP.

Proposition 16 (Interaction 13): Smaller firms have more difficulties installing computerized MRP.

8.4.5 Purchasing

Considerable literature[300,301] discuss the importance of the purchasing process, which include the selection and evaluation of suppliers, supplier certification, and strategic supplier partnerships. Purchasing processes vary among firms because of the different purchasing methods employed.

There are two opposing views on purchasing philosophy. The tenet of the traditional purchasing philosophy contends that suppliers have strong incentives to provide high quality products at the lowest price if competition among suppliers is high. Purchasing practices of short-term contracts and multiple sources of supply is believed to be a more effective form of purchasing – lower purchasing costs and lower risk of supply disruptions.

A different tenet asserts that the traditional purchasing philosophy tends to increase both the supplier's and manufacturer's administrative costs. The importance of good buyer-supplier partnering relationship is stressed. Suppliers work together with manufacturers and accept joint responsibilities for the completion of works orders. Successful partnering relationships promote organizational effectiveness. The importance of buyer-supplier relationships is frequently discussed in a variety of references[302,303] on the topics relevant to JIT practices. All of these papers unanimously assert that the traditional purchasing process is unsuitable for JIT systems[303].

Proposition 17 (Interaction 12): An ongoing relationship with suppliers to improve quality and delivery significantly increases the likelihood of maintaining an effective MPC system.

Proposition 18 (Interaction 12): The number of suppliers will affect the buyer-supplier relationships and administrative effort of the system. The smaller number of suppliers fosters in-depth partnering cooperation and simplifies the purchasing process.

8.4.6 Shop Order Planning

None of the literature under review has discussed the interactions between shop order planning and the manufacturing environment. However, it is expected that new future direction of work priority planning tools and their priority/dispatching rules shall be an important topic in responding to the changes in manufacturing technology and the aspects of international manufacturing operations.

8.5 Control and Execution Methodologies

From Sections 8.5.1 to 8.5.7, modules such as capacity control, purchasing control, inventory control, shop order control, control of data accuracy, change control, and performance evaluation are considered. Eleven propositions are drawn.

8.5.1 Capacity Control

Traditional MPC systems, i.e. MRP and MRPII, emphasize the importance of capacity balance. However, new MPC approaches, i.e. OPT and JIT, stress the importance of flow balances, rather than capacity. In our opinion, capacity balance and control is also significant. A firm must maintain the highest possible plant capacity utilization in order to minimize production cost. Plant capacity is affected not only by forecast demands but also by another environmental factor – supply. A prudent variation of subcontracting assignments is an effective means to control and monitor a firm's capacity.

Proposition 19 (Interaction 15): The balance of a plant capacity can be adjusted and controlled by the subcontracting arrangements.

8.5.2 Purchasing control

Uncertainties arise when suppliers do not deliver on time which is detrimental to all control functions of an organization[274]. For effective purchasing control, it is important for an organization to have the support from high quality suppliers and subcontractors. Supplier selection and evaluation processes could be used to maintain a list of quality suppliers. However, these processes are time-consuming and require considerable resource and effort. It is better to reduce the number of suppliers since multiple sources of supply make the purchasing control function more complicated.

Proposition 20 (Interaction 16): Multiple sources of supply complicate the purchasing control process.

8.5.3 Inventory control

The proper control of inventory is important for the success of an organization. High inventory cost are generally caused by poor demand forecasts, long and fluctuating lead times, insufficient capacity, poor supplier and subcontractor performance, inaccurate BOM data, inaccurate routing, and inaccurate inventory information etc. Most of the literature related to inventory-control focuses upon internal factors, i.e. the optimization of resources allocation, the amount of inventory investment and the desired level of customer service. However, the control function is also affected by external factors such as the pressures of the business cycle[304] and the variance in demands[305]. The size of inventory will increase when there is an economic downturn and fluctuating market conditions.

Proposition 21 (Interactions 18 & 19): The size of the inventory is directly related to the business economic situation and unsteady market conditions.

Markets have gradually shifted from a seller's market to a buyer's markets over the last decade. This change has urged manufacturing organizations to increase delivery performance and flexibility. There is a general tendency that in a buyer's market the holding of relatively high output inventories is necessary since flexibility and promptness in sales are required, whilst there is no need to hold high input inventories

since supply is reliable[306]. However, in a seller's market, companies do not hold high finished goods because demand far exceeds supply. High input inventories must be held to protect their production against uncertain supplies since it is hard to buy raw materials/components in the market[306].

Proposition 22 (Interaction 17): The decoupling point of inventory depends on the market conditions. High output inventories are necessary in a buyer's market, while high input inventories are required for a firm operating in a seller's market.

For small inventory investment and moderate demand variance, it is equally effective to hold inventories at the subassembly level or at the end-item level. However when the demand variance is high, it is better to keep inventories at the subassembly level[307].

Proposition 23 (Interaction 17): The decoupling point of inventory depends on the demand variance and the desired level of inventory investment.

A portion of the inventory holding is the result of anticipation in demand forecasts errors. The smaller the forecasts error is, the larger the reduction in inventory holding for this purpose. The need for holding larger inventory arises when the management of demand deteriorates.

Proposition 24 (Interaction 18): The size of inventory is directly related to the availability of management skills to handle demand variances.

The existence of a high number of high-value items indicates the need for good inventory control to minimize the cost of inventory holding[274].

Proposition 25 (Interaction 15): The higher the inventory investment, the more urgent the manufacturing organization has to seek out effective manufacturing control methods to reduce inventory costs.

8.5.4 Shop Order Control (SFC)

The activities of shop order control include load control, work order control, dispatching control, and input/output control. There is only one reference[307] in the survey defining the interaction between input/output control and the manufacturing environment.

Input/output control is used to identify the capacity problems of a firm so that remedial capacity actions at the shop floor can be taken to eliminate the problems. This function is at the lowest level of the hierarchical capacity planning and control system. As such, the parameters of the long and medium-term capacity plans become the constraints of the input/output control. Its performance is affected by the queues at the shop floor level. Effective input/output control depends on reliable lead times of the production system since lead times are directly related to queueing times.

The advancement in IT helps organizations to handle a large number of transactions and data in the MPC system context. As a consequence, the manufacturing organization will be able to communicate and integrate internally and externally, to manage interdependencies and to deal with variability. Lead time is expected to come down as a result. Thus, IT helps to improve the input/output control process.

Proposition 26 (Interaction 21). The performance of input/output control is directly related to the control of lead times. IT enhances effective input/output control.

8.5.5 Control of Data Accuracy

Accurate data flow is mandatory within the MPC system. The control of data accuracy includes inventory accuracy, BOM accuracy, routings accuracy and honest reports.

Proposition 27 (Interaction 22): The interdepartmental relationships among MPC, manufacturing information system, industrial engineering, accounting, product development is important in order to maintain the accuracy of routing, BOM file, inventory data.

8.5.6 Change Control

A considerable amount of engineering changes and the lack of a disciplined engineering change procedure affects data integrity and causes disruption to the MPC system. Thus it degenerates the performance of the system considerably. The external causes of frequent engineering changes are usually due to continuous modification of customer requirements. A better change control policy helps to avoid degeneration of MPC system performance.

Proposition 28 (Interaction 23): The number of engineering changes is inversely related to MPC system performance.

8.5.7 Performance Evaluation

The performance evaluation process depends on the goals of an organization. The standards derived from the goals are the essential yardsticks in developing an effective MPC system. It is used to report the aberrant conditions promptly so that immediate remedial actions can be taken to align outcomes with goals.

The performance evaluation process contains myriad data and records. It involves many people in the organization. Thus, an effective communication and information system must be implemented so that performance data is available for constant review within the system.

8.6 MPC – Human Factor

Management's emphasis of human value increases the MPC system effectiveness. Van der Meer et al.[308] asserts that by offering the shop floor people a greater involvement in the control processes and giving them the appropriate support, improvement in productivity can be achieved.

Proposition 29 (Interaction 24): The effectiveness of the MPC system is directly related to the ability of managers to skillfully manage their human resources.

One of the major causes for the MPC failure is the lack of human skill. The involvement of a highly skilled and experienced workforce is the crucial factor for

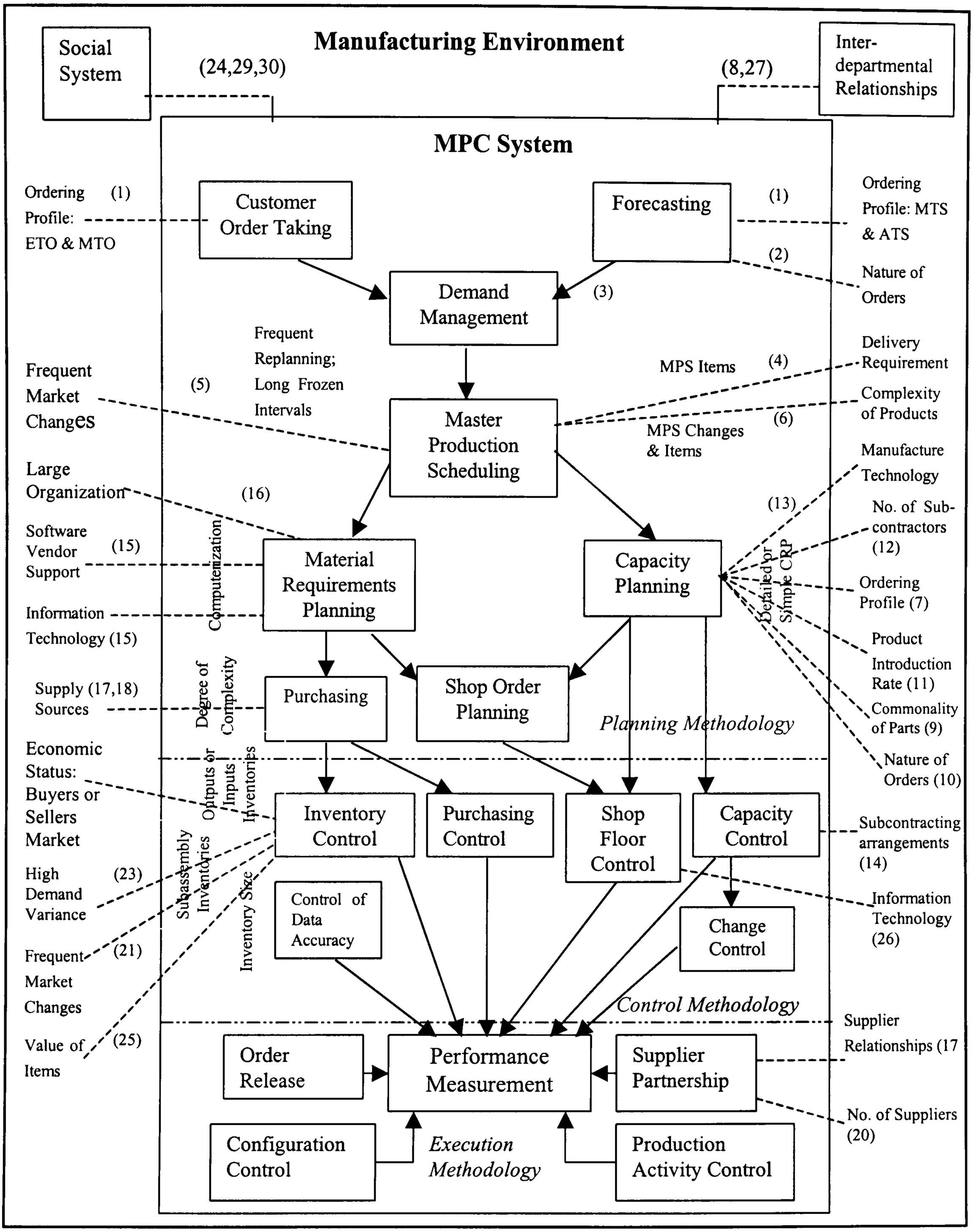
MPC success. MPC system must be implemented within the organizational framework that uses and develops the skills, knowledge and creativity of the human resources.

Proposition 30 (Interaction 23): The availability of a highly skilled, experienced workforce and the willingness of their participation in the organization are among other things directly related to the effectiveness of MPC system.

8.7 MPC Framework

On the basis of the above 30 propositions, a MPC framework is established to specify the external and internal relationships of the MPC system. The basic structure of this proposed framework is shown in Figure 8.2.

At the upstream end of the MPC system, the starting point will either be from the order-taking function or the forecasting module. Under MTS and ATS environments, the organization builds up stocks in anticipation of customer orders and there is a need for a forecasting module. The effort to improve demand forecast is essential for MPC effectiveness. The MPS module, based on demand data, is used to stabilize the MPC system. Replanning frequency, frozen interval, and item level of the MPS will be affected by external factors such as fluctuating market conditions, the complexity of products and the delivery requirements. Besides, the MPS module drives both MRP and CRP modules that develop material plans, schedule orders, compute resources for accomplishing the manufacturing orders. The choice of MRP module is associated with the size of an organization, software vendor support and the advancement of information technology. The CRP module associates with factors such as ordering profile, product introduction rate, commonality of parts, nature of orders, subcontracting arrangement, and manufacturing technology. The MRP module releases material requirement schedules to purchasing module that institute the purchasing orders. The degree of complexity of the purchasing module is affected by the supply sources, i.e. the number of suppliers and supplier relationships. The shop order planning module requires inputs from MRP and CRP modules to generate the shop order schedules, in which the elements of lead time, move time, queue time, machine setup time, and run time for



Legend:
- ⟶ Process & data flows between MPC system variables.
- --------- Relations of MPC-manufacturing environment.
- ( ) The number in parenthesis refers the propositions from 1 through 30.
- _..._..._... The boundary between planning methodology and control methodology.

Figure 8.2: MPC Framework

every production order is considered.

At the downstream end of the MPC system, inventory control module will be influenced by external factors such as economic conditions, fluctuating market conditions, inventory investment, and demand variances. Supplier relationships and sources of supply will affect the purchasing control function. The advancement of IT helps to cut down the lead times and queues of the shop floor and thereby improve its performance. The capacity control module is directly related to the subcontracting arrangement that controls and monitors the capacity of an organization.

In addition, the availability of experienced workforce and management skills to handle MPC system, and the interdepartmental relationships are also essential ingredients for MPC effectiveness.

8.8 Reference Models of MPC Systems

Biemans[39] defines a reference model of MPC system "as a configuration of components that each execute their own, globally defined, distinct tasks but interact to realise the task of the system as a whole" (p.11). Howard et al.[272] contend that MPC reference models "can act as the blueprint for manufacturing activities, business processes, flow of physical items, flow of information and all their interrelationships" (p.381). Therefore, the reference model is an effective method to develop an understanding of the processes and act as a tool to plan for changes. Review of Biemans's[39] and Howard et al.'s[272] reference models are considered and they are discussed in Sections 8.8.1 and 8.8.2 respectively. In Section 8.8.3, I develop a reference model based on the MPC framework and the 30 propositions described earlier.

8.8.1 Biemans's Reference Models of MPC Systems

Biemans[39] decomposes the MPC process into two reference models, namely, a "reference model for MPC systems" and a "reference model for MPC system management". The "reference model for MPC systems", composed of the global tasks

of MPC system, is a viewed as a closed system operating in a stable environment. Therefore, a "reference model for MPC system management" is developed, which can prepare the MPC system model for environmental changes.

Biemans's model for MPC systems is a generic representation of a hierarchical organization that coordinates decision-making units from company controller level to lower level (refer to Figure 8.3). The tasks of the reference model are: inventory control, operations scheduling, coordination of machines, determination of the trajectories of joints of machines, servoing of joints, and feedbacks of tasks.

MPC systems with application specific information to change the product portfolio, production capacity, or production costs in responding to the changing demands of the manufacturing environments. This reference model is organized a number of tasks such as the analysis of production targets, product design, machine design, process planning, development of control procedures, maintenance activities, and the monitoring process etc. Figures 8.4 shows the Biemans's[39] "reference model for MPC system management".

8.8.2 Howard et al.'s MPC System Reference Architecture

Howard et al.[272] describe a generic reference model for an MPC system that is applicable to a majority of manufacturing organizations. Their reference model is an adaptation of the basic MRPII system. It consists of four basic modules, namely, strategic planning and sales, engineering and system support, planning and scheduling, and logistics. The basic modules are composed of 14 sub-modules. Figure 8.5 shows the MPC system reference architecture.

The emphasis of the reference model is on its capability to handle mass customisation. Thus, at the top level of the architecture, it is mapped to individual manufacturing environments. At the functional (lower) level, details of the functionality of manufacturing activities could be captured for a defined range of situations. Howard et al.[272] validate the reference model in 4 medium-sized batch manufacturing organizations in the U.K. They demonstrate that a reference MPC

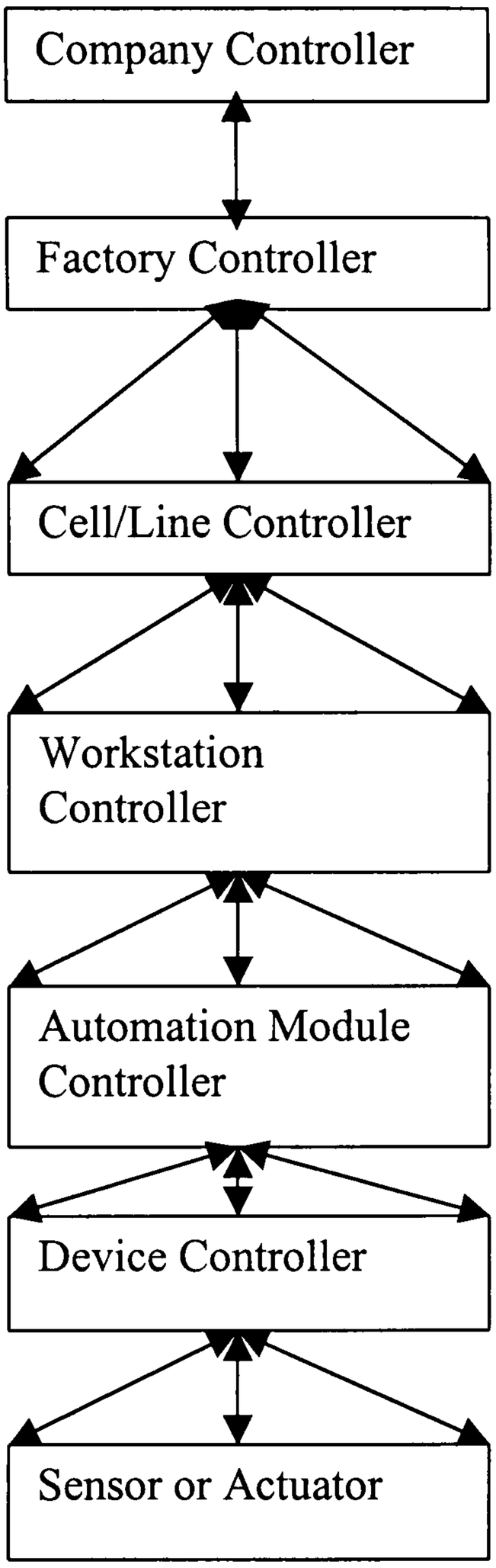
Control Level	Control Service	Task of Controller
		Determine firm and forecast production targets.
	Dispatch products at due dates.	Plan production – which items to process in which time slot- to dispatch products timely.
	Process item in allotted time slot.	Schedule when, where, which operations are executed on parts.
	Execute operation on part.	Coordinate the execution of processing steps on objects to realize operations.
	Execute processing step on object.	Determine required paths of joint variables, which describe the state of effectors.
	Follow joint path.	Issue control signals so that joint variables are servoed by physical parameters.
	Modulate physical parameters.	
	Sensing tasks, services omitted.	

Figure 8.3: Reference Model for MPC Systems (Source: Biemans's[39,p.136])

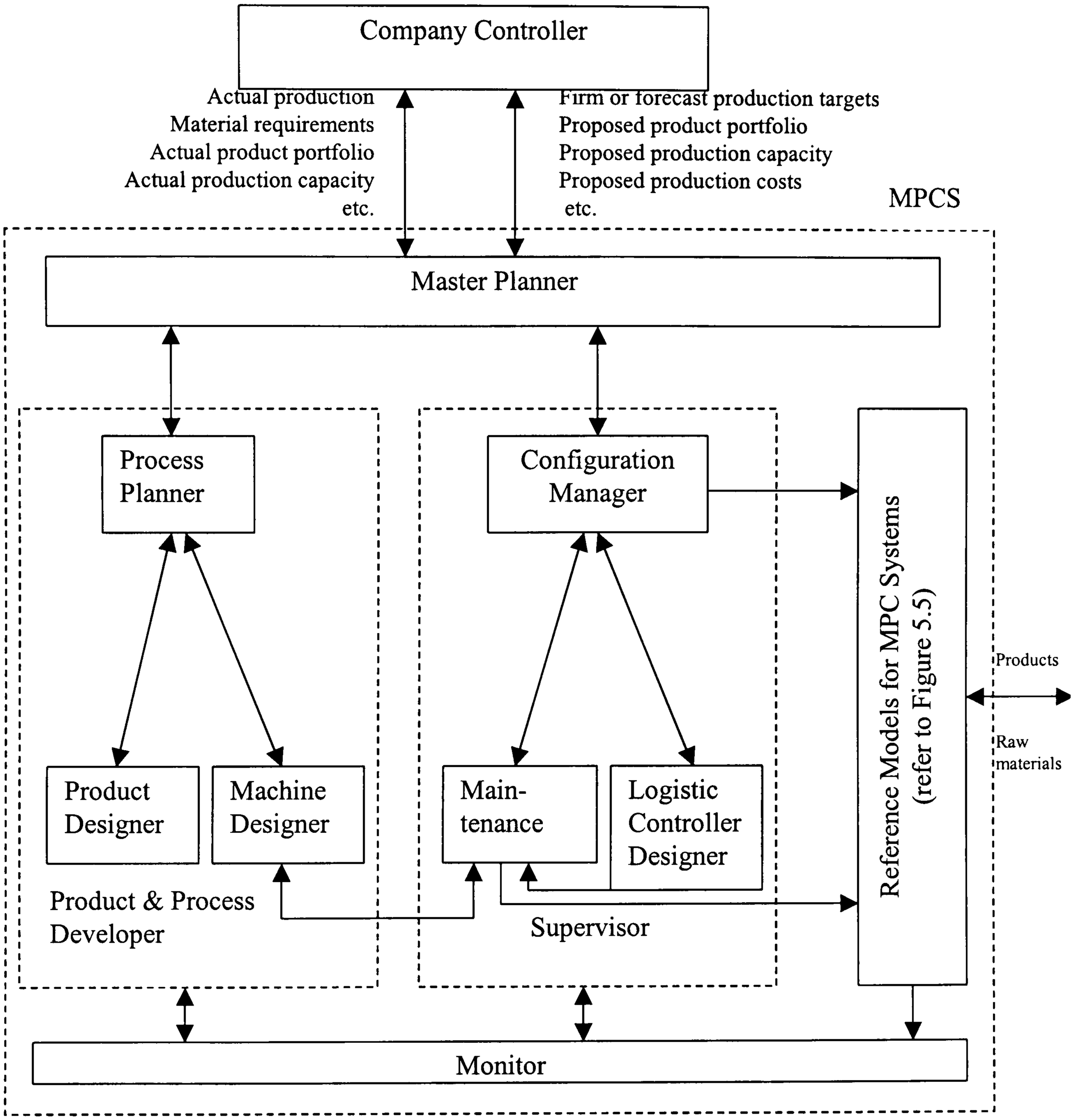


Figure 8.4: Reference Model for MPC System Management (Source: Biemans's[39,p.194])

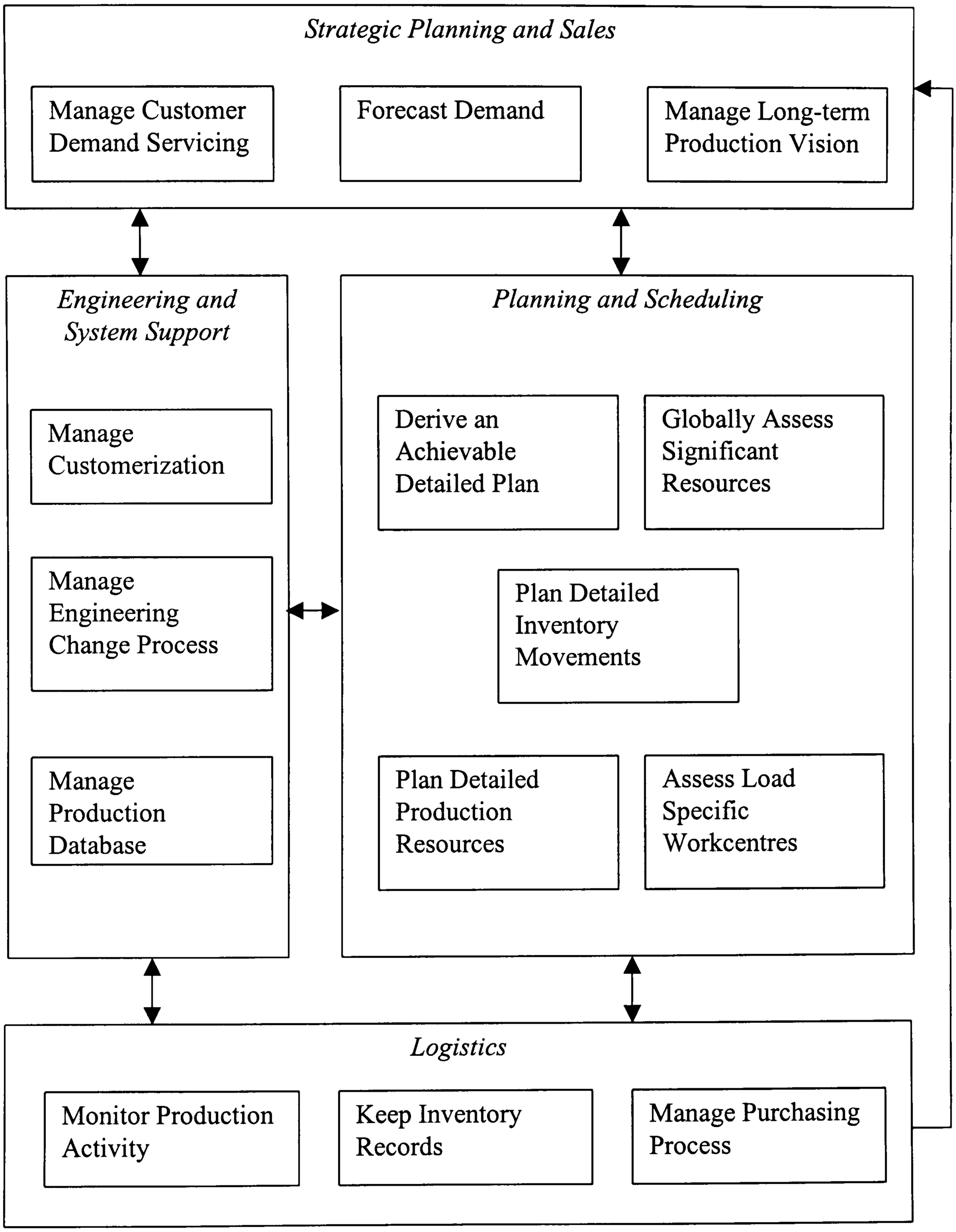


Figure 8.5: MPC System Reference Architecture (Source: Howard e. al.[272,p.384])

model can be applied in different manufacturing environments. However, the model does not represent exactly the same MPC functions in each individual organization. It is necessary to reorganize the sub-modules of the reference model to make it more accurately representing the individual manufacturing situation.

8.8.3 Reference MPC Model for Elemental Configuration Research

The basic motivation of developing a reference model is to make use of the model as a basis for the investigation of elemental configurations in MPC system under various external influences (refer to Section 5.2.1). It is expected that, similar to Howard et al.'s MPC System Reference Architecture (refer to section 8.8.2), the reference MPC model may exhibit a set of configurations, in which each configuration may suit for its own manufacturing situations.

In order to structure a reference MPC model, the MPC framework in Section 8.7 (refer to Figure 8.2) and the thirty propositions from Section 8.4 to Section 8.6 are referred. The model, therefore, represents a synthesis of the theoretical literature on MPC approaches.

The aims of the reference MPC model developed for the elemental configuration research are:

(a) It should be as general as possible that embraces all the MPC functions.

(b) It should identify the key linkages MPC functions and their environments.

(c) It should support the research in MPC configurations. In a word, each configuration derived from the model can be applied to most organizations in a defined external setting.

The proposed reference MPC model, from manufacturing environment perspective, consists of three basic units: MPC system, intermediaries, and manufacturing environments (refer to Figure 8.6). The key features are described as follows:

(a) The MPC system comprises four components: strategic manufacturing planning, manufacturing planning and scheduling, manufacturing control, and MPC execution. They are further broken down into 20 sub-components.

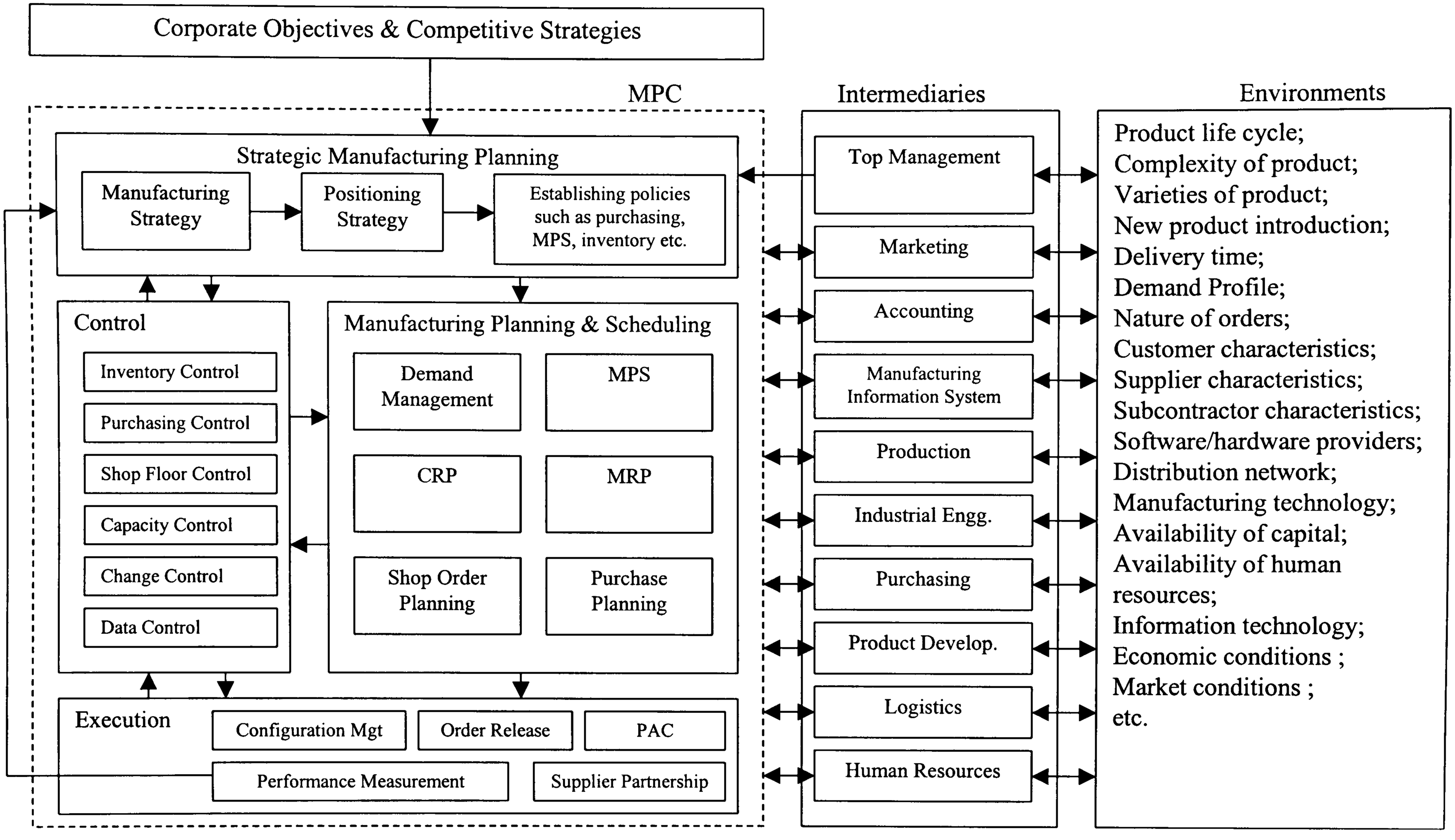


Figure 8.6: Reference MPC Model for Elemental Configuration Research

(b) The intermediaries act between the MPC system and the manufacturing environment. They interpret both the demands of the environment and the capacity of the manufacturing system so that the system could match with the environment. There are 10 intermediaries: top management, marketing and sales, production, purchasing, manufacturing information system (MfgIS), industrial engineering (IE), accounting, product development, logistics and human resources.

(c) There are 18 environmental forces that relate to the MPC system. These forces are: pproduct life cycle, complexity of product, varieties of product, new product introduction rate, delivery time, demand profile, nature of orders, customer characteristics, supplier characteristics, subcontractor characteristics, software/hardware providers, distribution network, manufacturing technology, availability of capital, availability of human resources, IT, economic conditions, and market conditions etc.

(d) As discussed earlier in Sections 3.1 and 3.2 of Chapter 3, the corporate objectives and competitive strategies of an organization provide a framework of plans for the entire organization. The objectives and strategies are also acted as imperatives that influence the operations of an MPC system.

The major difference between the proposed reference MPC model to Biemans's and Howard et al.'s reference models is the emphasis of autopoiesis (refer to Section 4.5), in which the manufacturing environment is considered as part of the organization. The domain of interaction of the MPC system is dependent on how the intermediaries interpret it and how the MPC system specifies the pattern of MPC-environment relations.

The reference MPC model also highlights two important points:

(a) A generic representation of an MPC system must take into consideration of the internal setting and external influences.

(b) The internal relationships among different functions of an organisation and the external relationships with environmental players should also be defined.

(c) Table 8.3 summarizes the essential features of MPC functions, internal relationships, internal setting, external influences, and the external relationships that need to be considered, based on the 30 propositions developed.

MPC Function	Propositions	Internal Relationship	Internal Setting	External Influences	External Relationship
Demand management	1, 2, 3	MPC-marketing	Positioning strategy	Product life Cycle; nature of orders; customer demand; delivery time; demand profile; nature of product.	Customer relationship
MPS	4, 5, 6	MPC-marketing	Positioning strategy; MPC policy.		Customer relationship
Capacity planning	7, 8	MPC-production-marketing	Positioning strategy	Uncertainty	
	9	MPC-IE-marketing	Product groupings	Varieties of products	
	10			New customers	
	11			Product introduction rate	
	12	MPC-production-purchasing	Subcontracting policy; make-or-buy decision	Subcontractors	Subcontractor partnership
Materials planning	14, 15, 16	MPC-MfgIS	Choice of MRP system	Availability of software	Support of software providers
Purchase planning & control	17, 18, 20	MPC-purchasing	Purchasing policy	Suppliers	Supplier partnership
Capacity balance & control	19	MPC-production-IE	Subcontracting policy	Subcontracting arrangement	Subcontractor partnership
Inventory control	21		Inventory policy	Economic situations; market conditions.	
	22		Purchasing policy	Market conditions	Supplier partnership
	23	MPC-accounting	Level of inventory investment; positioning strategy.	Nature of orders; nature of product; demand profile.	

Table 8.3: A Summary of MPC Functions, Internal & External Relationships

MPC Function	Propositions	Internal Relationship	Internal Setting	External Influences	External Relationship
Inventory control (con't)	24, 25		Management skills	Demand variances; value of materials.	Customer relationship; distribution network.
Input/output control	26	MPC-IE-Quality Control	Control of lead times; continuous improvement programmes.	Availability of IT and manufacturing technology	IT providers; company-university co-operations; researches in shop floor control and scheduling.
Data accuracy & configuration management	27	MPC-MfgIS-IE-accounting-product development	Production targets; BOM accuracy, documentation auditing, workflow management.		
Change control	28	MPC-marketing-IE	Change control policy; documentation auditing, workflow management.	Frequency of change in customer requirements	Cooperation between customer and manufacturing organization with respect to engineering change or product development.
Human factors	29, 30	International relationship among all departments involved.	Team-working; participation management.		
Performance evaluation		MPC-accounting-IE	Manufacturing strategies; performance metrics; reporting system.		

Table 8.3: A Summary of MPC Functions, Internal & External Relationships (Continued)

8.9 Field Study

The selection of the sample organizations for field study is based upon several considerations. Among these are: the nature of the company and its environment, the availability of strategic context and performance data, the validity and authenticity of the data, and the willingness of senior executives to participate in this study. With regard to the nature of the sample organization and its environment, the following criteria are used:

(a) Firm Size – organizations with employees fewer than 100 persons are considered as small companies, with the number of employees between 101 and 1500 regarded as medium-sized companies, and an organization of over 1500 employees is a large establishment;
(b) Types of plants – based on VAT classifications[309];
(c) Strategic orientations – based on Miles & Snow typology[234];
(d) Organizational environment – based on three dimensions such as munificence, complexity, and dynamism[239];
(e) Organizational performance – based on the profit margin and the perceived comparison relative to close competitors.

After reviewing a number of companies, six organizations, all operating in Hong Kong, are chosen for the field study. The sample cases provide a diversity of aspects:

(a) 2 companies are large organizations, 2 companies are medium-sized organizations, and 2 organizations are small companies;
(b) 1 prospector firm, 3 defender firms, 1 analyzer firm and 1 reactor firm;
(c) 2 high-performance firms, 2 average performers and 2 low performers;
(d) various kinds of organizational environment exist ranging from moderate complexity/dynamism to low complexity/dynamism.

These six sample cases are considered to be robust and thorough and will provide the generalizability of the findings. A summary of the sample population is shown in Table 8.4. Some observations that have been collected from case studies relating to manufacturing logistics are presented from Sections 8.91 to 8.96.

Profile of Sample Organizations	Company A	Company B	Company C	Company D	Company E	Company F
Products	Electronic toys	Edible oils	Automatic machines	Printed matter	Semiconductors	Electrical wires and wire harnesses
No. of employees	7,000	220	80	100	1,800	1250
Miles & Snow's Strategic Typology	Prospector	Defender	Analyzer	Reactor	Defender	Defender
Environmental Uncertainty	Moderate (uncertain demand)	Moderate (material price uncertainty)	Moderate (material price uncertainty	Low	Moderate (uncertain demand)	Moderate (uncertain demand)
Environmental Complexity	High	Low	Moderate	Low	Low	Moderate
Positioning Strategy	MTO	MTS	MTO/MTS	MTO/MTS	MTO	MTO/MTS
VAT Classification	A	T	A	V	V	A
Competitive priorities	Product and quality differentiation	Cost leadership and quality	Cost leadership and product differentiation	Cost leadership and agility	Cost leadership and quality	Cost leadership and product differentiation
OEM/ODM/OBM	ODM/OBM	OBM	ODM/OBM	OEM/OBM	OEM/ODM	OEM/ODM
Product mix	Standard product mainly	Standard product mainly	Standard and special product	Standard product mainly	Standard and special product	Standard and special product
Product life cycle	Short	Very long	Long	Long	Short	Moderate
Performance	High	Low	Average	Average	High	Low

Note:
VAT classification denotes V-type, A-type, or T-type plant[309].
OEM/ODM/OBM denotes original equipment manufacturer, original design manufacturer, or original brand manufacturer.
Note: The performance is perceived by the executives of the sample organizations, on the basis of profit growth as compared with competitors in the same industry.

Table 8.4: Profiles of Six Sample Organizations

8.9.1 Company A (Prospector)

Company A is a large public-listed company that designs, manufactures, and sells through its international distribution network the consumer electronic products including electronic toys, educational software, personal computers, and cordless telephones. Its environment is becoming complex since the consumers' ever-changing expectations for electronic products and the growing consciousness of their children's knowledge in electronics and computers. In order to cope with the situation, the main concern for Company A is to focus strategically on the product design and development, which is performed in-house.

The organizational strategies of the company are:

(a) Strategic alliances. In order to keep abreast with the latest microelectronic development for product design, the company must work closely with their semiconductor companies or Integrated Circuit (IC) design houses right from the start of the product development cycle. Good partnering relationship with their microelectronic suppliers is important.

(b) IT strategy. The company is fully aware of the use of IT for product design, i.e. Computer Aided Design (CAD) systems for design, computer aided testing of microelectronics.

(c) Market intelligence strategy. The company recognizes that market intelligence must be built up in order to continue its market leadership. The insatiable demand for cheaper and better products is the main momentum driving the company to introduce better products all the time.

(d) Integrated MPC strategy. The company uses MRPII system for internal manufacturing logistics and control. Its purpose is to make the products less costly to manufacture and deliver quickly to the market. It is supported by Management Information System (MIS) Department.

Generally, the company considers that product design and development contributes to a large part of the value-added process. Their manufacturing focus is more on the back-end activities, i.e. the design of a commercially successful product and strategic alliances

with microelectronic suppliers. Company A has a strong emphasis on customer fit, competitive fit and technological fit (refer to Table 8.5 for comparison with other sample companies).

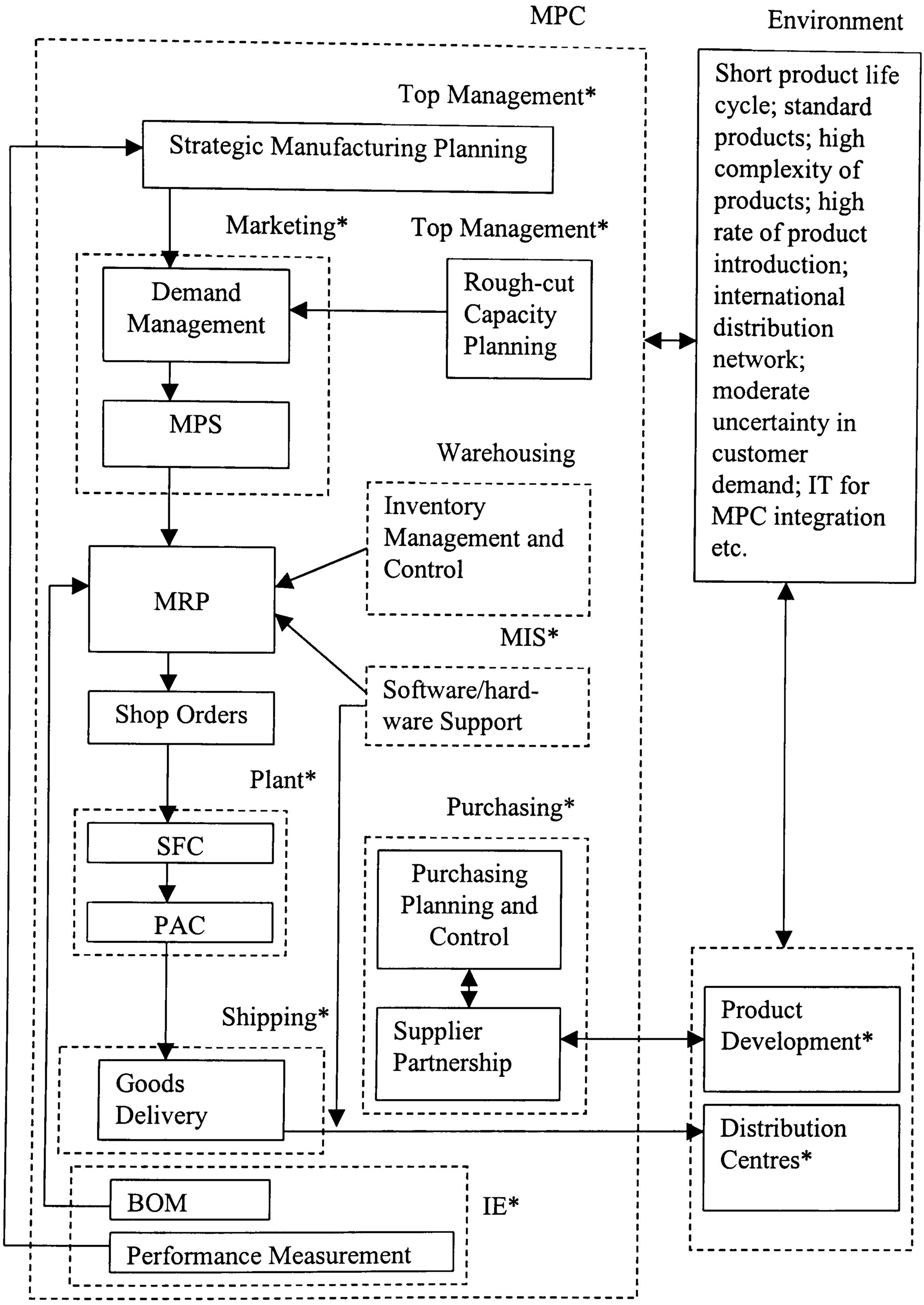
Sample Organization	Strategic fit				
	Customer	Competitive	Technological	Resource	Organizational
Prospector A	✓	✓	✓		
Defender B		✓		✓	
Analyzer C	✓		✓	✓	
Reactor D	✓			✓	
Defender E	✓		✓	✓	✓
Defender F	✓	✓		✓	

Table 8.5: A Summary of the Strategic Fit of Sample Organizations.

The management perceived that culture (the availability of entrepreneurial-spirit and knowledgeable workforce) and IT are two important logistics infrastructures that would strengthen the business.

In terms of net profit growth, Company A's performance is excellent. It has increased by 300% over the past five years.

The MPC structure is shown in Figure 8.7. It is organized in a similar way to MRPII system. Rough-cut capacity planning is considered important in meeting with the top management vision as organizational growth is emphasized. Since Company A is responsible for a long range of business process, i.e. from product development to distribution, an integrated MPC model is stressed.



[Note: Those sub-systems marked with * are "intermediaries".]

Figure 8.7: MPC Model in Company A (A Prospector and a High Performer)

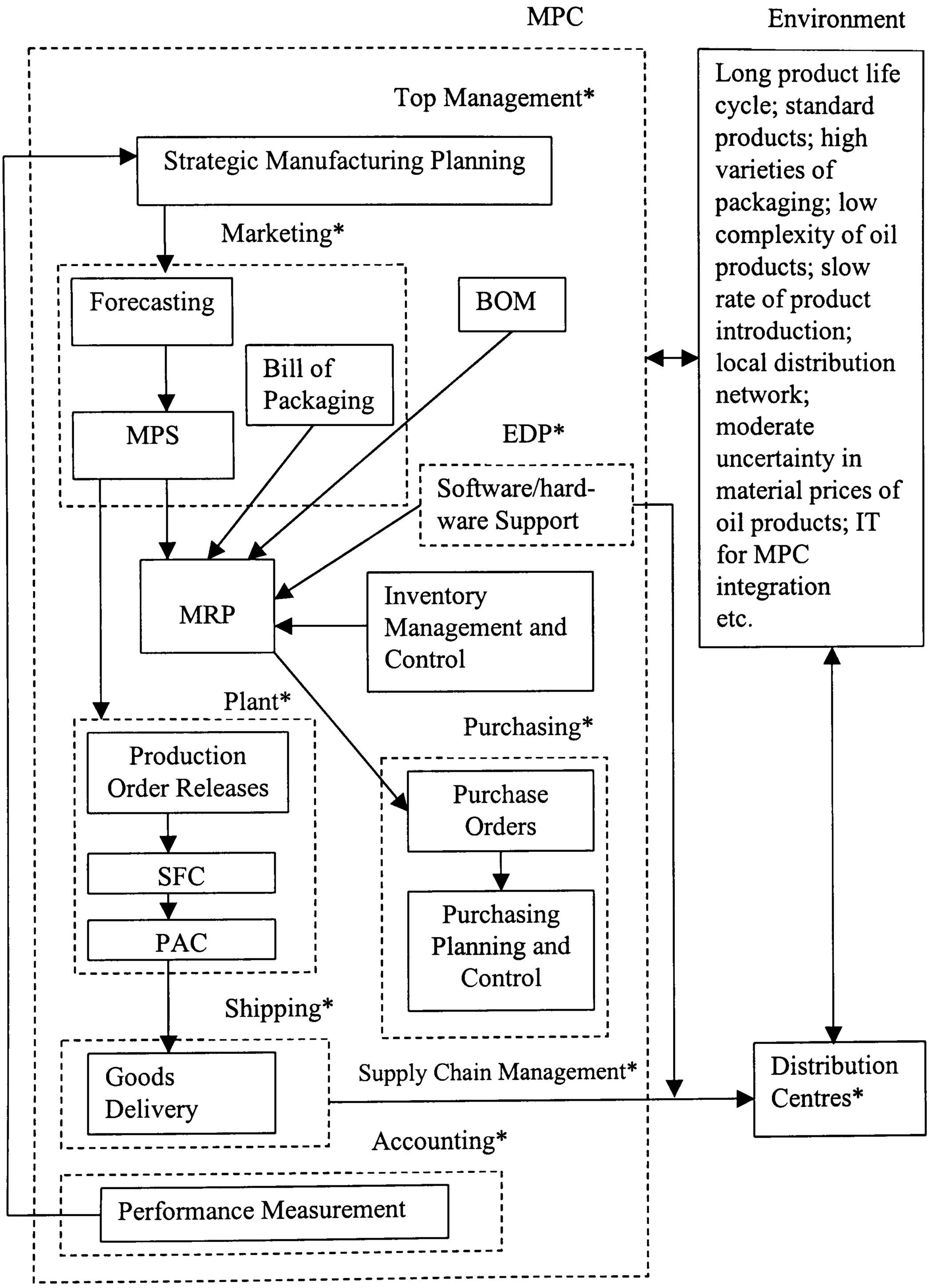
8.9.2 Company B (Defender)

Company B is a large public-listed company engaging in the manufacture and distribution of edible oils. It has a long history of providing high-quality edible oils and enjoys a considerable market share. Similar to a number of Hong Kong manufacturers, Company B has moved its production facilities from Hong Kong to China. The office in Hong Kong performs the headquarter functions, i.e. sales and marketing, accounting, financial, and transportation. The China plant includes a new edible oil refinery, an automated oilseed crushing unit and a blending and bottling plant. The plant is mainly engaged in production, purchasing, MPC, quality, maintenance, and production engineering.

The company faces the challenges – delivering products just-in-time while keeping a tight control on costs. The company has started a large-scale ERP system to support the existing logistics. Its purpose is to integrate the company's financial, distribution, logistics and manufacturing at all the company's major locations. Internal integration of all the activities in different sites is the main concern for Company B. It emphasizes cost-efficiency and sustainable profitability.

The company is market-oriented and it focuses on competitive fit and resource fit (refer to Table 8.5 for comparison with other sample companies). In terms of profit, Company B's performance is poor. It has recorded losses for several years due to the unfavourable import and agricultural policy imposed by China, where the company has a significant proportion of edible oil products sold.

The MPC structure is shown in Figure 8.8. The forecasting module is important for Company B and it relies on the Marketing Department, as intermediaries, to enact with the business environment. Besides, the Marketing Department has the authority to change the packaging design and thus they are responsible for the Bill of Packaging (BOP). Given the low range of edible oil products to be sold, the BOM is simple. Further, the capacity of the refinery and the packaging lines are fixed. If there were a need to enlarge the plant capacity, the investment would be high. In this regard, the rough-cut capacity



[Note: (a) Those sub-systems marked with * are "intermediaries". (b) EDP denotes Electronic Data Processing Department in Company B and it serves for the computerization processes in the entire company.]

Figure 8.8: MPC Model in Company B (A Defender and a Low Performer)

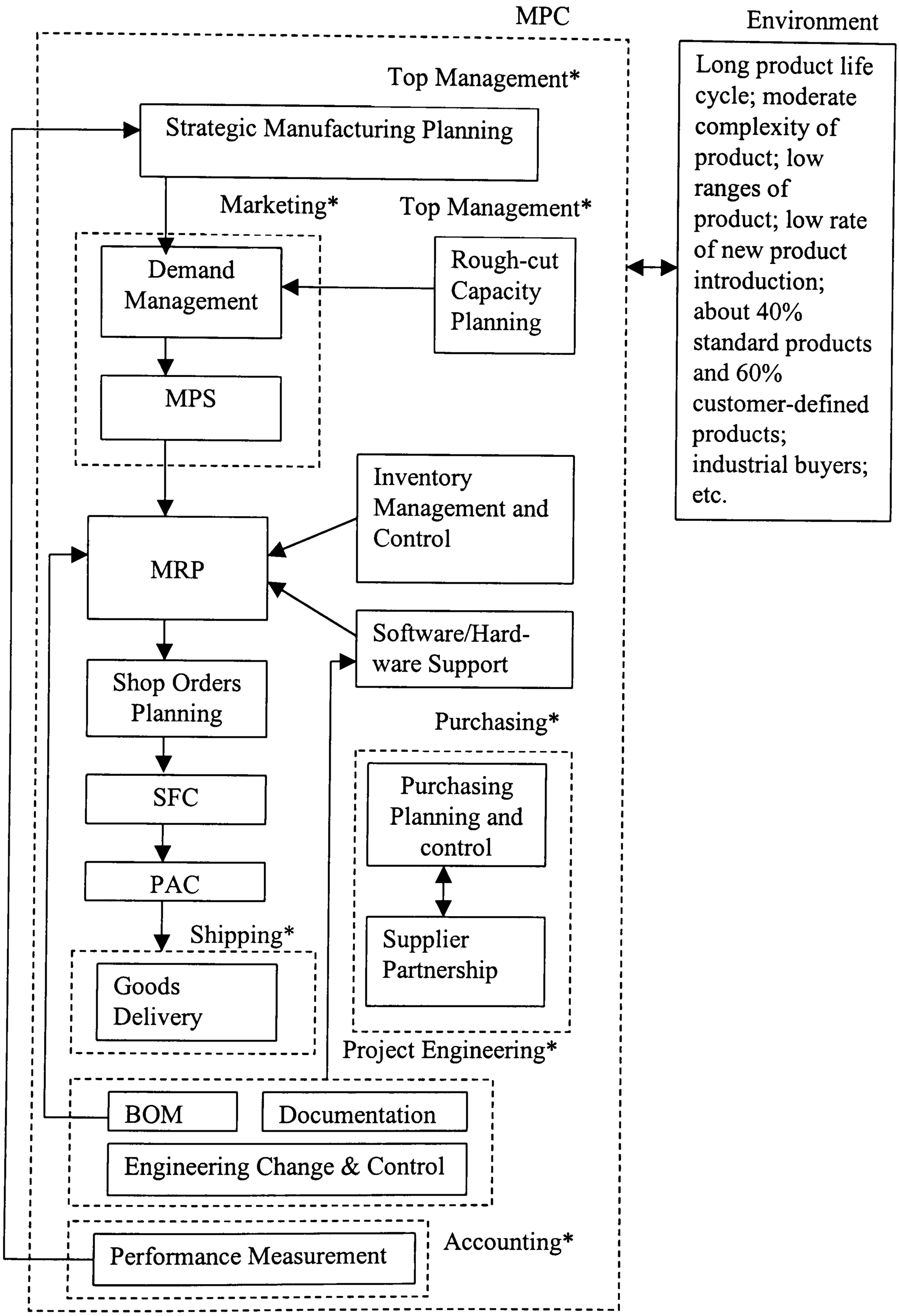
planning decision is the top management's task. Contrary to the traditional thinking, Company B assigns the production scheduling and job loading responsibility to the Production Department. The plant determines the production schedules according to the Marketing's forecast and MPS. The company stresses on the importance of the downstream supply chain management. The ERP software is used to connect the company with the distribution network at the retail level supports the goods delivery module.

8.9.3 Company C (Analyzer)

Company C is a automatic machine manufacturer of about 15 years' standing. It manufactures electronic assembly machine such as wire bonding, die bonding and inspection machines. Its production plant is in Hong Kong and it maintains a flexible production strategy that mixes with MTO, MTS, and ETO. The machines are 99% exporting to other countries and its customers are industrial buyers.

The company's plant is classified into "A" type, that is, about 12 types of machines are manufactured with a high number of components. The company adopts a "home grown" MPC system which is largely a manual system whilst supported by a limited computerization process. Company C puts competitive fit, technological fit and resource fit as priority (refer to Table 8.5).

Company C structures its MPC system similar to MRP system (see Figure 8.9). The system includes modules such as demand management, MPS, MRP, shop order planning and control, PAC, and purchasing etc. Given that the company has about 60% of its order to be customer-defined orders, the top management assigns BOM, documentation control and engineering change and control modules to the Project Engineering Department. This department, acts as intermediaries, interprets the customers' special orders and carries out the design and engineering works as a "project". Then it transfers the "project" to MPC Department when the customer approves the specifications of the product.



[Note: Those sub-systems marked with * are "intermediaries".]

Figure 8.9: MPC Model in Company C (An Analyzer and a Moderate Performer)

8.9.4 Company D (Reactor)

Company D is a supplier of envelopes and printed matter to one of the largest supermarket chains in Hong Kong. A manufacturing plant is set up in China to fulfil the orders received by Company D in Hong Kong.

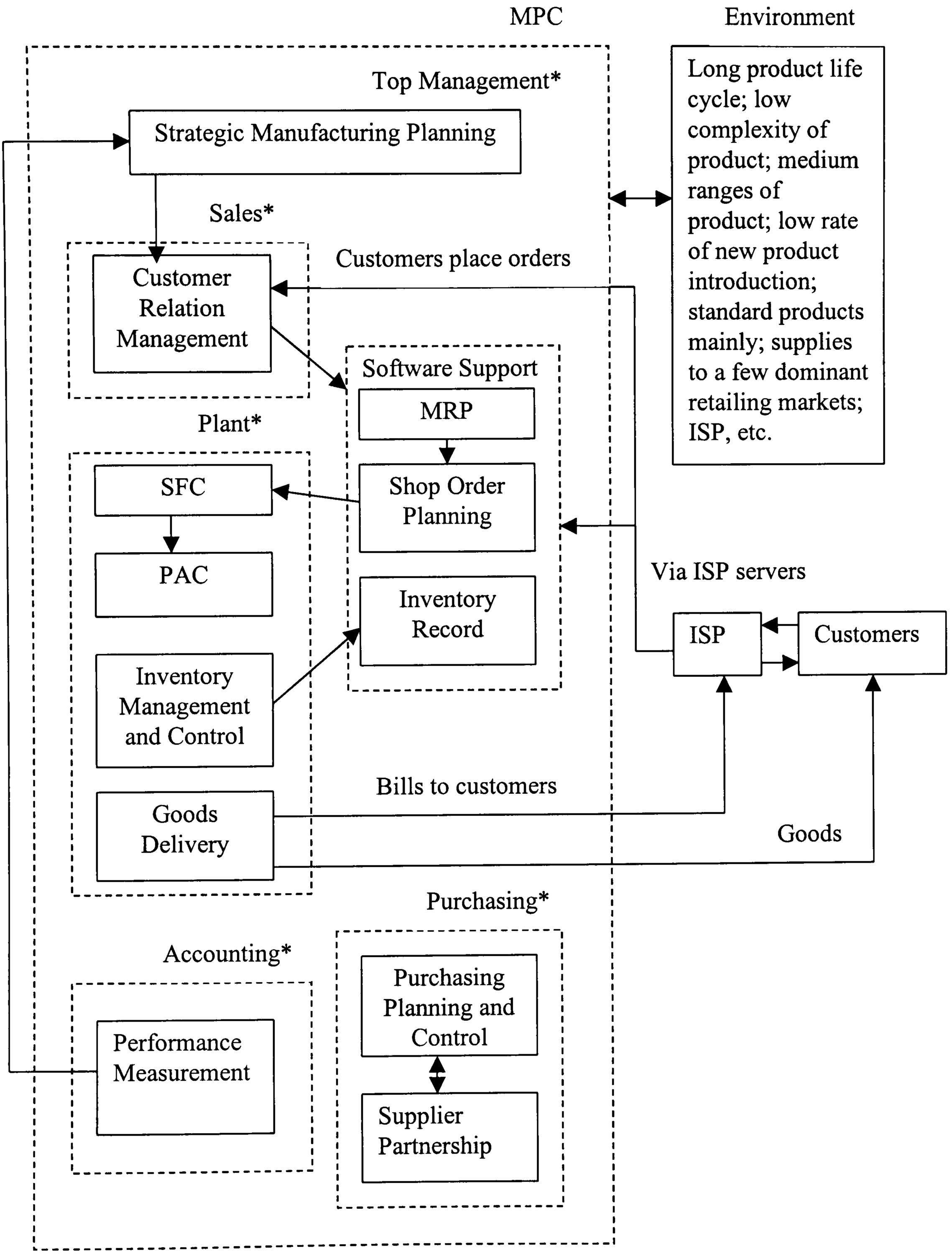
In responding to one of its major customer's serious request, Company D in 1997 has used one of the Hong Kong Business Association's web-based e-business software to receive the purchase orders from the supermarket chain. The role played by the Hong Kong office is to act mainly as the sales agent for the production plant in China. Company D sends all its orders and invoices to its China plant via internet directly. Accordingly, the company is able to integrate different functions within a business, from sales to manufacturing and to distribution in a single company-wide IT practice.

The investment in using the service of internet service provider (ISP) is small. This arrangement is considered to be particularly useful for small- and medium-sized enterprises (SMEs). Besides, it saves the expenses of installing additional software and the capital investment in a proprietary e-business network. The company is also benefiting from the operational efficiency and the reduction in human errors via web-based trading. The company's focuses are customer fit and resource fit (refer to Table 8.5).

The MPC structure is shown in Figure 8.10. Some transactions such as Customer Relations Management (CRM), MRP, shop order planning, inventory record, customer orders receipt, and invoices to customers are carried out via ISP's servers. Thus, the services and software of ISP are important factors for the MPC effectiveness.

8.9.5 Company E (Defender)

Company E has begun its operations for over 30 years. Its production plant is in Hong Kong and it maintains an MTO position strategy. The owner of the company believes that the future and the success of the company is directly linked with product development and operational effectiveness.



[Note: Those sub-systems marked with * are "intermediaries".]

Figure 8.10: MPC Model in Company D (A Reactor and a Moderate Performer)

The company's plant is classified into "V" type since there are many semiconductors to be manufactured with a few raw materials required. The company adopts a MRPII system to integrate its manufacturing planning and control.

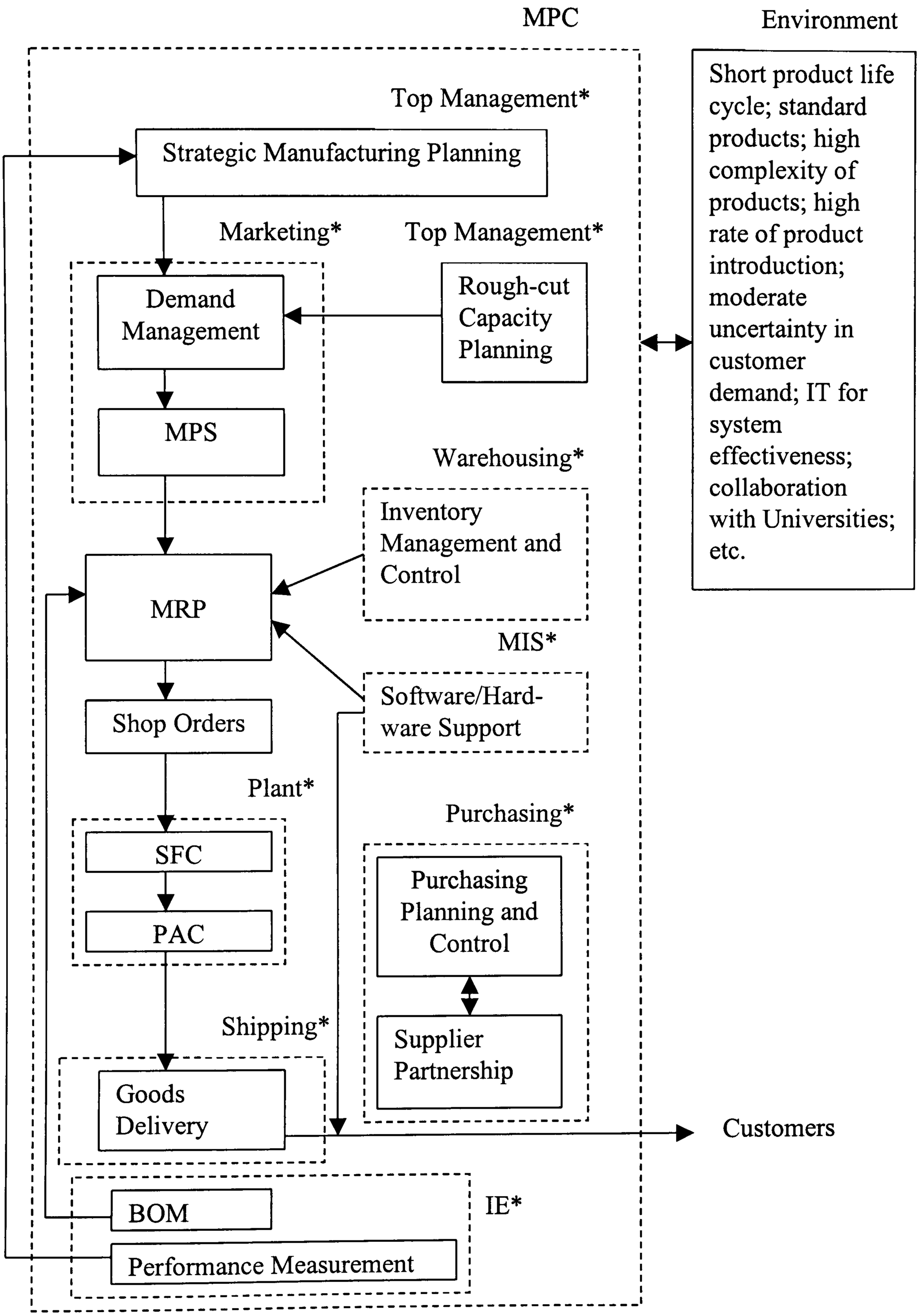
Company E's strategy is to capture a big market share by providing customer-made products with high quality and quick delivery services for its customers. It stresses more on customer fit, technological fit, resource fit and organizational fit (refer to Table 8.5). The company performs a high performance and it is widely known as a very efficient company in the electronics industry.

The MPC structure is same as the MRPII system (see Figure 8.11), which is similar to Company A (refer to Figure 8.7) with two exceptions. (a) Company A has integrated its MPC system with international distribution network, whilst Company E focuses more on the internal manufacturing planning and control processes. (b) Company A emphasizes on the collaboration with suppliers in the product development process, but Company E underlines the importance of supplier partnership for the achievement of quality and stable supplies.

8.9.6 Company F (Defender)

Company F has begun its operations since 1975. The company started its manufacturing of telephone cables until early 1990's. Then it is diversified its business into the production of automobile wire harnesses that is a joint venture of a well-known Japanese automobile enterprise. The production was moved to China in the late 1980s and the office in Hong Kong is engaged in sales and marketing, finance, accounting, and purchasing. The office in Hong Kong has a staff of 20 people, while the workforce in China is about 1200. It later manufactures a wide range of audio-video cables and computer cords.

The company establishes a joint venture with a well-known Japanese automobile enterprise for a major reason that it is intended to learn the Japanese management. As a result, Company F has two different systems that sometimes confuse the employees, i.e.



[Note: Those sub-systems marked with * are "intermediaries".]

Figure 8.11: MPC Model in Company E (A Defender and a High Performer)

a Japanese-style management for the manufacture of wire harnesses and a Western-style management for the manufacture of other cable products. MPC is also different for these two different types of management system though both of the systems adopt MRP logic. For example, in the MPC context, only the materials receiving, inventory control and goods delivery are necessary for the wire harnesses production, but all MRPII functions are needed to perform for the production of remaining cable products. Figure 8.12 shows the MPC model for the entire organization.

Unlike other sample organizations, the top management of Company F considers that the performance related to MPC processes must be evaluated by the Production Planning and Material Control (PPMC) Department. However, other sample companies, as mentioned earlier, assign this evaluation process to either Accounting Department or Industrial Engineering Department. The company stresses the importance of customer fit, competitive and resource fit (refer to Table 8.5). The performance of Company F is low.

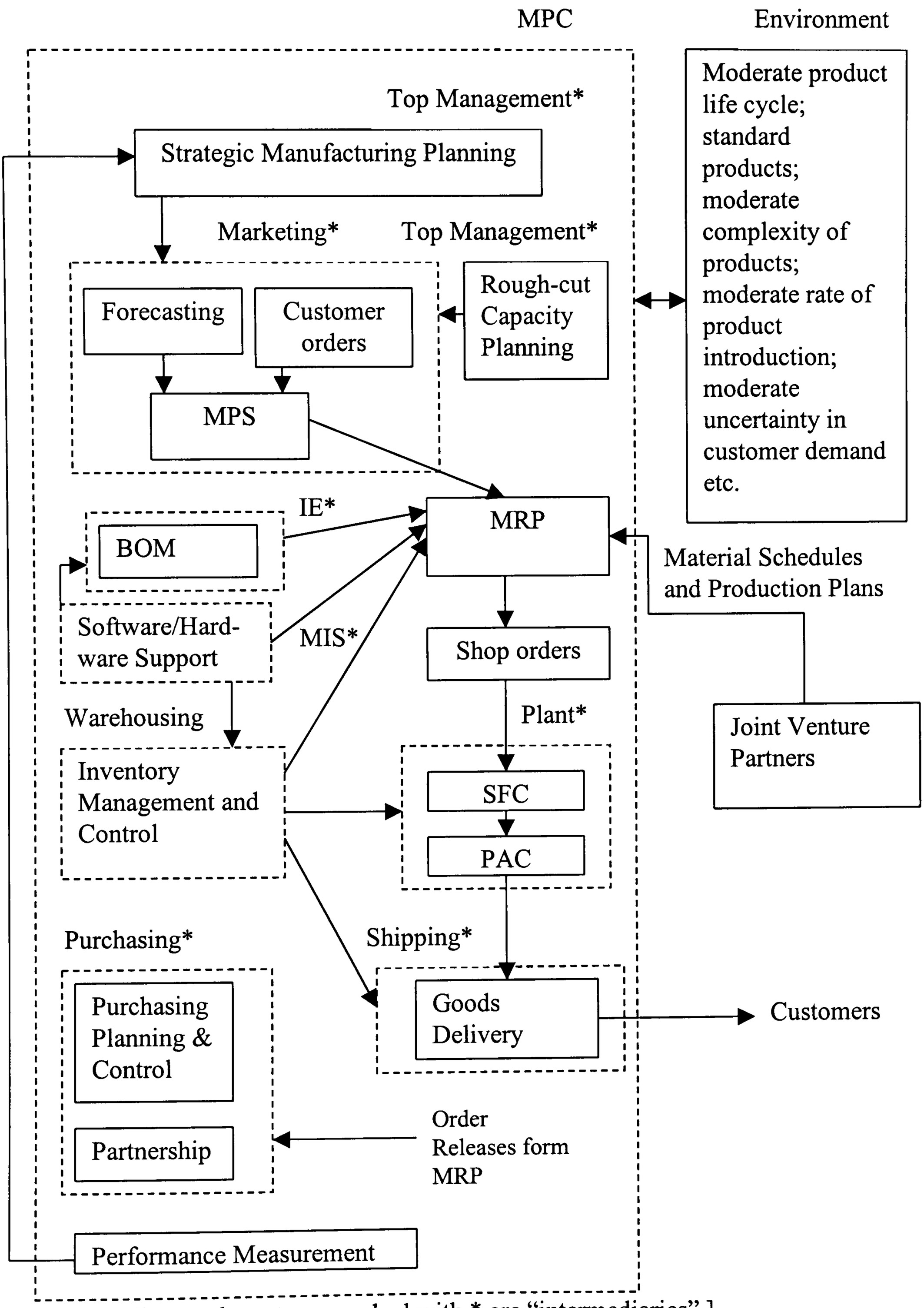
8.9.7 Discussion

Similar to Howard et al.'s[272] study, the reference model does not represent exactly the MPC system of each sample organization. At individual sample organizations, the modules used in each MPC system vary but most of the MPC processes have comprised a significant number of modules that are present in the reference model.

It demonstrates that the MPC system requires a number of internal departments or some external partners to work together. The intermediaries play an important role in the interpretation of the environments so that appropriate actions could be taken. Examples of these are:

(a) The Purchasing Department of Company A is assigned to foster a good supplier partnership. Any advance in technology, or new components will bring to the attention of Product Development Department for new product design.

(b) The Marketing Department of Company B enacts the marketing conditions and provides to the Production Planning Department the forecast and the list of promotional or packaging items that will be required.



[Note: Those sub-systems marked with * are "intermediaries".]

Figure 8.12: MPC Model in Company F (A Defender and a Low Performer)

(c) In Company C, the Project Engineering Office liases with the potential buyers and works out the technical requirements of customer order. The BOM and other technical details will transfer to the Production Planning and Control Department for order planning.

(d) In Company D, the Sales Department works closely with the ISP and its retail customers in order to ensure a number of MPC functions and business transactions could be carried out via internet.

(e) The MIS Department of Company E continues to seek for the upgraded software in order to improve their MPC system effectiveness.

(f) The Production Planning and Material Control Department is not only responsible to ensure the goods delivered to the Joint Venture partner on time, but also to learn from the partner the Japanese-style management and system. The Department has the duty to transfer learning.

Besides, it is observed that the differences in functionality of the MPC system among sample organizations could be emerged at the sub-system level. For example, some sample organizations assign Accounting Department to carry out performance measurement in MPC area, whilst Company F allocates the PPMC Department such duty. One of the major reasons could be that a sub-system in an organization would be in the best position to enact the environmental view for a particular module. However, in another organization, a different sub-system would be more suitable to carry out the module.

Overall, the proposed reference model appears to fit relatively well in a wide range of organization types. Therefore, the model can be used to represent the MPC system from different manufacturing environment perspective and for different manufacturing strategies.

8.10 Summary

In order to identify the organizational configurations at MPC level, this chapter proposes a new MPC reference model (see Figure 8.2) that presents an alternative way of viewing the MPC system through a manufacturing environment perspective. The development of this

reference model is based on a literature theoretical synthesis on MPC approaches. As a result, a set of 30 propositions is postulated for building up a MPC framework. The framework is an observation of some natural rules and draws attention to the fundamental propositions that are often overlooked in the development and the choice of an appropriate MPC system.

There are four benefits in making use of the proposed MPC model. Firstly, an organization is encouraged to extend the planning and control of its operations beyond the system boundaries. It is important nowadays as organizations become more interlinked with their environments. Secondly, the reference model provides a logical structure for an organization to establish its own MPC system by considering its own specific set of environmental forces. The theory of autopoiesis is considered in which the manufacturing environment is regarded as part of the organization. The choice of an appropriate MPC system is dependent on how the intermediaries of an organization specify the pattern of MPC-environment relations in an enacted world. The use of conventional MPC approaches without considering the organization's manufacturing situations is not recommended. Thirdly, the reference model determines the manner in which the MPC system is stratified into various decision levels and the type of relationship that exists between these decision-making entities. The model specifies how environment, intermediaries, strategies, planning, control, and execution aspects are integrated to achieve manufacturing goals. Fourthly, it is demonstrated by the field study that the model can be used to provide an overall representation of the MPC system since it embraces a wide range of modules for a large variety of organizational types.

As discussed earlier in Chapter 5, the organizational configuration approach in MPC systems provides a new research paradigm to examine the configurations-environment relationship with performance implications in the functional level of an organization. It is anticipated that the configuration study at the micro level in MPC discipline will generate insight and to advance a predictive task for MPC research. The review of both elemental and relational configurations in MPC systems in Chapter 5 and the development of the reference MPC model in this Chapter will assist the testing of research hypotheses in the following Chapter.

Chapter 9 Results and Discussions

This Chapter describes the results of both archival-based (by industrial and trade statistics) and perceptual (by questionnaire survey) data. The environmental construct based on archival-based approach is presented. Then the results of the data analyzed are discussed. They are organized into four sections: descriptive statistics which enumerates the demographic information of the survey respondents; inferential statistics which includes the examination of each hypothesis based on Pearson correlation and regression analysis; archival-based industrial and trade statistics which comprises of several hypothetical relationships; and path models which evaluate the hypotheses in MPC configurations.

9.1 Environmental Constructs

The result of the classification of organizational environments is presented in Table 9.1. It is interesting to note that all the twenty major industries under study have their environment munificence ranking from low to medium level. There are three possible reasons for not a single sample industry falling into the "high munificence" category. First, after two and a half decades of rapid export growth, Hong Kong manufacturing industry has been slowed down in recent years. Second, the 1997 Asian turmoil has weakened the growth prospects for at least two years. Third, most of the Hong Kong manufacturers have relocated their production bases offshore and it is unfortunate that the trade census and statistics are impossible to disclose the full picture.

The survey result that exhibits the scores of the perceptual complexity and dynamism is presented in Table 9.2. A juxtaposition of the scores and ranks on complexity and dynamism factors between the archival method and perceptual method is exhibited in Table 9.3. With respect to the complexity dimension, the rankings based on the perceptual method for fabricated metal products industry and electrical appliances & houseware industry are much different from that based on the archival approach. According to the archival-based approach, the environmental dimension in the electrical appliances & houseware industry is classified as "high complexity"; while, by the perceptual approach,

Sample Industry	Environmental Dimension					
	Munificence Factor		Complexity Factor		Dynamism Factor	
	Score	Category	Score	Category	Score	Category
Food	0.2156	Medium	0.9333	Low	0.5697	Medium
Beverages	0.0468	Medium	0.7239	Low	0.5220	Medium
Wearing apparel	0.0096	Medium	1.9700	High	0.6102	Medium
Leather & leather products	-0.5933	Low	1.1141	Medium	0.3098	Low
Textiles	-0.2563	Low	1.3953	Medium	0.5361	Medium
Paper & paper products	-0.3038	Low	0.9212	Low	0.5527	Medium
Printing, publishing & allied industries	0.1212	Medium	1.1152	Medium	0.5362	Medium
Plastic products	-0.4630	Low	1.2262	Medium	0.7150	High
Basic Metal	-0.0404	Low	0.9190	Low	0.5699	Medium
Fabricated metal products	-0.7705	Low	1.6694	Medium	0.3932	Low
Radio, TV & communication equipment	0.06142	Medium	1.5050	Medium	0.6592	Medium
Electrical & electronic products	0.2245	Medium	N.A.		0.9022	High
Electronic parts & components	0.2356	Medium	2.025	High	0.7988	High
Electrical appliances & houseware	0.1135	Medium	1.1139	Medium	0.7847	High
Machinery Apparatus & Equipment	-0.2415	Low	1.3157	Medium	0.6411	Medium
Containers & boxes of paper	-0.6337	Low	N.A.		0.7398	High
Articles of pulp, paper & paperboard	-0.4551	Low	N.A.		0.6226	Medium
Cans & domestic utensils of metal, except aluminum	-0.7417	Low	N.A.		0.8418	High
Dry batteries (excluding lead accumulators)	-0.1889	Low	N.A.		0.3410	Low
Chemicals & chemical products	-0.0017	low	1.2071	Medium	0.5155	Medium

[Note: 'N.A.' stands for statistical data is not available for measurement.]

Table 9.1: Scores and Categories on Munificence, Dynamism, and Complexity for 20 Sample Industries in Hong Kong (by Archival-based Method)

Sample Industry	Environmental Dimensions			
	Complexity Factor (Scale between 1 and 3)		Dynamism Factor (Scale between 1 and 7)	
	Mean	Standard deviation	Mean	Standard deviation
Plastic products	1.7708	0.5860	4.9500	0.7194
Fabricated metal products	1.6667	0.3178	4.1091	0.2926
Radio, TV & communication equipment	1.9667	0.4583	4.5400	0.5936
Electrical & electronic products	2.2179	0.4311	5.1346	0.5121
Electronic parts and components	2.1111	0.4157	5.0576	0.5883
Electrical appliances & houseware	2.0256	0.3055	4.3231	0.7587
Machinery Apparatus & Equipment	1.9487	0.3887	4.0769	0.7381

Table 9.2: Scores and Categories on Complexity and Dynamism for 7 Sample Industries in Hong Kong (By Perceptual-based Method)

Sample Industry	Environmental Dimensions			
	Complexity Factor		Dynamism Factor	
	Archival method (Rank)	Perceptual method (Rank)	Archival method (Rank)	Perceptual method (Rank)
Plastic products	1.2262 (5)	1.7708 (5)	0.7150 (4)	4.9500 (3)
Fabricated metal products	1.6694 (2)	1.6667 (6)	0.3932 (7)	4.1091 (6)
Radio, TV & communication equipment	1.5050 (3)	1.9667 (3)	0.6592 (5)	4.5400 (4)
Electrical & electronic products	N.A.	2.2179 (-)	0.9022 (1)	5.1346 (1)
Electronic parts and components	2.0250 (1)	2.1111 (1)	0.7988 (2)	5.0576 (2)
Electrical appliances & houseware	1.1139 (6)	2.0256 (2)	0.7847 (3)	4.3231 (5)
Machinery Apparatus & Equipment	1.3157 (4)	1.9487 (4)	0.6411 (6)	4.0769 (7)

[Note: 'N.A.' stands for HKSAR government's census and industrial production statistical data is not available for measurement.]

Table 9.3: Comparison of Scores and Ranks on Complexity and Dynamism for 7 Sample Industries in Hong Kong (Archival Method versus Perceptual Method)

it is identified as "medium complexity". With respect to the dynamism dimension, discrepancies are also found.

Fabricated metal products industry and electrical appliances & houseware industry are classified as "medium dynamism" based on the perceptual approach; while by using the archival approach they are ranked as "low dynamism" and "high dynamism" respectively. Based on the archival approach, plastic products industry is in the "high dynamism" category; while by perceptual method the classification is on the borderline, i.e. between high and medium levels of environmental dynamism.

Using the perceptual approach, the scores for environmental dynamism and complexity appear to be widely dispersed for all sample industries under survey, except the perceptual dynamism score for the fabricated metals industry. For instance, the bulk of distribution for electrical appliances & houseware industry in the context of dynamism is 4.3231 ± 1.5174, i.e. within 2 standard deviations from the mean. Some organizations in electrical appliances & houseware industry are operated under high dynamism, i.e. scores between 5 and 5.8405; while some organizations may subject to low dynamism, i.e. scores between 2.8057 and 3. Thus, the manufacturing environment is not only industry-specific, but also firm-specific. It implies that, within a single manufacturing industry, organizations may operate in a continuum of environmental conditions. Different organizations may cope with different environmental conditions even though they operate in the same industry. The study also demonstrates that the archival method usually provides the norm of environmental conditions in the industry level, while the perceptual approach furnishes a range of conditions in both the industry and organization levels.

Apart from the discrepancies found, the classifications by the perceptual approach in the other five sample industries are consistent with the results obtained from the archival approach. Thus, the measures of environmental dimensions for twenty major industries based on archival approach in Table 9.1 are generally reliable.

9.2 Descriptive Statistics

Tables 9.4 and 9.5 summarize the types of organizations surveyed in terms of Miles & Snow's strategic archetypes and supply chain strategies. The largest single strategic

archetype is the prospector organizations with 36.2% falling into this category. The number of responses for the other three archetypes is similar. It shows that the types of organizations, classified by Miles & Snow's strategic types, are fairly distributed. In the context of supply chain strategy, the largest single type is the lean chain with 51.7% falling into this category, next is the agile supply chain which accounts for 25%. Of the sample organizations, 23.3% claim that they adopt the leagile supply chain strategy.

Type of Organizations	Number of Responses	Percent
Defender	22	19.0
Prospector	42	36.2
Analyzer	27	23.3
Reactor	25	21.6
Total	116	100.0

Table 9.4: A Summary of the Types of Responding Organizations, Based on Miles Snow's Strategic Archetypes

Type of Supply Chains	Number of Responses	Percent
Lean	60	51.7
Agile	29	25.0
Leagile	27	23.3
Total	116	100.0

Table 9.5: A Summary of the Types of Responding Organizations, Based on Supply Chain Strategy

The detail of the number of employees was shown in Table 9.6, with the mean equal to 2,485 and the standard deviation of 4,100. The age of the business was summarized in Table 9.7. The ages of the organizations range from less than 1 year to 75 years with the mean of 20.8 years and the standard deviation of 15.6 years. With respect to the sales turnover of the responding organizations, 34.5% of replies would not disclose the turnover figures. The average revenue of the replies is 19.87 billion Hong Kong Dollars and the profile is shown in Table 9.8.

No. of employees	Number of Responses	Percent
Less than 50	17	14.7
50 to149	11	9.5
150 to 499	15	12.9
500 to 999	11	9.5
1000 to 1499	13	11.2
1500 to1999	5	4.3
2000 to 2499	9	7.8
2500 to 2999	5	4.3
3000 to 3999	8	6.9
4000 to 4999	2	1.7
5000 to 5999	3	2.6
6000 to 7999	4	3.4
8000 to 10000	2	1.7
Over 10001	7	6.0
Total	114	98.3
Missing	2	1.7
Total	116	100.0

Table 9.6: Number of Employees

Age of Organization	Number of Responses	Percent
Less than 1 year	1	0.9
1.0 to 1.99	2	1.7
2.0 to 3.99	4	3.4
4.0 to 5.99	5	4.3
6.0 to 7.99	5	4.4
8.0 to 9.99	18	15.5
10 to 14.99	6	5.2
15.0 to 19.99	21	18.1
20.0 to 24.99	21	18.1
25.0 to 29.99	7	6.0
30 to 39.99	10	8.6
40 to 49.99	7	6.0
50 to 69.99	5	4.4
Over 70	4	3.4
Total	116	100.0

Table 9.7: The Ages of Responding Organizations

Sales Turnover per Year (HK$ in million)	Number of Responses	Percent
Less than 10	4	3.4
10 to149	14	12.1
50 to 99	7	6.0
100 to 499	24	20.7
500 to 999	11	9.5
1000 to1999	7	6.0
2000 to 4999	3	2.6
5000 to 10000	4	3.4
Over 10001	2	1.7
Total	76	65.4
Missing	40	34.5
Total	116	100.0

Table 9.8: Profile of Annual Sales Turnover

Table 9.9 depicts the production base of the responding organizations. One sample organization does not reveal the production base of their organization. As expected, most of the organizations (83.6%) establish their production plants in China.

Production Base	Number of Responses	Percent
China	82	70.7
Hong Kong	10	8.6
Both HK& China	15	12.9
Others	8	6.9
Total	115	99.1
Missing	1	0.9
Total	116	100.0

Table 9.9: Production Bases of Responding Organizations

Tables 9.10 outline the manufacturing (positioning) strategy of sample organizations. The largest single strategy they adopt is make-to-order (MTO), which accounts for 86.2% of the sample. Next is the make-to-stock strategy (MTS) which is about 25%. The smallest proportion of organizations in this survey is 3.4%, which claims that they adopt the assemble-to-stock (ATS) strategy. In addition, about 9.5% of the organizations adopt engineer-to-order (ETO) strategy.

	Make-to-Order		Make-to-Stock		Assemble-to-stock		Engineer-to-order	
	Number of Responses	Percent	Number of Responses	Percent	Number of Responses	Percent	Number of Responses	Percent
Yes	100	86.2	29	25	4	3.4	11	9.5
No	15	12.9	86	74.1	111	95.7	104	89.7
Total	115	99.1	115	99.1	115	99.1	115	99.1
Missing	1	0.9	1	0.9	1	0.9	1	0.9
Total	116	100.0	116	100	116	100.0	116	100

Table 9.10: Manufacturing (Positioning) Strategy of Responding Organizations

Table 9.11 depicts the summary of the respondent organizations that have master production schedule (MPS) function. 82.8% of the organizations answered that they included MPS function in their MPC system.

MPS function	Number of Responses	Percent
Yes	96	82.8
No	20	17.2
Total	116	100.0

Table 9.11: The Use of MPS Function

From Table 9.12, it can be seen that 74.1% of the organizations included capacity requirements planning (CRP) function in their MPC system. Two sample organizations would not disclose whether they would employ CRP function or not.

CRP function	Number of Responses	Percent
Yes	86	74.1
No	28	24.1
Total	114	98.3
Missing	2	1.7
Total	116	100.0

Table 9.12: The Use of CRP Function

Table 9.13 demonstrates the portion of the organizations that include material requirements planning (MRP) function in their MPC system. One sample organization

would not disclose whether it would employ MRP function or not. 89.7% of organizations applied MRP function.

MRP function	Number of Responses	Percent
Yes	104	89.7
No	11	9.5
Total	115	99.1
Missing	1	0.9
Total	116	100.0

Table 9.13: The Use of MRP Function

45.7% of sample organizations answered that they would seek for the subcontracting services in order to adjust their plant capacity. Five sample organizations would not reveal if they had subcontractors or not. The results are shown in Table 9.14.

Subcontracting	Number of Responses	Percent
Yes	53	45.7
No	58	50
Total	111	95.7
Missing	5	4.3
Total	116	100.0

Table 9.14: The Use of Subcontractors for Adjusting Plant Capacity

Table 9.15 indicates the purchasing control practices. 51.7% of the responding organizations applied multiple sources of supplies, whilst 44.8% chose few sources of supplies. Four sample organizations would not disclose their purchasing control strategy.

Purchasing Control	Number of Responses	Percent
Multiple Sources of Supplies	60	51.7
Few Sources of Supplies	52	44.8
Total	112	96.6
Missing	4	3.4
Total	116	100.0

Table 9.15: Purchasing Control

Table 9.16 covers the decoupling point the responding organizations adopt. The most favored decoupling point is at the component level, in which 61.2% of organizations replied that they adopt this practice. The percentages of organizations that adopt end-item and sub-assembly as decoupling points are 29.3 and 23.3 respectively. Three sample organizations would not disclose their decoupling point strategy.

	Decoupling Point					
	End-item		Sub-assembly		Component	
	Number of Responses	Percent	Number of Responses	Percent	Number of Responses	Percent
Yes	34	29.3	27	23.3	71	61.2
No	79	68.1	86	74.1	42	36.2
Total	113	97.4	113	97.4	113	97.4
Missing	3	2.6	3	2.6	3	2.6
Total	116	100	116	100	116	100

Table 9.16: The Decoupling Point

With respect to the types of MPC system the responding organizations mainly use, MRP and MRPII systems are the most popular which account for 33.6% and 23.3% of the sample respectively. No organizations adopt OPT nor CONWIP systems. The implementation of JIT, or ERP, or manual systems is 7.8% each. Twenty-three sample organizations (19.8%) would not disclose their MPC system (see Table 9.17).

MPC System	Number of Responses	Percent
MRP	39	33.6
MRPII	27	23.3
JIT	9	7.8
ERP	9	7.8
Manual	9	7.8
Total	93	80.2
Missing	23	19.8
Total	116	100.0

Table 9.17: Types of MPC System Being Implemented

9.3 Inferential Statistics

This Section has two parts: (1) results based on the examination of the hypotheses using correlation, regression, and ANOVA; (2) results from the testing of hypotheses using archival-based data.

In Chapter 6, a total of 30 relationships were hypothesized. They are listed in Table 9.18 and will be referred in subsequent Sections. The sample organizations are classified into seven groupings for the hypotheses testing. They are defender, prospector, analyser, reactor, lean, agile, and leagile organizations. The results of the statistical calculation, including the test of all responding organizations, by using SPSS 10.0 for windows are given in Appendices 6 – 13 (Correlation Matrices), and 14 (Regression).

Code	Statement of Hypothesis
H1	Manufacturing strategy will have a direct effect on the MPC system effectiveness.
H1a	Manufacturing strategy will have a direct effect on the MPS performance.
H1b	Manufacturing strategy will have a direct effect on the CRP performance.
H1c	Manufacturing strategy will have a direct effect on the MRP performance.
H1d	Manufacturing strategy will have a direct effect on the purchasing performance.
H2	Competitive strategy will have a direct effect on the MPC system effectiveness.
H2a	Competitive strategy will have a direct effect on the MPS performance.
H2b	Competitive strategy will have a direct effect on the CRP performance.
H2c	Competitive strategy will have a direct effect on the MRP performance.
H2d	Competitive strategy will have a direct effect on the purchasing performance.
H2e	Defender organizations, adopting a pure-cost strategy, will tend to keep a higher inventory level than analyzer organizations which adopt pure-differentiation or cost-differentiation strategy.
H3	Operational environment will have direct effect on the MPC system effectiveness.

Table 9.18: List of Hypotheses

Code	Statement of Hypothesis
H3a	Product development is positively associated with the MPC system effectiveness.
H3b	External relationship is positively associated with the MPC system effectiveness.
H3c	Internal relationship is positively associated with the MPC system effectiveness.
H4a	Inventory performance has been continuously improved over time for high performing manufacturing organizations.
H4b	In the context of inventory performance, high performing manufacturing organizations out-perform low performing organizations.
H4c	The inventory performance for the lean supply chain is better than the agile supply chain.
H4d	For organizations adopting extended supply chain, the inventory performance is better than their previous undertaking that operated as either an agile or a lean supply chain.
H4e	For organizations employing (sub)contractors to execute a large proportion of manufacturing orders, the inventory performance would be better than the organizations undertaking most of the manufacturing themselves.
H4f	The inventory level is positively related to the level of environmental munificence, i.e. the inventory investment is high under high environmental munificence, or otherwise.
H4g	In the condition of low environmental munificence, organizations operating as lean supply chain will have better inventory performance than organizations operating as agile supply chain, or otherwise.
H4h	The inventory level is positively related to the level of environmental dynamism, i.e. the inventory investment is high under high environmental dynamism, or otherwise.

Table 9.18: List of Hypotheses (continued)

Code	Statement of Hypothesis
H4i	In condition of high environmental dynamism, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.
H4j	The inventory level is positively related to the level of environmental complexity, i.e. the inventory investment is high under high environmental complexity, or otherwise.
H4k	In the condition of high environmental complexity, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.
H4l	Organizations adopting IT have their improvement rates in inventory performance faster than organizations not adopting IT.
H4m	In condition of high environmental dynamism or high complexity, organizations adopting IT have the faster rates of improvement in inventory performance than organizations not adopting IT.
H5a	The manufacturing and competitive strategies have a moderating effect between organizational environment, operational environment and MPC system.
H5b	The configurations in MPC systems are related to particular organizational and operational environment.

Table 9.18: List of Hypotheses (continued)

9.3.1 Hypotheses for Manufacturing Strategy and MPC System

The hypotheses for manufacturing strategy and MPC system are H1, H1a, H1b, H1c, and H1d. Two types of statistical methods, Pearson correlation and linear regression, were used to determine these hypothesized relationships. The results are presented as follows:

H1: It is observed that: (a) the correlation between decoupling point (end item) and MPC system is 0.222; (b) the correlation between assemble-to-stock (ATS)

strategy and MRP performance is 0.218; (c) the correlation between ATS strategy and inventory performance is –0.215 (see Appendix 6). The regression analysis is carried out, yielding: (a) for decoupling point (end item), an unadjusted R-square of 2.8% with a beta of 0.376 and a constant of 2.462 with t = 1.641; (b) for MRP and ATO, an unadjusted R-square of 4.7% with a beta of 2.232 and a constant of -0.566 with t = 2.116; and (c) for inventory and ATO, an unadjusted R-square of 4.6% with a beta of -2.398 and a constant of 8.731 with t = -2.306 (see Appendix 14). Therefore, H1 is proven.

H1a: The following statistical results are obtained. (a) For defender organizations, make-to-stock (MTS) strategy and MPS have a correlation of -0.702 (see Appendix 7), and regression, yielding an unadjusted R-square of 49.3% with a beta of –2.5 and a constant of 7.5 with t = -2.961. (b) For analyser organizations, decoupling point (sub-assembly) and MPS have a correlation of 0.607 (see Appendix 9), and regression, yielding an unadjusted R-square of 36.8% with a beta of 2.429 and a constant of 0.571 with t = 3.499. (c) For analyser organizations, decoupling point (component) and MPS have a correlation of -0.484 (see Appendix 9), and regression, yielding an unadjusted R-square of 23.4% with a beta of -1.908 and a constant of 7.215 with t = -2.536. (d) For lean organizations, decoupling point (component) and MPS have a correlation of -0.357 (see Appendix 11), and regression yielding an unadjusted R-square of 12.8% with a beta of -1.189 and a constant of 4.65 with t = -2.263. Therefore, H1a is proven for defender, analyser and lean organizations. The regression results can be referred in Appendix 14.

H1b: The correlation and regression results for the hypothesized relationships between manufacturing strategy and CRP performance are mixed. (a) For defender organizations, engineer-to-order (ETO) strategy and CRP have a correlation of -0.475 (Appendix 7), and regression, yielding an unadjusted R-square of 22.5% with a beta of –3.667 and a constant of 10.667 with t = -2.018. (b) For analyser organizations, decoupling point (sub-assembly) and CRP have a

correlation of 0.489 (Appendix 9), and yielding an unadjusted R-square of 23.9% with a beta of 1.671 and a constant of 1.757 with t = 2.171. (c) For analyser organizations, assemble-to-stock (ATS) strategy and CRP have a correlation of 0.507, and regression, yielding an unadjusted R-square of 25.7% with a beta of 3.625 and a constant of -2.625 with t = 2.278. (d) For reactor organizations, decoupling point (end-item) and CRP have a correlation of 0.607, and regression, yielding an unadjusted R-square of 36.9% with a beta of 3.118 and a constant of -2.118 with t = 3.152. Therefore, H1b is proven for defender, analyser and reactor organizations. The regression results can be referred in Appendix 14.

H1c: With regards to MRP performance, the correlation results of decoupling point (sub-assembly) and ATS strategies are 0.18 and 0.218 respectively for all responding organizations (Appendix 6). The regression analysis yields the following results respectively (Appendix 14): (a) for decoupling point (sub-assembly) strategy, an unadjusted R-square of 3.2% with a beta of 0.735 and a constant of 2.515 with t = 1.725; (b) for ATS strategy, an unadjusted R-square of 4.7% with a beta of 2.232 and a constant of -0.566 with t = 2.116. Therefore, H1c is proven.

H1d: For all the seven groupings of organizations, the correlation results of manufacturing strategies and purchasing performance are not significant. Therefore, H1d is not proven.

9.3.2 Hypotheses for Competitive Strategy and MPC System

The hypotheses for competitive strategy and MPC system are H2, H2a, H2b, H2c, and H2d. Pearson correlation and regression were used to determine these relationships. The results are given as follows:

H2: With respect to MPC system performance, a correlation of 0.372 (Appendix 6) is observed for the competitive strategy based on all responding organizations.

Besides, it is also observed that the correlations of analyser, agile and leagile organizations between competitive strategy and MPC system performance are significant at 0.480 (see Appendix 9), 0.589 (see Appendix 12), and 0.480 (see Appendix 13) respectively. The regression analysis yields the following results (see Appendix 14):

(a) For all the responding organizations, an unadjusted R-square is 13.8% with a beta of 0.499 and a constant of 1.701 with t = 4.275.

(b) For analyzer organizations, an unadjusted R-square is 23% with a beta of 0.773 and a constant of 1.031 with t = 2.734.

(c) For agile organizations, an unadjusted R-square is 34.7% with a beta of 0.736 and a constant of 1.054 with t = 3.791.

(d) For leagile organizations, an unadjusted R-square is 23.1% with a beta of 0.704 and a constant of 1.162 with t = 2.739.

The above results illustrate that a moderate positive relationship between competitive strategy and MPC system is observed for all responding, analyser, agile and leagile organizations. Therefore, H2 is proven.

H2a: The correlation between competitive strategy and MPS performance is not significant for the seven groupings of organizations. Therefore, H2a is not proven.

H2b: For all the seven groupings of organizations, the correlation between competitive strategy and CRP performance is not significant. It appears that H2b is not proven.

H2c: There are no significant correlation results between competitive strategy and MRP performance for all the seven groupings of organizations. Hence, H2c is also not proven.

H2d: The correlation analysis of competitive strategy and purchasing is performed. Again, the test result demonstrates a non-significant relationship. Therefore, H2d is not proven.

H2e: The regression results (see appendix 14) are obtained for both defender and analyser organizations with regards to MPC system performance and inventory level. It is observed that the levels of significance are greater than 0.05. As such, null hypothesis is not rejected, i.e. the correlations between MPC system performance and inventory level for defender and analyser organizations are not significant. Therefore, there is no evidence that the defender organizations will tend to keep a higher inventory level than the analyzer organizations. H2e is not proven.

The above findings proved that competitive strategy has a direct effect on MPC system (hypothesis 2), but it has no correlation with the individual MPC module (hypotheses 2a to 2d). The test of indirect effect of competitive strategy on MPC system and its modules will be discussed in Section 9.3.5.

9.3.3 Hypotheses for Operational Environment and MPC System

Similar to Sections 9.3.1 and 9.3.2, the hypotheses for operational environment and MPC system are H3, H3a, H3b, and H3c are tested by Pearson correlation and linear regression. The following results are obtained:

H3: The operational environment and MPC system performance have a correlation of 0.427 for reactor organizations (see Appendix 10), whilst the correlations for other types of groupings are not significant. The regression analysis yields an unadjusted R-square of 18.2% with a beta of 0.277 and a constant of 2.431 with t = 2.264 (see Appendix 14). Therefore, H3 is proven for reactor organizations.

H3a: The correlation results for product development strategy and MPC performance are significant at 0.25, 0.353, 0.595, and 0.620 for all responding, prospector,

agile and leagile organizations respectively (see Appendices 6, 8, 12, 13). The regression results (see Appendix 14) are:

(a) For all responding organizations, an unadjusted R-square is 6.3% with a beta of 0.181 and a constant of 2.575 with t = 2.759.

(b) For prospector organizations, an unadjusted R-square is 12.4% with a beta of 0.434 and a constant of 2.076 with t = 2.382.

(c) For agile organizations, an unadjusted R-square is 35.3% with a beta of 0.51 and a constant of 1.735 with t = 3.842.

(d) For leagile organizations, an unadjusted R-square is 38.5% with a beta of 0. 414 and a constant of 1.521 with t = 3.952.

Hence, H3a is proven.

H3b: The correlations between external relationship and MPC performance are significant at 0.36, 0.595, 0.438, 0.329, 0.383, and 0.432 for all responding, defender, reactor, lean, agile, and leagile organizations respectively (see Appendices 6, 7, 10-13). The regression analysis yields the following results (see Appendix 14):

(a) For all responding organizations, an unadjusted R-square is 13.1% with a beta of 0.317 and a constant of 1.958 with t = 4.029.

(b) For defender organizations, an unadjusted R-square is 35.4% with a beta of 0.480and a constant of 1.633 with t = 3.307.

(c) For reactor organizations, an unadjusted R-square is 19.2% with a beta of 0.377 and a constant of 2.252 with t = 2.337.

(d) For lean organizations, an unadjusted R-square is 10.8% with a beta of 0.29 and a constant of 2.178 with t = 2.607.

(e) For agile organizations, an unadjusted R-square is 14.7% with a beta of 0.364 and a constant of 1.626 with t = 2.114.

(f) For leagile organizations, an unadjusted R-square is 18.6% with a beta of 0. 343 and a constant of 1.762 with t = 2.244.

It shows that for all types of supply chain and for defender and reactor organizations, the external relationship and MPC system are moderately related. Therefore, H3b is proven.

H3c: The correlations between internal relationship and MPC performance are significant at 0.348, 0.697, 0.332, and 0.492 for all responding, reactor, lean and agile organizations respectively (see Appendices 6, 10-12). The regression results are presented as follows:

(a) For all responding organizations, an unadjusted R-square is 12.1% with a beta of 0.292 and a constant of 1.95 with t = 3.932.

(b) For reactor organizations, an unadjusted R-square is 48.6% with a beta of 0.651 and a constant of 0.985 with t = 4.661.

(c) For lean organizations, an unadjusted R-square is 11% with a beta of 0.286 and a constant of 2.136 with t = 2.684.

(d) For agile organizations, an unadjusted R-square is 24.2% with a beta of 0.411 and a constant of 1.371 with t = 2.938.

Therefore, H3c is proven.

9.3.4 Hypotheses for Supply Chain Strategy, Organizational Environment and Performance

Archival approach, based on the industrial and trade statistics, is used to test the hypothesized relationships (H4 to H4m). Owing to the fact that the existing published data available for the study is limited, only thirteen major Hong Kong manufacturing industries could be identified to test the hypotheses.

H4a and H4b: Table 9.19 summarizes the slope of regression in inventory turnover ratio for the period between 1993 and 1998. The results by industries are mixed. Ten out of the thirteen industries have a positive slope of regression, i.e. a trend of improvement in inventory performance. However, three sample industries

have shown the negative result. There is no strong evidence that the inventory performance for all of the sample industries improved continuously.

The sample organizations for each industry were segregated into two groups for study, i.e. high performers and low performers. The slope of regression in inventory turnover ratio for each group was studied (see Table 9.19).

Sample Industry	Slope of Regression of Inventory Turn		
	All Sample Organizations	High Performers	Low Performers
Food	0.6441	1.6270	0.4174
Beverages*	0.1117	-	0.1117
Wearing apparel	0.5417	1.7272	0.1176
Leather and Leather products*	-1.1503	-	-1.1503
Printing & publishing	-01853	2.1219	-2.1391
Plastic products	8.0446	0.8880	17.812
Fabricated metal products	3.4996	3.0457	0.3250
Radio, TV & communication equipment	0.5052	1.3726	0.5379
Electrical & electronic products	0.2196	0.7884	0.3756
Electronic parts & components	0.3002	0.6573	0.2329
Electrical appliances & houseware	-0.2492	0.3895	-0.2428
Machinery, equipment & apparatus	0.3951	0.9046	0.1489
Containers, paper boxes & paperboard	0.6371	2.0790	-0.0403
Note: * No high performing sample organization is available for study.			

Table 9.19: Comparison of Slope of Regression (Inventory Turnover Ratio) for 13 Hong Kong Manufacturing Industries.

There are two observations noted. First, with the exception of beverage industry and leather & leather products industry that have no high performing organizations available for analysis, high performer groups have a positive slope of regression. It indicates that high performing organizations have improved their inventory performance over the period. Thus, H4a is proven. Second, with respect to inventory performance, high performing organizations in ten out of

eleven sample industries out-performed low performers. Only plastic products industry showed a different result. Given the fact that the sample size for plastic products industry available for the study is small and most of the other sample industries have shown a positive result, H4b is therefore mostly proven.

From H4a, we can derive that an organization with a better financial performance in general has achieved a lower inventory level. However, the converse may not be true. For instance, one of the sample organizations in plastic products industry had achieved an outstanding inventory performance but it had a poor financial performance. In this respect, it appears that high financial performance is a sufficient condition for high inventory performance, but high inventory performance is only a necessary condition for high financial performance.

H4c: Based on HKTDC's report[325], the industries were segregated into either an agile chain or a lean chain focus. Table 9.20 presents the slope of regression and the supply chain focus for the sample industries. Eight out of thirteen sample industries having a clear-cut focus were identified to test H4c. With the exception of leather & leather products industry, sample industries with lean supply chain focus, i.e. food, fabricated metal products, machinery, equipment & apparatus, containers, paper boxes & paperboard industries, have demonstrated a greater improvement rate of inventory performance than those industries functioning as an agile chain. This partially supports H4c.

H4d: Eleven organizations from wearing apparel, electrical & electronic products industry and radio, television & communication equipment industry, were identified for the analysis of H4d. These sample organizations have announced in recent years that they have strategically extended their primary operations in a supply chain by forming close partnerships with other organizations in various forms ranging from upstream supplies to downstream logistic activities. The improvement rates in inventory turnover ratio were computed

for two different periods: 1997-1998, and 1993-1996 (see Table 9.21). The results were mixed. Five organizations out of eleven have shown a better improvement rates for the period of 1993-1996 than that for the more recent period of 1997-1998. Therefore, there is no evidence that these sample organizations, fractionally operating as an extended supply chain, have improved their inventory performance. Perhaps the benefits of extending a supply chain are of long term. It might not be reflected by a short-term inventory performance measurement. Hence, H4d is unproven at this stage.

Sample Industry	Slope of regression of inventory turn	Lean Supply Chain Focus	Agile Supply Chain Focus
Food	0.6441	✓	
Beverages	0.1117	✓ (partially)	✓ (partially)
Wearing apparel	0.5417	✓ (partially)	✓ (partially)
Leather and Leather products	-1.1503	✓	
Printing & publishing	-01853		✓
Plastic products	8.0446	✓ (partially)	✓ (partially)
Fabricated metal products	3.4996	✓	
Radio, TV & communication equipment	0.5052	✓ (partially)	✓ (partially)
Electrical & electronic products	0.2196		✓
Electronic parts & components	0.3002		✓
Electrical appliances & houseware	-0.2492		✓
Machinery, apparatus & equipment	0.3951	✓	
Containers, paper boxes & paperboard	0.6371	✓	

Table 9.20: The Slope of Regression (Inventory Turnover Ratio) for 13 Hong Kong Manufacturing Industries, Segregated by Lean and Agile Supply Chain Focuses

Sample Organization	Sample Industry	Improvement in Inventory Turnover Ratio	
		2 Years (1997-1998)	4 Years (1993-1996)
USI Holdings Ltd.	Wearing apparel	+7.3%	-9.3%
Orient Resources Group		+26%	+42.7%
Tungtex (Holdings) Co.		+35.1%	+5.6%
IDT International Ltd	Electrical & electronic	+31.8%	+4.1%
Ecopro Hi-tech Holdings		+28.2%	-25.4%
Same Time Holdings		+5.3%	+19.9%
IQuorum Cybernet Ltd.		-2.5%	+22.4%
Shougang Concord Tech.		-5.3%	+1.6%
Tomorrow International		-11.8%	+13.1%
Sino InfoTech Holdings	Radio, TV & communication equipment	+6.8%	+2.2%
Founder Holdings Ltd.		+63.7%	+2.5%

Table 9.21: Improvement Rates in Inventory Turnover for 11 Hong Kong Manufacturing Organizations Applying Extended Supply Chain Partially.

H4e: Two representative cases were used to test H4e that related to manufacturing subcontracting. Table 9.22 shows the slope of regression in inventory turnover ratio for five selected sample organizations. In the first case, Playmates Interactive Entertainment has almost all of its manufacturing orders assigned to its (sub)contractors, while engaging mainly in strategy making, product design and development, quality assurance, manufacturing planning and control, sales and marketing, accounting and financial activities. The responsibilities of holding inventories are therefore shifted to its (sub)contractors. The slope of regression for Playmates Interactive Entertainment during the period 1993-1998 is 52.0424, about 50 times larger than the average performance of three other plastic products organizations, i.e. Perfectech, South China Industries and ICG AsiaWorks, which undertook most of the manufacturing activities. The second case is Grande Holdings Ltd. The organization is engaged in the development and design of consumer electronic and electrical products while manufacturing is delegated to its partnering organizations in the supply chain. The slope of regression is

9.4929, 43 times higher than the average result in the electrical and electronic product industry. Thus, H4e is proven.

Sample Organization	Slope of Regression of Inventory Turn	
	Individual Organization	All Sampling Organizations
Plastic products industry:		
Perfectech International	0.8882	1.0341*
South China Industries Ltd.	1.1445	
ICG AsiaWorks Ltd.	0.2466	
Playmates Interactive	52.0424	
Electrical & electronic products industry:		
Grande Holdings Ltd.	9.4929	0.2196
Note: * Figures excluding Playmates Interactive.		

Table 9.22: The Slope of Regression (Inventory Turnover Ratio) for Sample Organizations in Plastic Products and Electrical & Electronic Products Industries

H4f: Four sample industries were identified to test H4f. Machinery, equipment & apparatus industry, and containers, paper boxes & paperboard industry are considered as lean supply chain; while the electrical & electronic products industry and electronic parts & components industry are identified as agile supply chain focus (see Table 9.20). Sample organizations in these industries are segregated into two groups, say, "high growth" organizations and "low growth" organizations, for analysis. As discussed in Section 4.4.2 of Chapter 4, "high growth" organizations operate under high munificence, or otherwise. Table 9.23 summarizes the slope of regression for the four selected sample industries. In electronic parts & components industry (agile chain strategy), "low growth" organizations (low munificence) have a smaller inventory investment (smaller slope of regression) than the "high growth" organizations (high munificence). In electrical & electronic products industry, "low growth" organizations and "high growth" organizations have a similar inventory investment position. This result does not support Hypothesis 4f. Similarly, the result for the two sample industries with lean supply chain focus does not support the hypothesis either. For machinery, equipment & apparatus industry,

"low growth" organizations have a smaller inventory investment than "high growth" organizations. While for containers, paper boxes and paperboard industry, "low growth" organizations have a larger inventory investment than "high growth" organizations. Hence, there is no evidence that high inventory investment relates to high environmental munificence. In this regard, H4f is not proven.

Sample Industry	Supply Chain Strategy	Slope of Regression in Inventory Turn		
		All Sample Firms	High Growth Organizations	Low Growth Organizations
Electrical & electronic products	Agile	0.2196	0.2598	0.2542
Electronic parts & components	Agile	0.3002	0.1311	0.3950
Machinery, equipment & apparatus	Lean	0.3951	0.5183	-0.0102
Containers, paper boxes & paperboard	Lean	0.6371	-0.7711	1.3405

Table 9.23: The Slope of Regression (Inventory Turnover Ratio) for High Growth Organizations and Low Growth Organizations of 4 Sample Industries

H4g: With regards to the hypothesis, five sample industries, subject to low munificence, were selected for analysis. These sample organizations are classified into "agile" and "lean" groupings, based on the products the sample organizations manufactured. For example, if an organization is engaged in the manufacture of fashionable products, it will be placed in "agile chain" group. If an organization is engaged in the manufacture of traditional and standardized products, it will be categorized as "lean chain" group. Most of the organizations in these five sample industries are classified as lean supply chain, while a few of them is operated as agile supply chain. No agile organization is found in the machinery, equipment & apparatus industry and fabricated metal products industry. Table 9.24 presents the slope of regression for these five selected industries. The result is mixed. For containers, paper boxes & paperboard industry, the inventory performance of lean organizations

is marginally better than agile organizations. For leather & leather products industry, the inventory performance of lean organizations is better than agile organizations. However, for plastic products industry, the inventory performance of lean organizations is worse than agile organizations. Hence, H4g is refuted.

Sample Industry	Slope of Regression in Inventory Turn		
	All Sample Organizations	Agile Organizations	Lean Organizations
Machinery, equipment & apparatus (Low Munificence)	0.3951	-	0.3951
Containers, paper boxes & paperboard (Low Munificence)	0.6371	0.6239	0.6239
Plastics products (Low Munificence)	8.0446	17.812	0.8880
Fabricated metal products (Low Munificence)	-0.7705	-	-0.7705
Leather & leather products (Low Munificence)	-1.1503	-2.3023	-0.1558

Table 9.24: The Slope of Regression (Inventory Turnover Ratio) for High Growth Organizations and Low Growth Organizations of 5 Sample Industries

H4h: Two sample industries were chosen to verify the hypothesis. The selection criteria are based on the following: (a) the sample industries for comparison must be similar in nature; (b) the industries must be subject to similar munificence and complexity, but under different conditions of dynamism. Radio, television & communication equipment industry and electrical & electronic products industry satisfy the above criteria. Both industries relate to electronics discipline and operate under medium level of munificence and complexity according to the archival and perceptual methods. However, the electrical & electronic products industry is subject to a higher environmental dynamism than the radio, television, & communication equipment industry (see Table 9.3). With reference to Table 9.19, the slope of regression for radio, television & communication equipment industry is larger than electrical &

electronic products industry, i.e. the inventory investment is high (smaller slope of regression) under condition of high environmental dynamism. Therefore, H4h is proven.

H4i: With respect to H4i, containers, paper boxes & paperboard industry and plastic products industry were elected for evaluation. Both industries cope with similar environment, i.e. high dynamism and low munificence. Plastic products industry is identified as agile focus, while containers, paper boxes & paperboard industry is considered as lean focus. It is observed that the slope of regression for plastic products industry is slightly larger than the containers, paper boxes & paperboard industry (see Table 9.20). Since the difference in performance for the two selected industries is not significant to draw any conclusion and no other cross-industry data is available for further evaluation, H4i at the present stage has not yet proven.

H4j: Electrical & electronic products industry and electronic parts & components industry were selected to test H4j since these two industries have coped with comparatively higher complexity situations (see Tables 9.1 and 9.3). All forty-one organizations of these two sample industries were then classified into agile and lean groupings, based on the products the sample organizations manufactured. For instance, if an organization is engaged in the manufacture of traditional electronic products such as calculators, clocks, weighing scales, resistors, electronic power converters etc., it will be arranged in lean group. If an organization is engaged in the production of video games, electronic toys, micro chips, liquid crystal displays etc. that subject to higher rate of changes, it will be put in agile group. The result, as shown in Table 9.25, has demonstrated that agile organizations have a far better inventory performance than lean organizations. Hence, H4j is proven.

Sample Industry	Slope of Regression of Inventory Turn		
	All Sample Organizations	Agile Organizations	Lean Organizations
Electrical & electronic products	0.2196	0.5461	-0.0474
Electronic parts & components	0.3002	0.5162	-0.3170

Table 9.25: The Slope of Regression (Inventory Turnover Ratio) for Agile Organizations and Lean Organizations for 2 Sample Industries

H4k: Similar to H4i, there exists a technical problem that no cross-industry data is suitable for the evaluation of Hypothesis 4k. An interesting point to note is that the electronic parts & components industry, electrical & electronic products industry and electrical appliances & houseware industry, which are considered as agile supply chains under high environmental dynamism, have a positive slope of regression (see Table 9.20). They perform quite well in the context of inventory performance, while the printing & publishing industry, operating as agile supply chain subject to medium environmental complexity and dynamism, has a negative slope of regression, i.e. poor inventory performance. This is the prima facie evidence that, under the condition of high environmental complexity, organizations operating as agile supply chain will have better inventory performance than operating as lean supply chain. However, at the present stage, H4k has not yet proven, nor there exists any evidence to reject it.

H4l: Table 9.26 presents the extent of IT adoption for seven major industries as derived from the questionnaire survey (see Question 47 of Appendix 1). The electronics parts & components industry, and radio, television & communication equipment industry have a relatively higher IT adoption rate than electrical & electronic products industry. By comparing the slope of regression for these three sample industries, the hypothesis can be tested. From Table 9.19, the former two industries have a better inventory

performance than the latter industry. This tentatively supports H4l. However, the inventory performance of electronic parts & components industry is worse than the plastic products industry although its IT adoption rate is higher. Based on the consideration that the sample size of plastics products industry available for the study is small, it is not significant enough to reject the hypothesis. In this respect, H4l is therefore partially proven.

Sample Industry	Survey Organizations		
	Adopted IT Fully/mostly (%)	Adopted IT partially (%)	No IT Adoption (%)
Plastic products	38.1	47.6	3
Fabricated metal products	53.3	33.3	13.3
Radio, TV & communication equipment	70	20	10
Electrical & electronic products	53.8	23.1	23.1
Electronic parts & components	84.8	15.2	0
Electrical appliances & houseware	40	50	10
Machinery, equipment & apparatus	69.2	15.4	15.4

Table 9.26: A Summary of IT Adoption Rates for 7 Major Manufacturing Industries

H4m: Four sample industries were selected to test H4m, namely, electronic parts & components industry, electrical appliances & houseware industry, plastic products industry, and containers & boxes of paper industry. These industries have coped with higher dynamism or higher complexity (see Table 9.1). The electronic parts & components industry is regarded as "high IT adoption" grouping, while the other three industries are categorized as "low IT adoption" grouping. The slope of regression for these two different groupings is compared. The result shows that plastic product industry and fabricated metal industry have a far better inventory performance than electronic parts & components industry (see Table 9.19). Therefore, H4m is not proven.

9.3.5 Hypotheses for Configurations in MPC Systems

As previously described in Section 6.4.5 of Chapter 6, two path models (see Figures 6.4 and 6.5) are proposed and they represent the configurations of MPC systems subject to manufacturing strategy, competitive strategy, dynamism, complexity and operational environment. Path analysis, with the generalized least squares (GLS) criterion, was performed to test the models.

The software package, SEPATH of STATISTICA 6.0 for Windows, was utilized in this study to test 16 path models based on all sample population, Miles & Snow's strategic archetypes and supply chain strategies. As suggested by Bollen and Long[336], multiple goodness-of-fit measures should be considered to examine the path models. Thus, four fit indices are used in this study. They are chi-square/degree of freedom $\left(\chi^2 / df\right)$, root mean square residuals (RMRs), root mean squared error of approximation (RMSEA), and goodness-of-fit index (GFI). Authors such as Joreskog & Sorbom[337] and Jaccard,and Wan[338] suggest that the model demonstrates a good fit when χ^2 / df is closed to 1, RMRs is closed to zero, RMSEA is less than 0.05, and GFI is greater than 0.9.

According to Hambrick[339], it is practical to divide sample organizations into high and low performance groupings effective research analysis. A number of researches have applied this methodology. For instance, Lawrence and Lorsch[50] divided their sample into two sub-samples based on organizational performance in their organization-environment study. As such, this thesis segregates the statistical data into high and low MPC performers for the testing of hypotheses 5a and 5b. In this study, high MPC performers are those responding organizations that report in the questionnaire the rating between 1 and 3, whilst low performers report the rating between 4 and 7 (see Question 60(f), Appendix 1).

One of the concerns is the ratio of the number of independent samples to the number of paths being tested. Mitchell[340] suggested an ideal ratio to be between 10 to 20. However, in reality, few organizational studies can achieve such a ratio. Several examples on organization studies[341-344] accomplished the ratios between 3 and 5.7. In this study, the ratios of sample size (all sample population) for path models 1 and 2 are 20 and 4.8 respectively. The ratios for the seven groupings for models 1 and 2 lie between the ranges of 3.6 - 10 and 0.9 - 2.5 respectively. In this respect, no path analysis will be carried out

for those low performing groupings with small sizes. The test results of hypotheses 5a and 5b are described in the following paragraphs.

H5a: The first path model is tested according to the overall sample population and the seven different organization types. The proposed model links dynamism, complexity, operational environment, competitive strategy, manufacturing strategy and MPC system (see Figure 6.4, Chapter 6).

(a) Path model for all responding high performing organizations:

There are 87 responding organizations that could achieve high MPC performance. The χ^2 / df, RMRs, RMSEA and GFI indices of the resultant path model are 3.39, 0.562, 0.124, and 0.774 respectively. Its model is shown in Figure 9.1 illustrated with parameter estimates in each path.

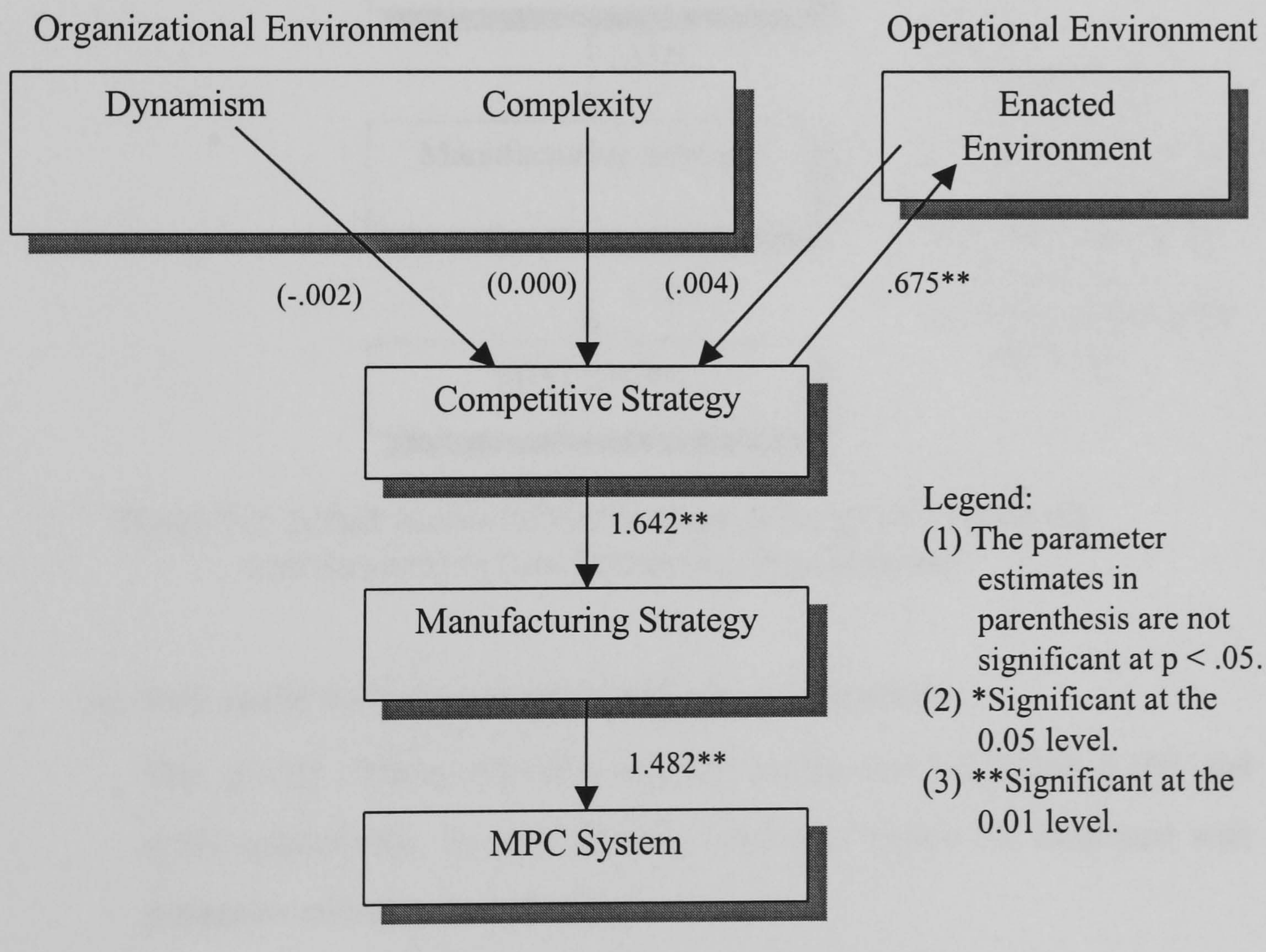


Figure 9.1: A Path Model for Environment-Strategy-MPC Network (All Responding High Performing Organizations)

(b) Path model for all responding low performing organizations:

There are 29 responding organizations that report a low MPC performance. The χ^2/df, RMRs, RMSEA and GFI indices are 0, 0.339, 0, and 0 respectively. Its model is shown in Figure 9.2 illustrated with parameter estimates in each path.

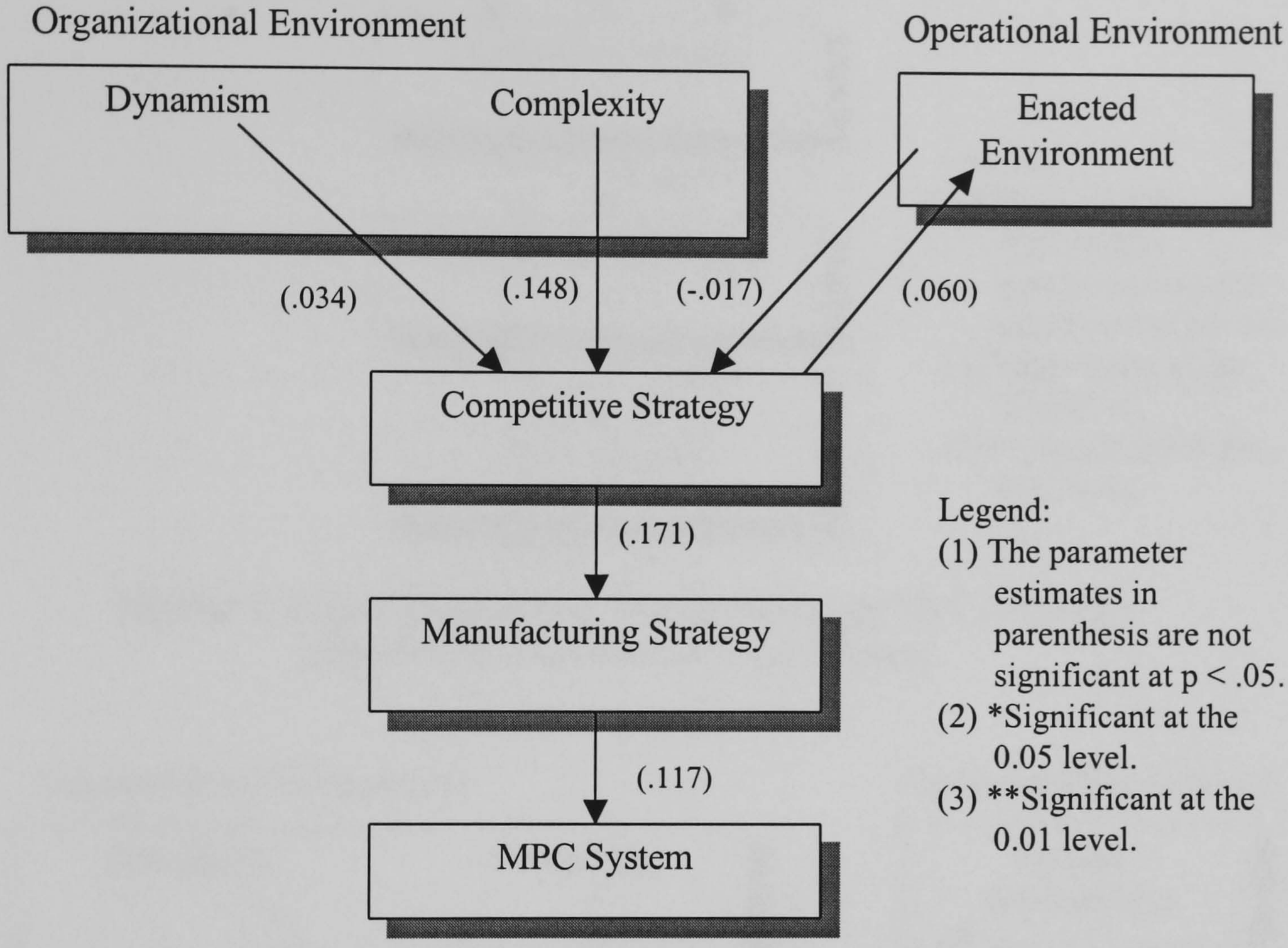


Figure 9.2: A Path Model for Environment-Strategy-MPC Network (All Responding Low Performing Organizations)

(c) Path model for high performing defender organizations:

The χ^2/df, RMRs, RMSEA and GFI indices are 2.6, 0.264, 0.169, and 0.574 respectively. Its path model is shown in Figure 9.3 illustrated with parameter estimates in each path.

(d) Path model for high performing prospector organizations:

The χ^2/df, RMRs, RMSEA and GFI indices are 2.71, 0.655, 0.154, and 0.639 respectively. Its path model is shown in Figure 9.4 illustrated with parameter estimates in each path.

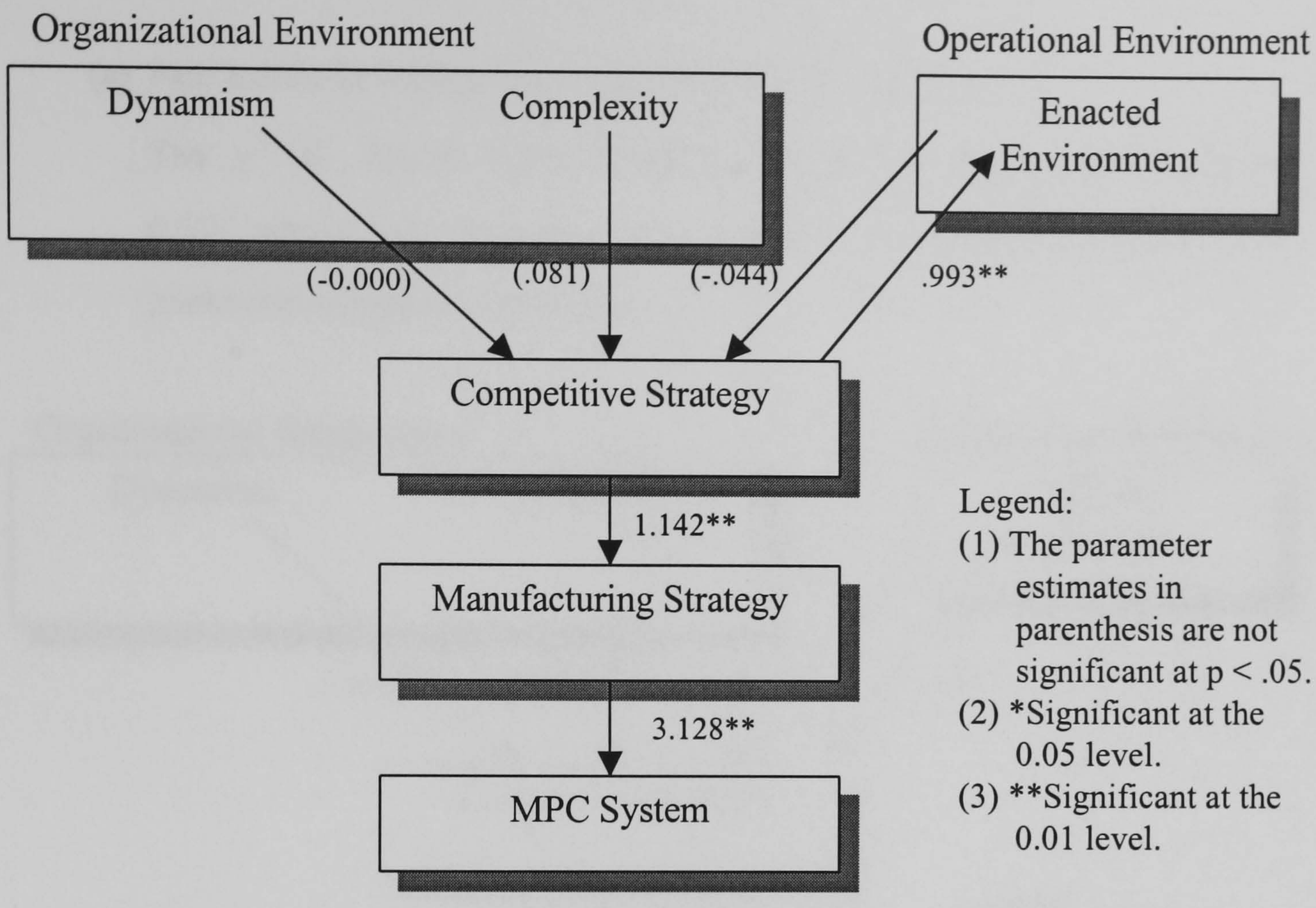


Figure 9.3: A Path Model for Environment-Strategy-MPC Network
(High Performing Defender Organizations)

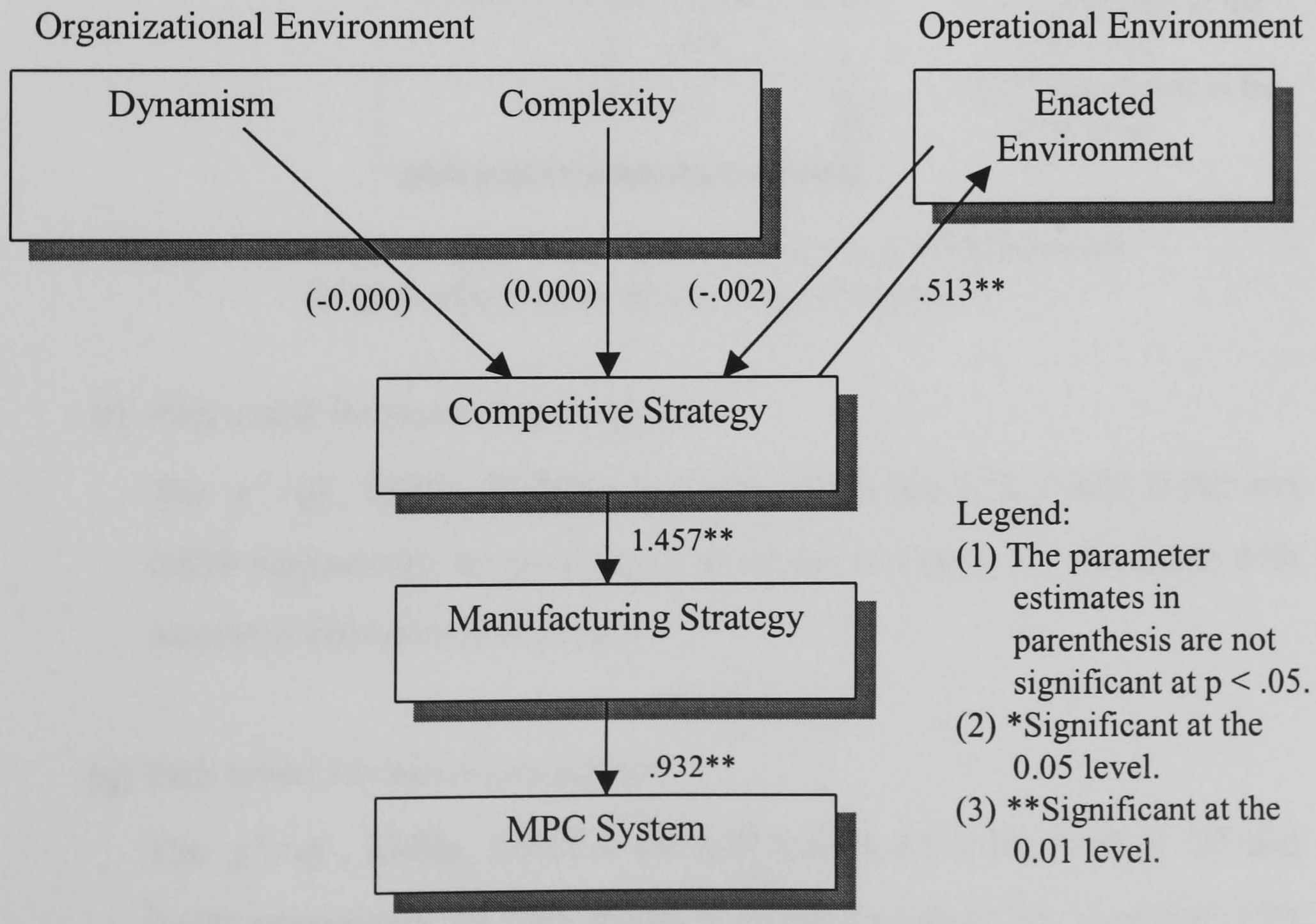


Figure 9.4: A Path Model for Environment-Strategy-MPC Network
(High Performing Prospector Organizations)

(e) Path model for high performing analyzer organizations:

The χ^2/df, RMRs, RMSEA and GFI indices are 2.39, 0.249, 0.162 and 0.575 respectively. Its path model is shown in Figure 9.5 illustrated with parameter estimates in each path.

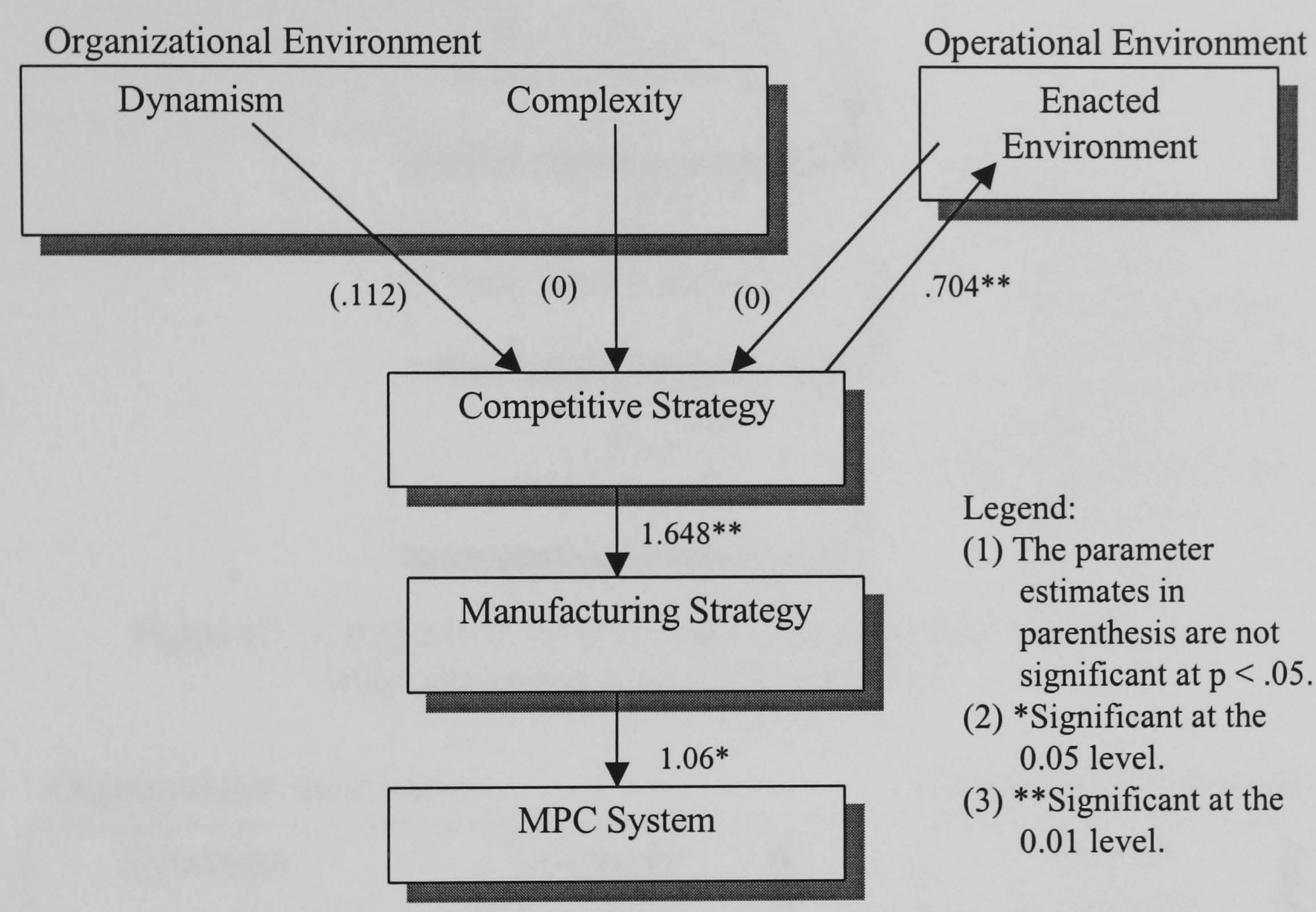


Figure 9.5: A Path Model for Environment-Strategy-MPC Network (High Performing Analyzer Organizations)

(f) Path model for reactor organizations:

The χ^2/df, RMRs, RMSEA and GFI indices are 2.72, 0.859, 0.102 and 0.639 respectively. Its path model is shown in Figure 9.6 illustrated with parameter estimates in each path.

(g) Path model for lean organizations:

The χ^2/df, RMRs, RMSEA and GFI indices are 2.41, 0.195, 0.137 and 0.689 respectively. Its path model is shown in Figure 9.7 illustrated with parameter estimates in each path.

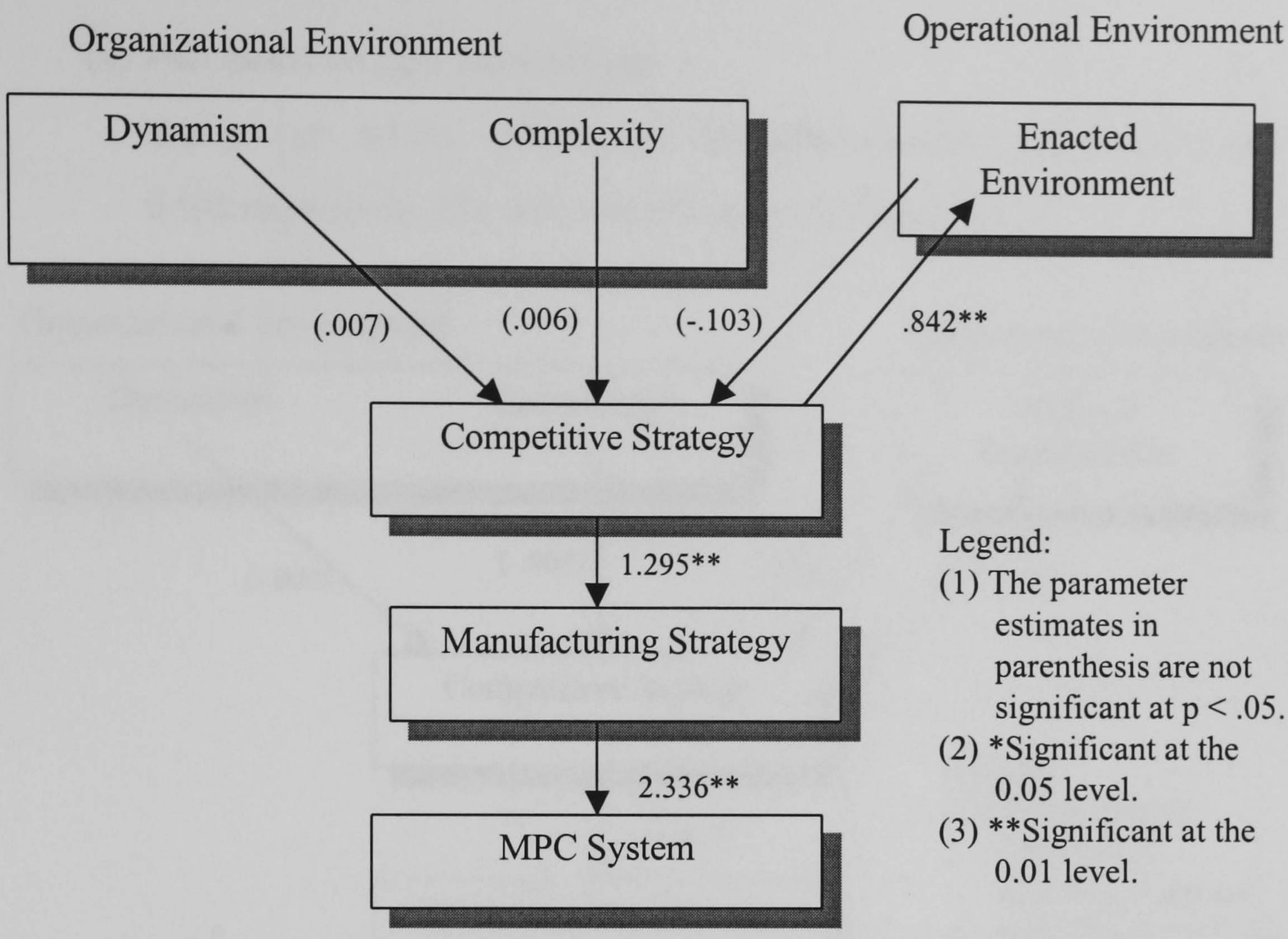


Figure 9.6: A Path Model for Environment-Strategy-MPC Network
(High Performing Reactor Organizations)

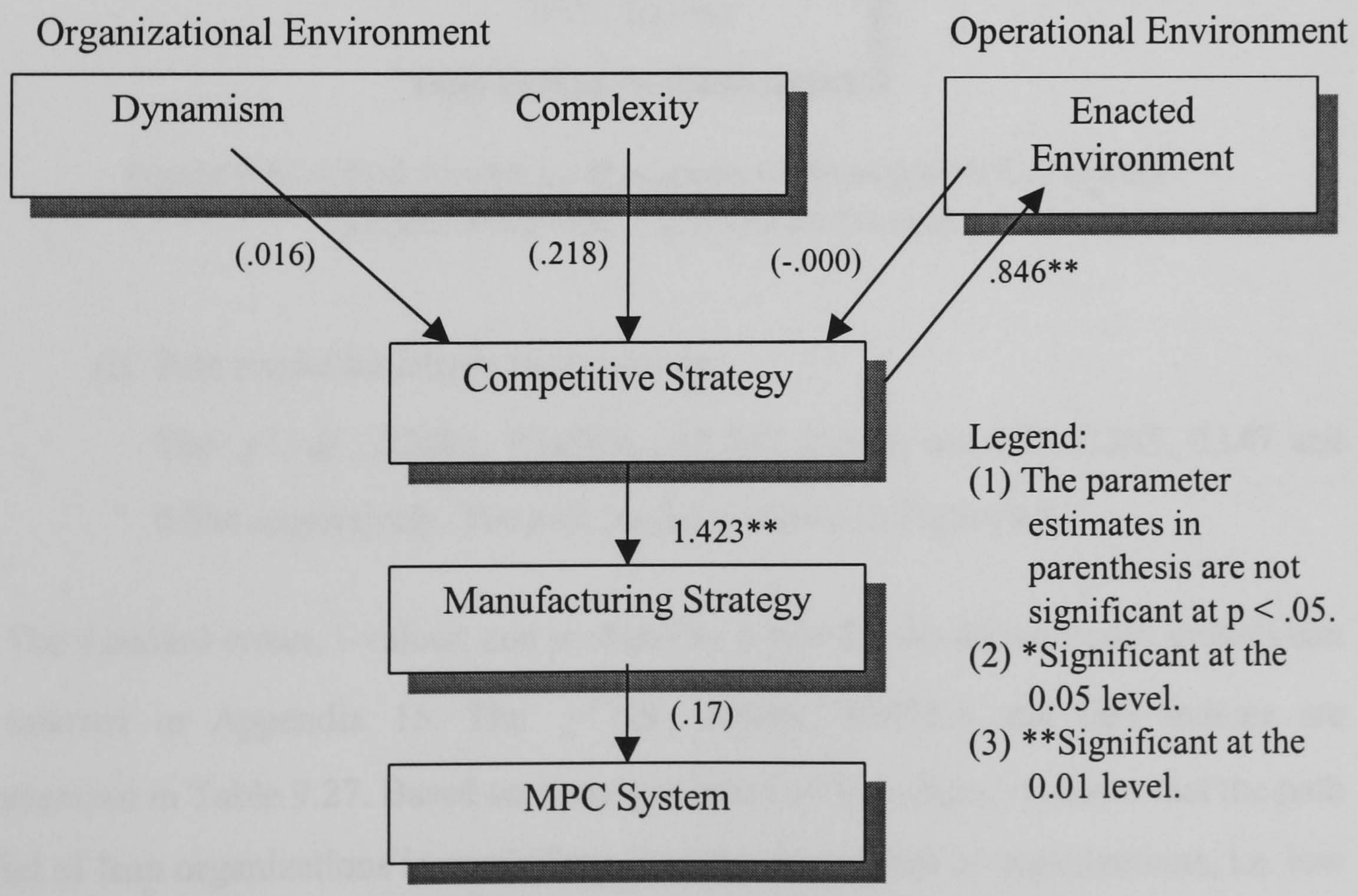


Figure 9.7: A Path Model for Environment-Strategy-MPC Network
(High Performing Lean Organizations)

(h) Path model for agile organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.07, 0.514, 0.135 and 0.592 respectively. The path model is shown in Figure 9.8.

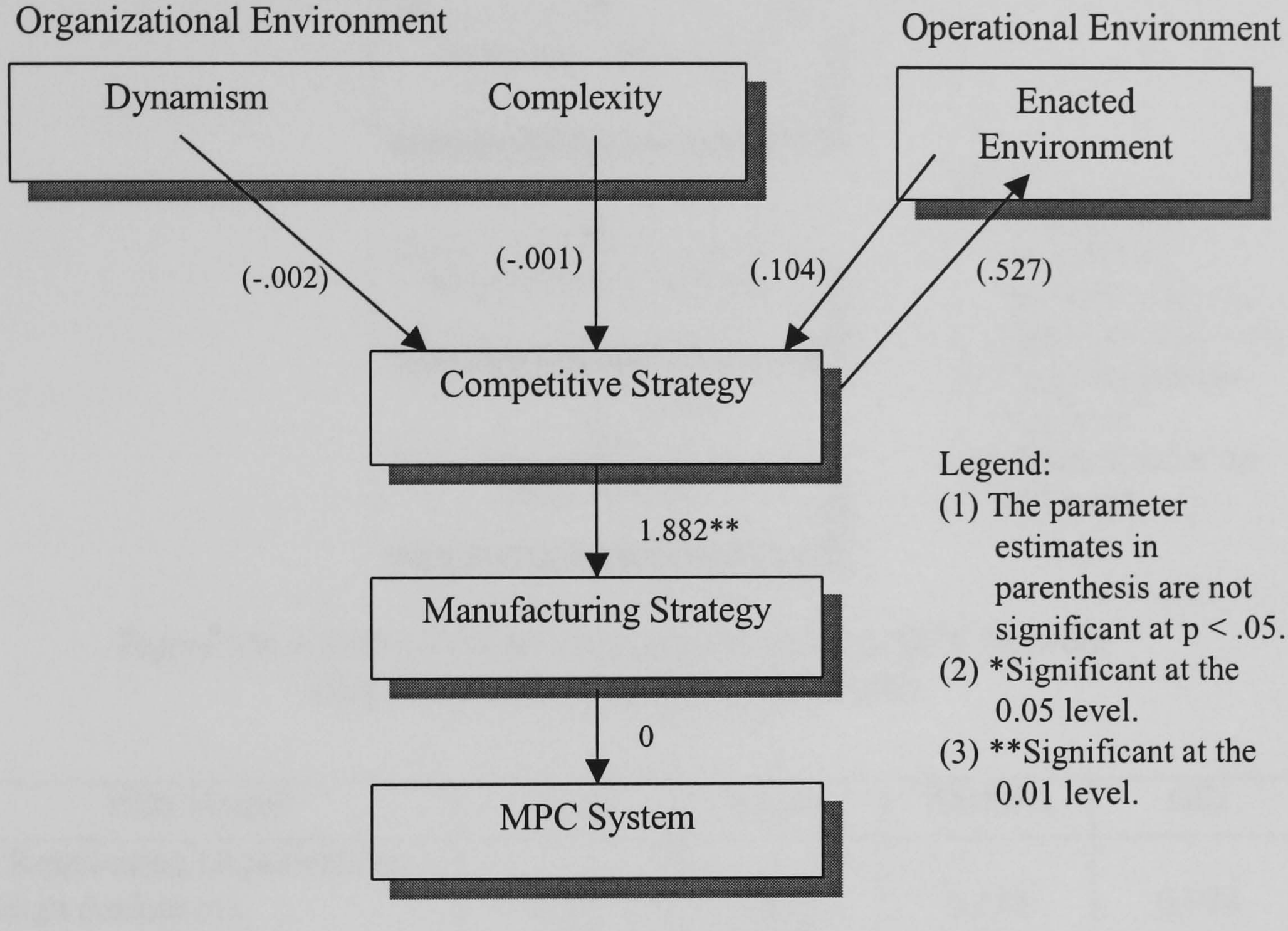


Figure 9.8: A Path Model for Environment-Strategy-MPC Network (High Performing Agile Organizations)

(i) Path model for leagile organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.36, 0.295, 0.147 and 0.554 respectively. The path model is shown in Figure 9.9.

The standard errors, t-values, and probability levels for the above 9 path models can be referred in Appendix 15. The χ^2 / df, RMRs, RMSEA and GFI indices are summarized in Table 9.27. Based on these goodness-of fit indices, it shows that the path model of lean organizations is much fitter than the other types of organizations, i.e. low RMRs and high GFI. The model does not fit the data of low performing organizations.

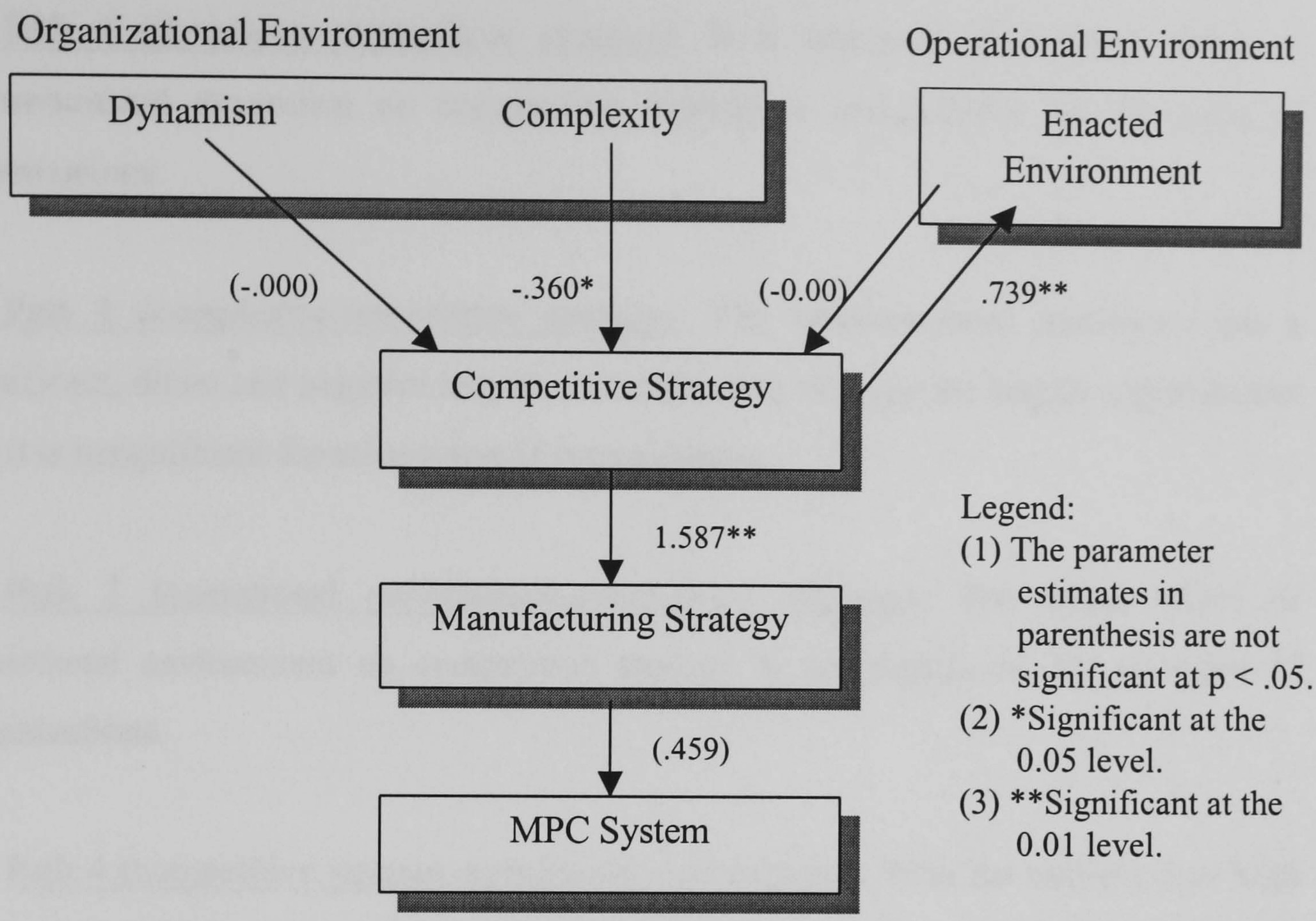


Figure 9.9: A Path Model for Environment-Strategy-MPC Network (High Performing Leagile Organizations)

Path Model	χ^2 / df	RMRs	RMSEA	GFI
All Responding Organizations:				
High performers	3.39	0.562	0.124	0.774
Low performers	0	0.339	0	0
Defenders (High performers)	2.60	0.264	0.169	0.574
Prospectors (High performers)	2.71	0.655	0.154	0.639
Analyzers (High performers)	2.39	0.249	0.162	0.575
Reactors (High performers)	2.72	0.859	0.102	0.639
Lean (High performers)	2.41	0.195	0.137	0.689
Agile (High performers)	2.07	0.514	0.135	0.592
Leagile (High performers)	2.36	0.295	0.147	0.554
[Note: χ^2 / df , chi-square/degree of freedom; RMRs, root mean square residuals; RMSEA, root mean squared error of approximation; GFI, goodness-of-fit index.]				

Table 9.27: A Summary of the Goodness-of-Fit Indices for Environment-Strategy-MPC Network

In each of these path models, there are 6 paths for analysis and they are discussed as follows:

Path 1 (dynamism-competitive strategy): It is observed that direct effect of environmental dynamism on competitive strategy is insignificant for all types of organizations.

Path 2 (complexity-competitive strategy): The environmental dynamism has a significant, direct and negative impact on competitive strategy for leagile organizations but it is insignificant for other types of organizations.

Path 3 (operational environment-competitive strategy): The direct effect of operational environment on competitive strategy is not significant for all types of organizations.

Path 4 (competitive strategy-operational environment): With the exception of high agile performers and low performing organizations, competitive strategy is significantly and positively related to the operational environment.

Path 5 (competitive strategy-manufacturing strategy): For all types of high performing organizations, competitive strategy has a significant, positive and strong impact on manufacturing strategy. Competitive strategy has no effect on manufacturing strategy for low performers.

Path 6 (manufacturing strategy-MPC system): The result demonstrates that manufacturing strategy has a significant and positive effect on MPC system for all high performing organizations classified by Miles & Snow's strategic archetypes. It is interesting to note that the effect of manufacturing strategy on MPC system is insignificant for organizations classified by supply chain strategies.

The above path analysis is consistent with the test result of H1 that manufacturing strategy has a direct effect on MPC system (refer to Section 9.3.1). However, this path model further extends the logic that manufacturing strategy for some types of organizations influence the MPC system. Based on the results from paths 5 and 6, it is also deduced that competitive strategy has an indirect effect on MPC system.

The summary assessment of the paths 1 to 6 is presented in Table 9.31 (pp.258-9).

H5b: The second path model is tested according to the overall sample population and the seven different organization types. The proposed network links dynamism, complexity, operational environment, master production schedule (MTS), capacity requirements planning (CRP), materials requirements planning (MRP), purchasing, inventory, forecasting and MPC system (see Figure 6.5, Chapter 6).

(a) Path model for high performing organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 6.47, 0.53, 0.228, and 0.755 respectively. The path model is shown in Figure 9.10.

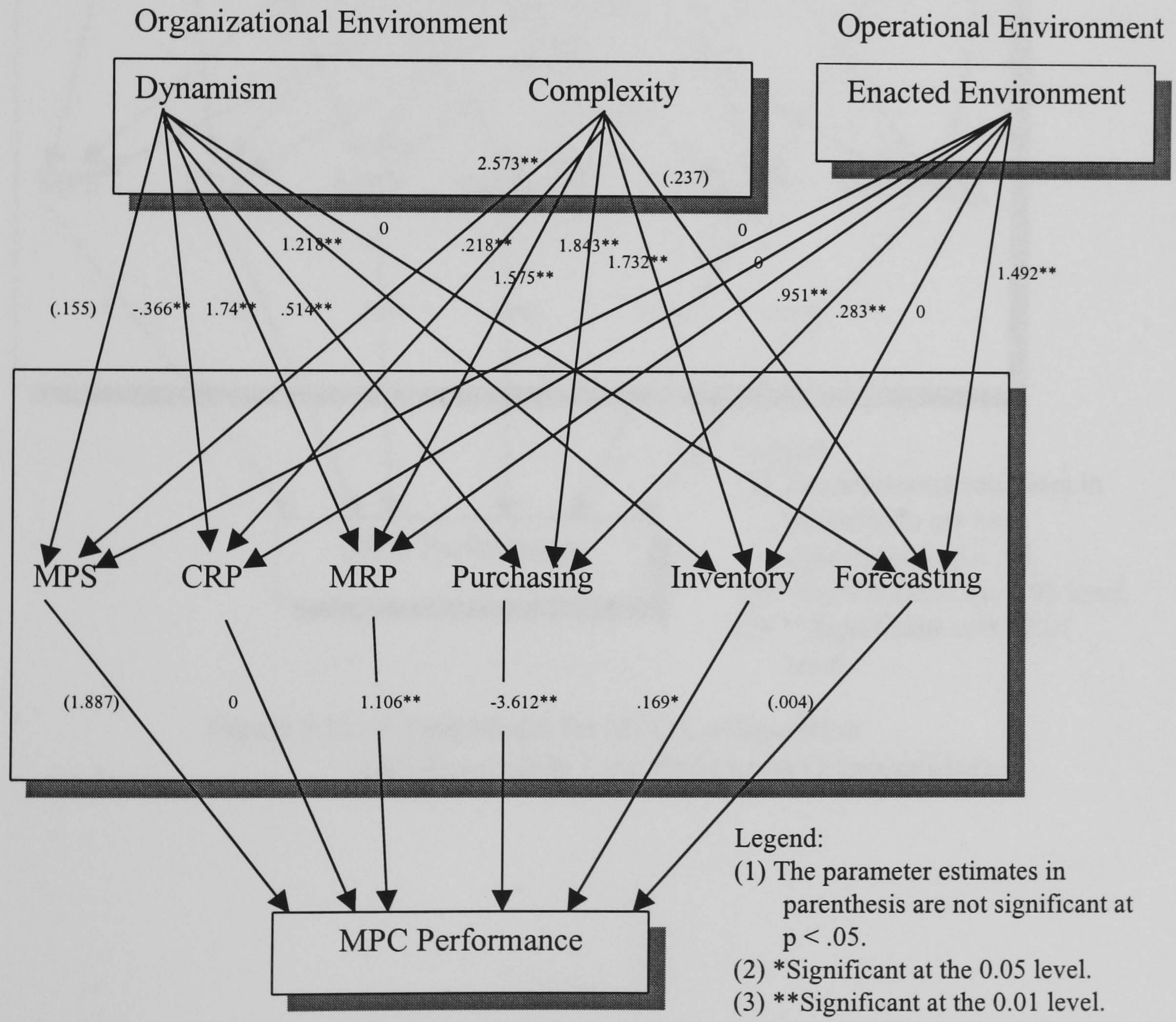


Figure 9.10: A Path Model for MPC Configuration
(All Responding High Performing Organizations)

(b) Path model for low performing organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.46, 0.424, 0.235, and 0.671 respectively. The path model is shown in Figure 9.11.

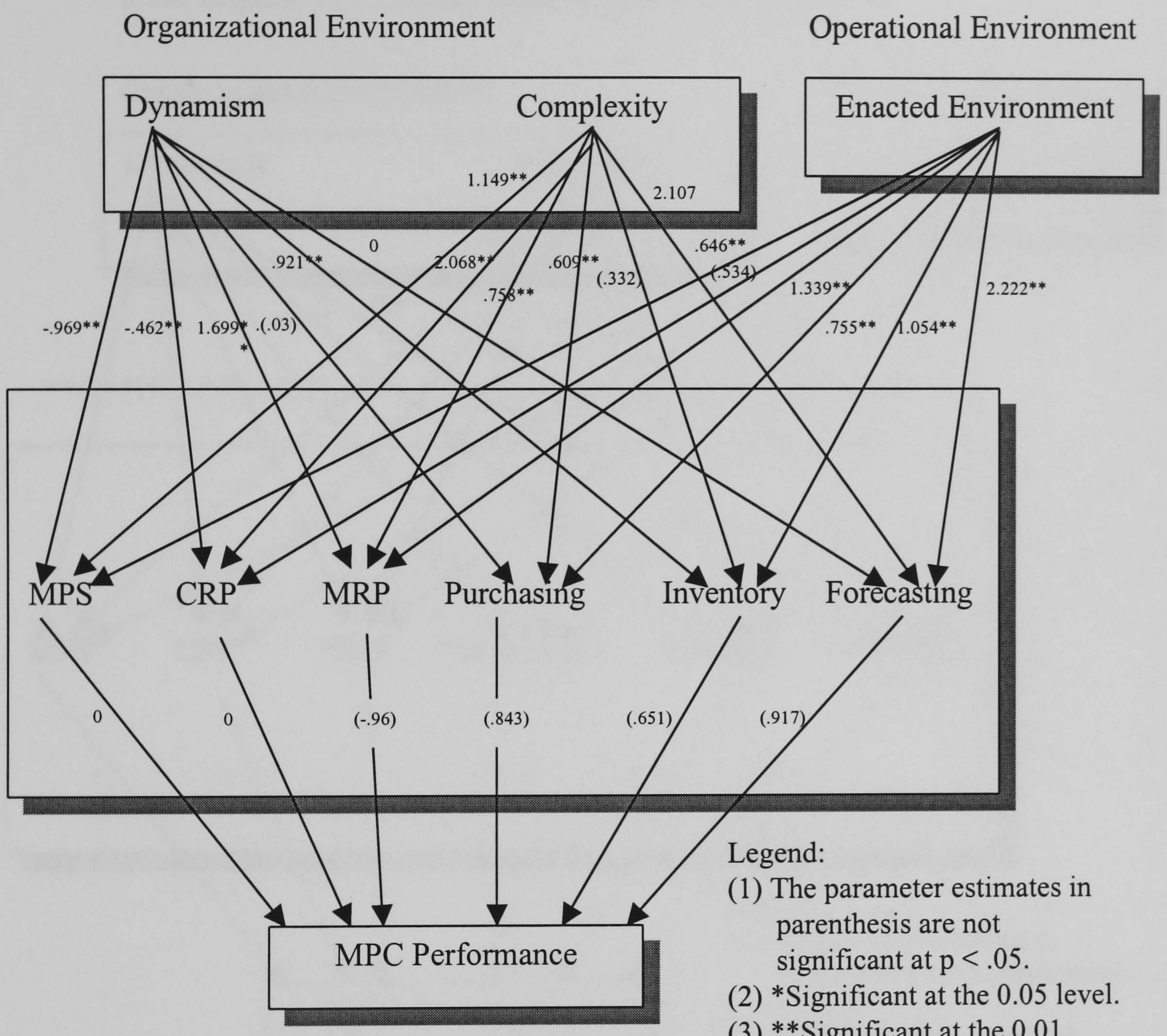


Figure 9.11: A Path Model for MPC Configuration
(All Responding Low Performing Organizations)

(c) Path model for high performing defender organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 3.47, 0.869, 0.254, and 0.553 respectively. The path model is shown in Figure 9.12.

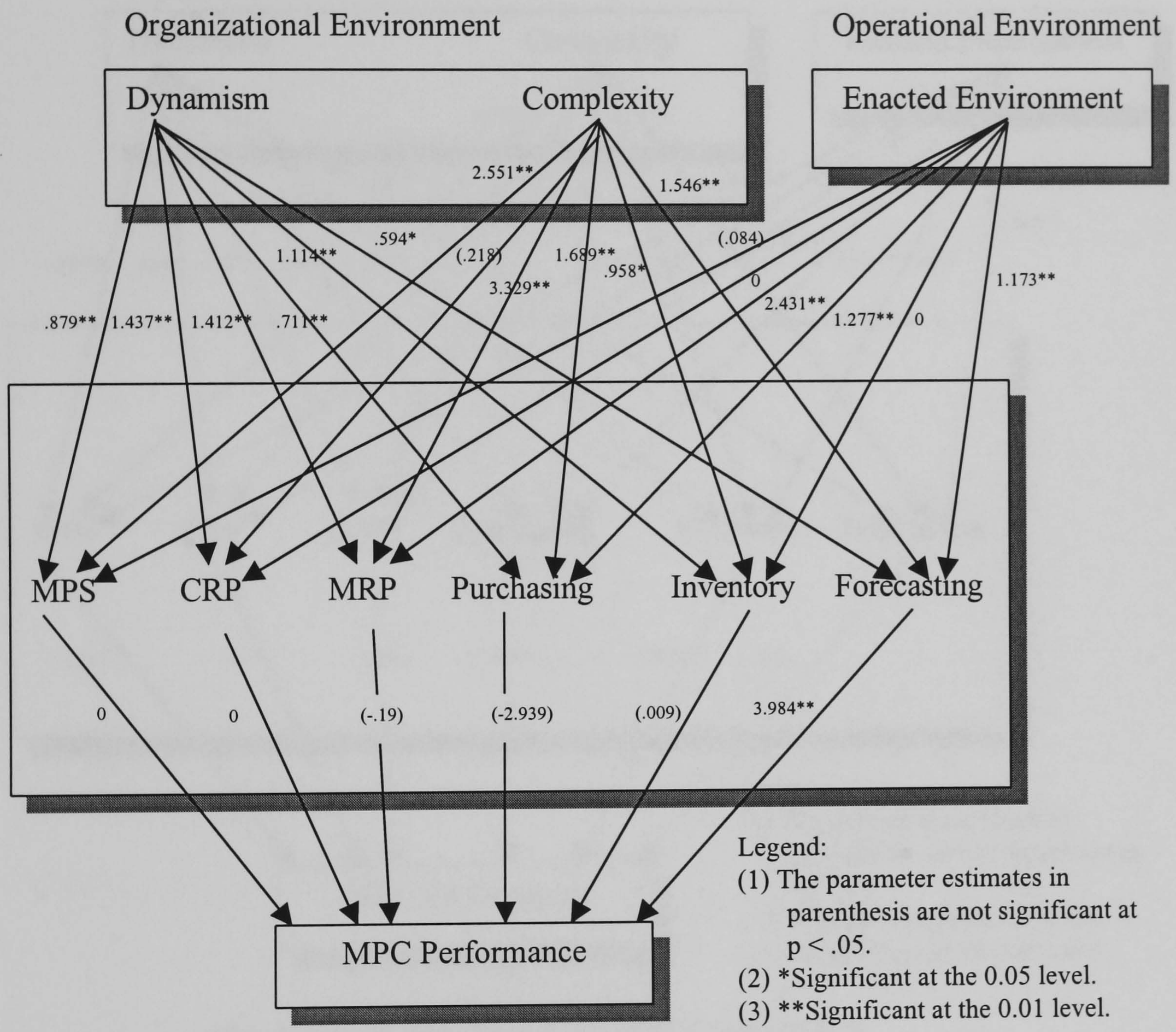


Figure 9.12: A Path Model for MPC Configuration
(High Performing Defender Organizations)

(d) Path model for high performing prospector organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 3.37, 0.485, 0.206, and 0.723 respectively. The path model is shown in Figure 9.13.

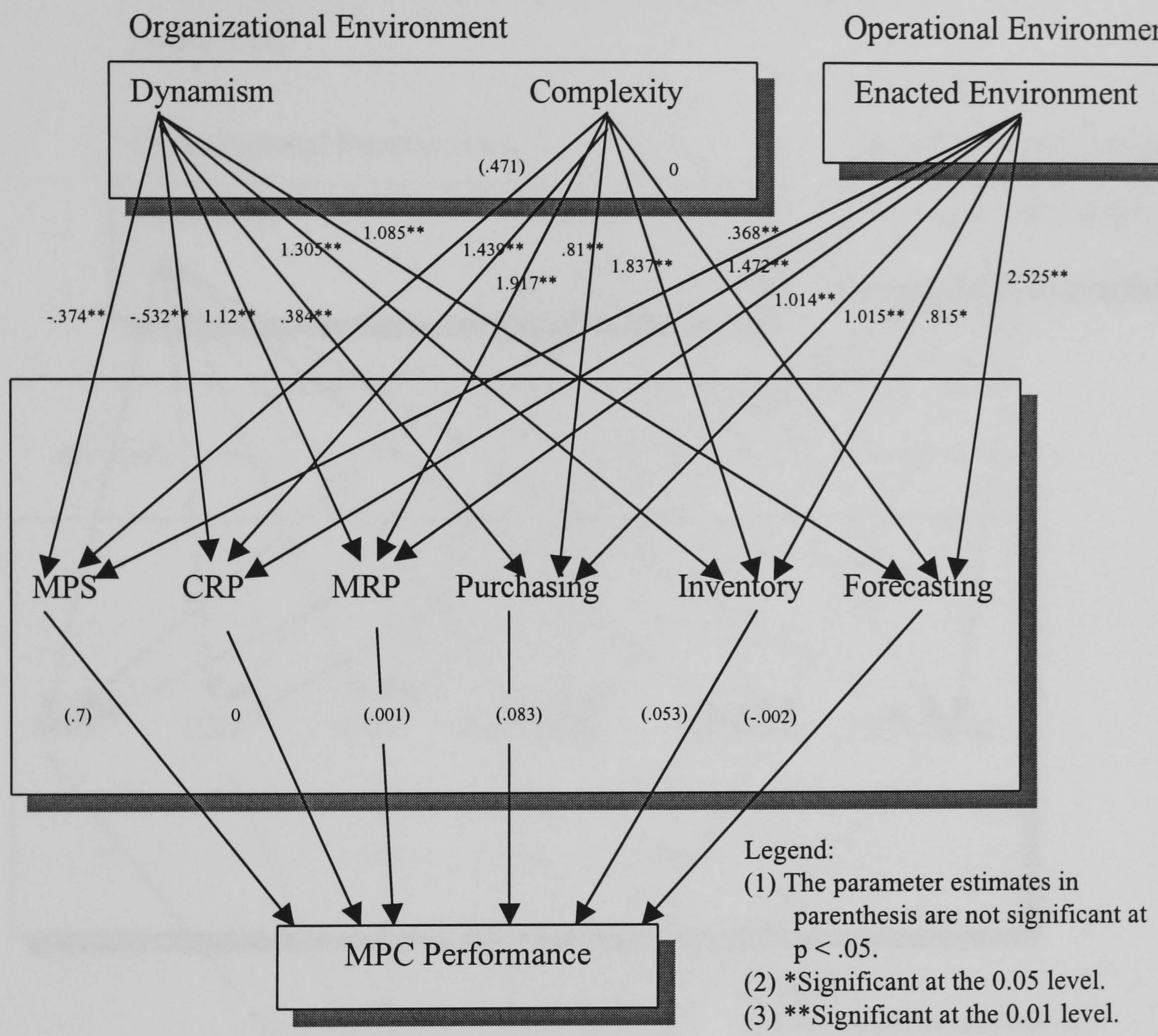


Figure 9.13: A Path Model for MPC Configuration
(High Performing Prospector Organizations)

(e) Path model for high performing analyzer organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 3.09, 0.484, 0.236, and 0.647 respectively. The path model for analyzer organization is shown in Figure 9.14.

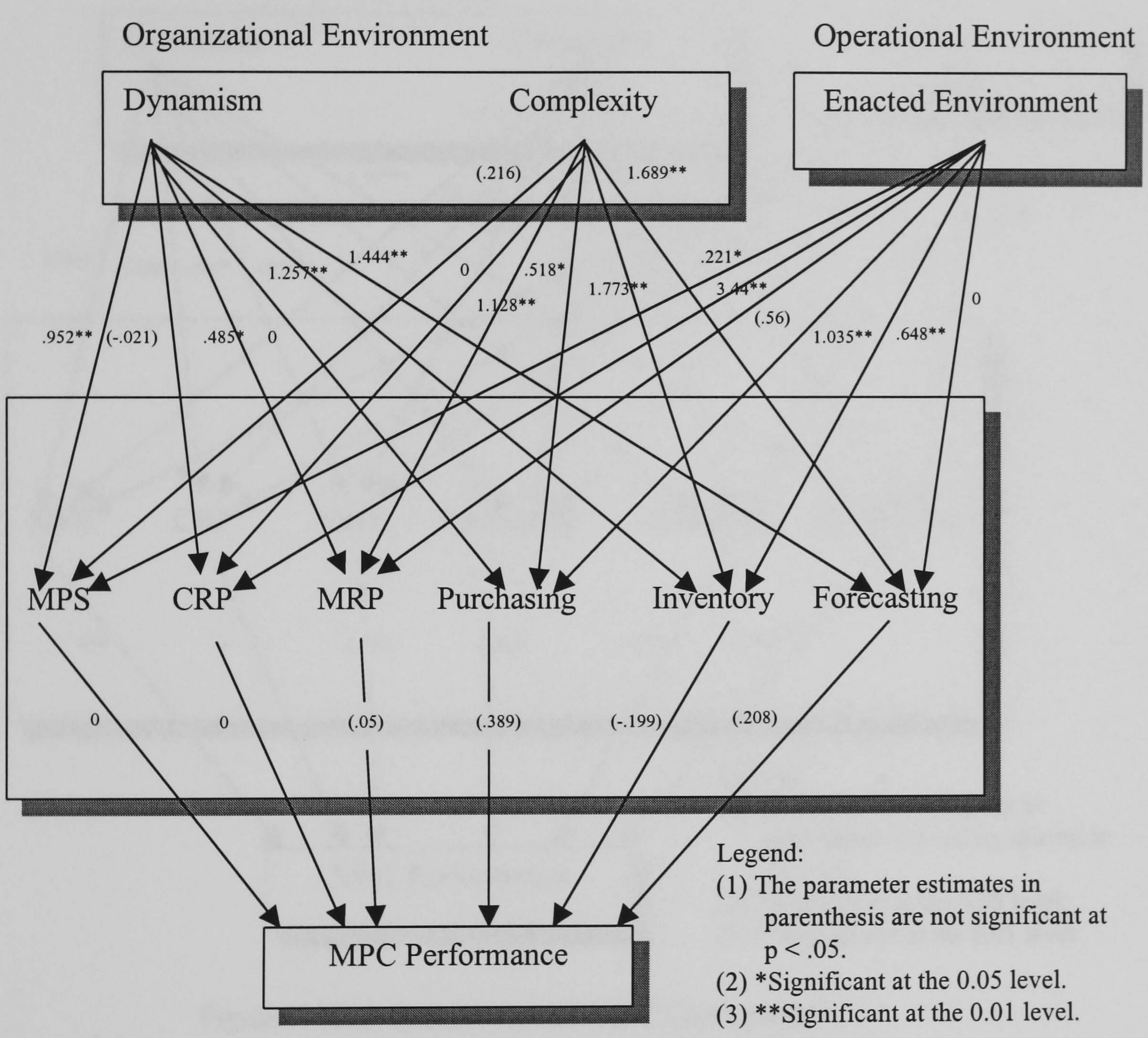


Figure 9.14: A Path Model for MPC Configuration
(High Performing Analyzer Organizations)

(f) Path model for high performing reactor organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 4.21, 0.47, 0.191, and 0.600 respectively. The path model is shown in Figure 9.15.

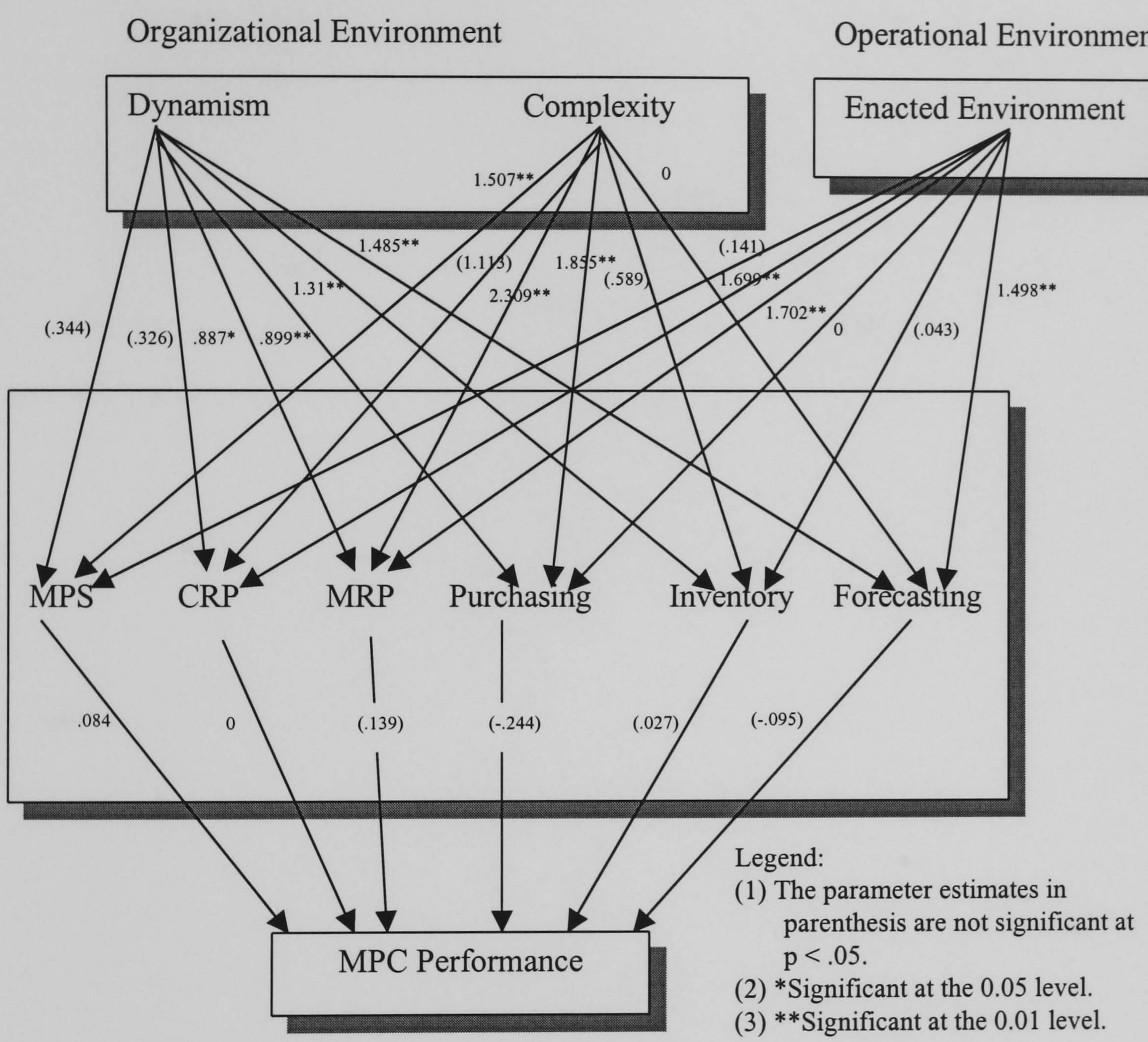


Figure 9.15: A Path Model for MPC Configuration
(High Performing Reactor Organizations)

(g) Path model for low performing reactor organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.94, 0.363, 0.329, and 0 respectively. The path model is shown in Figure 9.16.

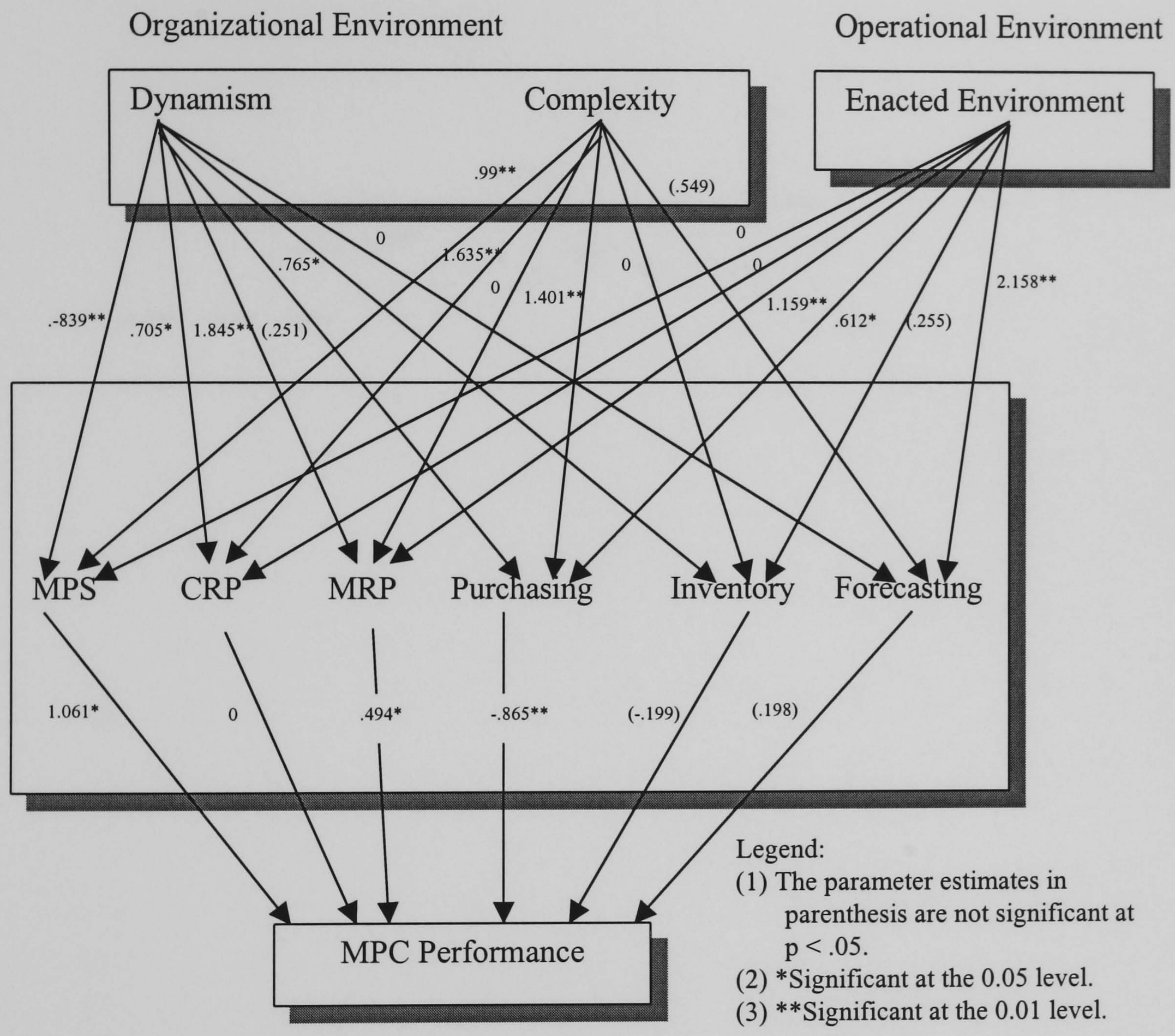


Figure 9.16: A Path Model for MPC Configuration
(Low Performing Reactor Organizations)

(h) Path model for high performing lean organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 4.39, 0.752, 0.216, and 0.724 respectively. The path model is shown in Figure 9.17.

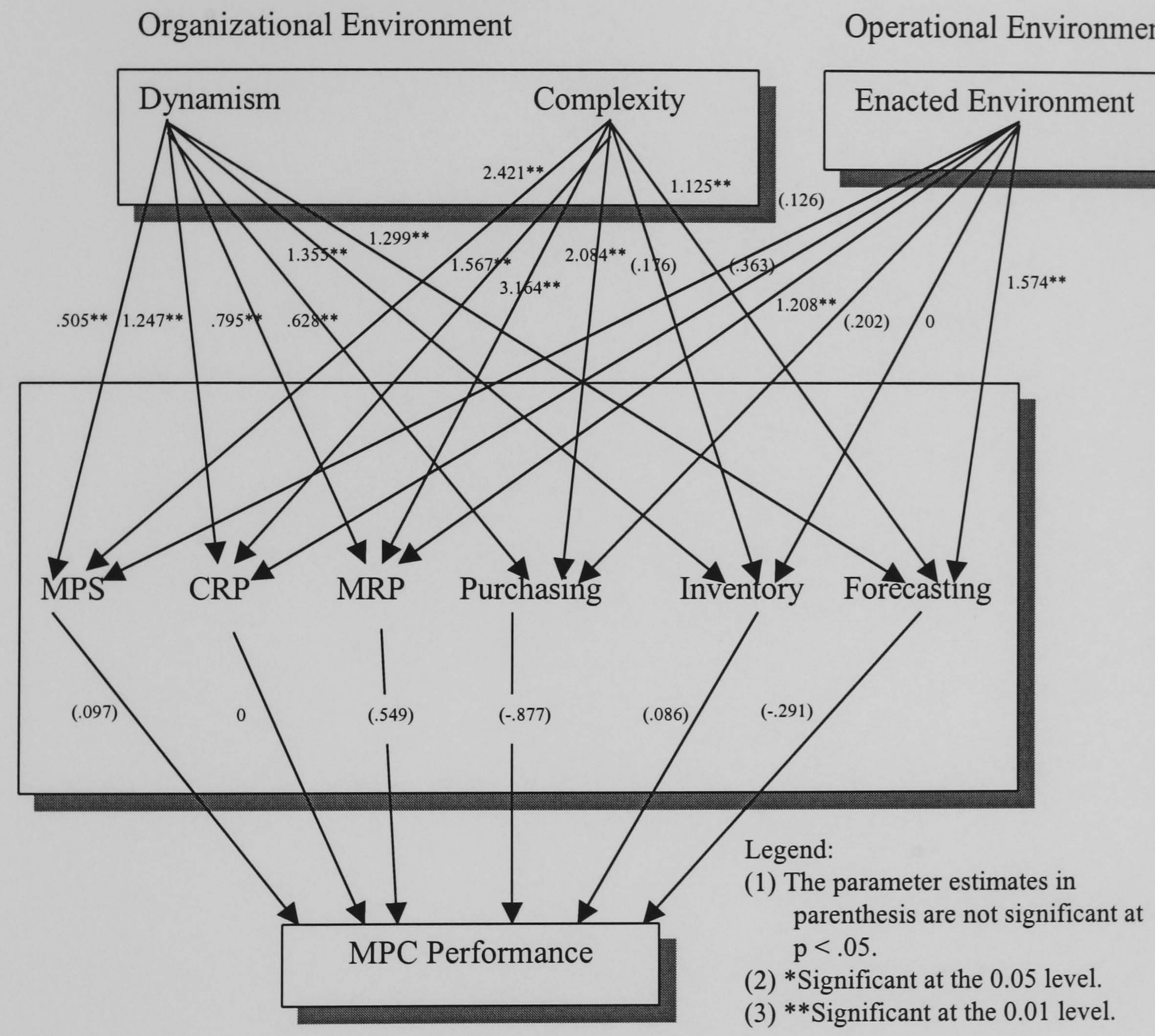


Figure 9.17: A Path Model for MPC Configuration
(High Performing Lean Organizations)

(i) Path model for low performing lean organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 1.64, 0.244, 0.225, and 0.619 respectively. The path model is shown in Figure 9.18.

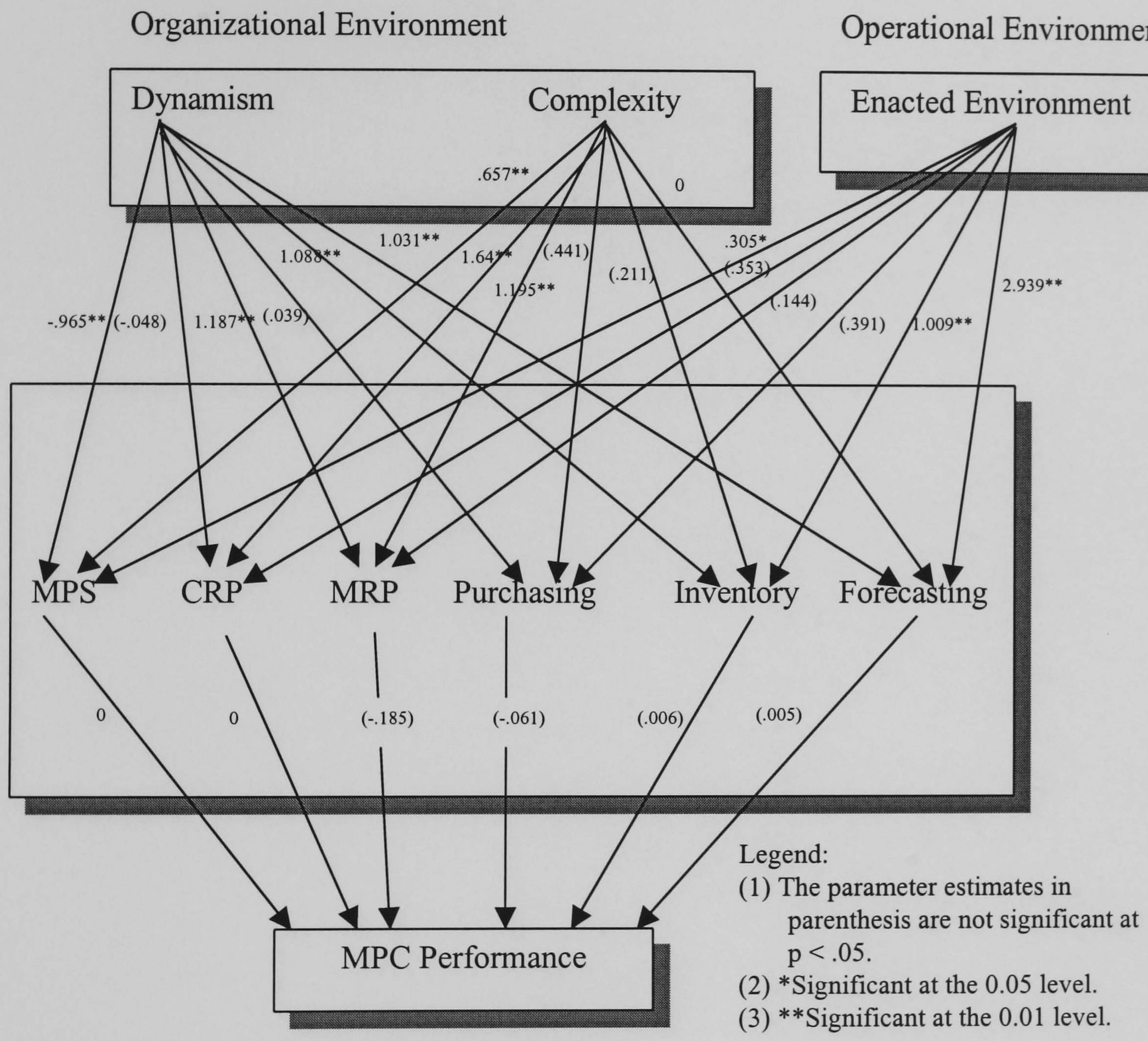


Figure 9.18: A Path Model for MPC Configuration
(Low Performing Lean Organizations)

(j) Path model for high performing agile organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.46, 0.358, 0.190, and 0.685 respectively. The path model is shown in Figure 9.19.

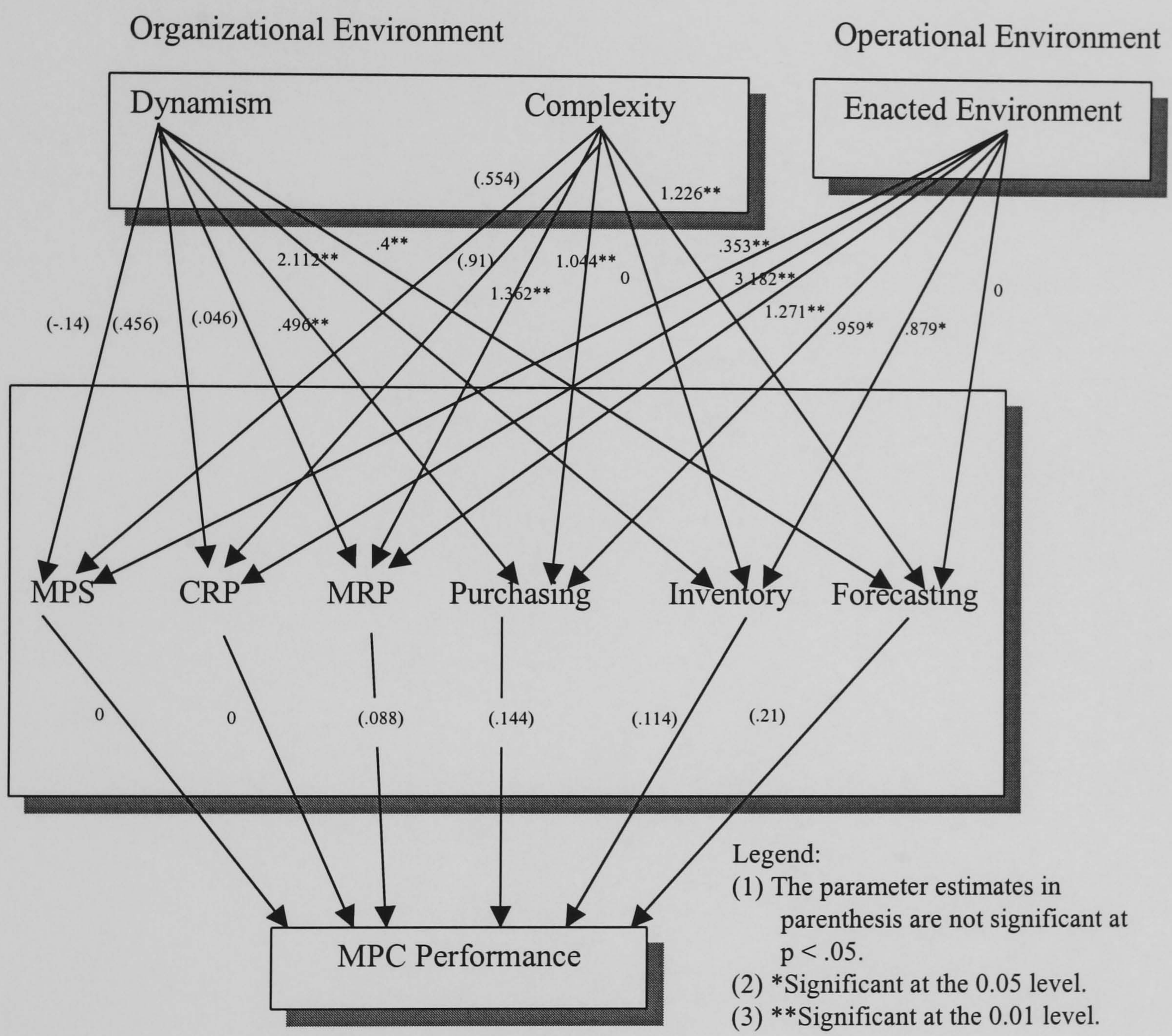


Figure 9.19: A Path Model for MPC Configuration
(High Performing Agile Organizations)

(k) Path model for high performing leagile organizations:

The χ^2 / df, RMRs, RMSEA and GFI indices are 2.06, 0.57, 0.222, and 0.670 respectively. The path model is shown in Figure 9.20.

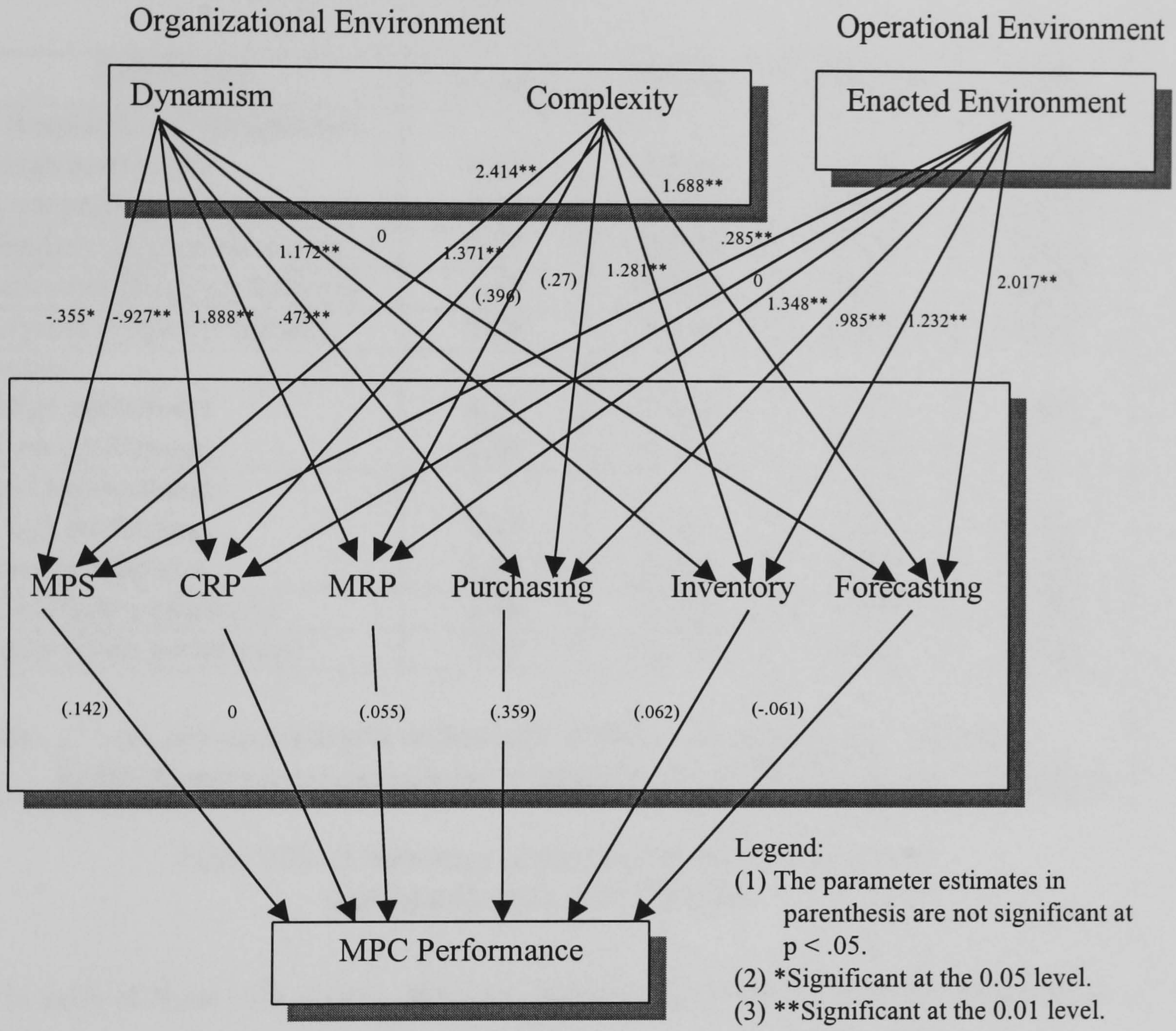


Figure 9.20: A Path Model for MPC Configuration
(High Performing Leagile Organizations)

Their standard errors, t-values, and the corresponding probability levels can be referred in Appendix 16.

The χ^2 / df, RMRs, RMSEA and GFI indices are summarized in Table 9.28. Based on these goodness-of fit indices, it shows that the path models of the analyzer organizations and agile supply chain are much fitter than the organizations classified by

other types of strategic archetypes or supply chain strategies. The models for high and low performers are compared. It is observed that the model does not fit the data of low performing reactor organizations but it fits both high and low lean performers. Besides, there is no evidence that high performers fit the path model better than low performers when all the sample population is considered.

Path Model	χ^2 / df	RMRs	RMSEA	GFI
All Responding Organizations:				
High performers	6.47	0.530	0.228	0.755
Low performers	2.46	0.424	0.235	0.671
Defenders (High performers)	3.47	0.869	0.254	0.553
Prospectors (High performers)	3.37	0.485	0.206	0.723
Analyzers (High performers)	3.09	0.484	0.236	0.647
Reactors:				
High performers	4.21	0.470	0.191	0.600
Low performers	2.94	0.363	0.329	0
Lean Organizations:				
High performers	4.39	0.752	0.216	0.724
Low performers	1.64	0.244	0.225	0.619
Agile (High performers)	2.46	0.358	0.190	0.685
Leagile (High performers)	2.06	0.570	0.222	0.670

[Note: χ^2 / df , chi-square/degree of freedom; RMRs, root mean square residuals; RMSEA, root mean squared error of approximation; GFI, goodness-of-fit index.]

Table 9.28: A Summary of the Goodness-of-Fit Indices for Configurations in MPC Systems

In each of these path models, there are 24 paths for analysis. They are discussed as follows:

Path 7 (dynamism-MPS): The results are mixed. Environmental dynamism is inversely related to master production schedule (MPS) effectiveness for high prospector, low reactor, low lean and high leagile performers. In these organizations, the higher the dynamism, the less effective is the MPS performance. On the contrary, dynamism has a positive impact on MPC effectives for high defender, high analyzer, and high lean performers.

Path 8 (dynamism-CRP): The results are also mixed. The environmental dynamism is inversely related to capacity requirements planning (CRP) effectiveness for high prospector, high analyzer, and high leagile performers. However, dynamism has a positive effect on MPC effectives for high defender, low reactor, and high lean performers.

Path 9 (dynamism-MRP): With the exception for agile organizations, the result shows that environmental dynamism has a significant and positive effect on material requirements planning (MRP) effectiveness. The effect is non-significant for agile organizations.

Path 10 (dynamism-purchasing): With the exception for high prospector, low reactor and low lean performers, the result shows that environmental dynamism has a significant and positive effect on purchasing effectiveness. The effect is non-significant for high prospector, low reactor and low lean performers.

Path 11 (dynamism-inventory management): The environmental dynamism has a significant and positive effect on the performance of inventory management for all the tested models.

Path 12 (dynamism-forecasting): The test result demonstrates that the environmental dynamism is not related to the forecasting function for low reactor and high leagile performers. However, for other types of organizations, dynamism has a significant and positive effect on the forecasting performance.

Path 13 (complexity-MPS): It is observed that environmental complexity is not related to MPS effectiveness for high prospector, high analyzer and high agile performers. However, for other types of organizations, complexity has a significant and positive effect on the MPS performance.

Path 14 (complexity-CRP): Environmental complexity is not related to CRP effectiveness for high defender, high analyzer, high reactor and high agile performers. However, for other types of organizations, complexity has a significant and positive effect on the CRP performance.

Path 15 (complexity-MRP): With the exceptions to the low reactor and high leagile performers, the environmental complexity has a significant and positive effect on MRP effectiveness. With respect to the types of MPC systems they implement, it is observed that they are normally distributed as compared to other types of organizations (see Tables 9.29 and 9.30). In this regard, it is conceived that the low reactor and high leagile performers do not consider the complexity-MRP path as important as other types of organizations do.

	Lean Chain		Agile Chain		Leagile Chain	
	No. of Responses	Percent	No. of Responses	Percent	No. of Responses	Percent
MRP	17	28.3	14	48.3	8	29.6
MRPII	14	23.3	5	17.2	8	29.6
JIT	5	8.3	2	6.9	2	7.4
ERP	7	11.7	0	0	2	7.4
Others	4	6.7	2	6.9	3	11.1
Total	47	78.3	23	79.3	23	85.2
Missing	13	21.7	6	20.7	4	14.8
Total	60	100.0	29	100.0	27	100.0

Table 9.29: Types of MPC Systems (By Supply Chain Strategy)

	Defender		Analyzer		Prospector		Reactor	
	No. of Responses	Percent	No. of Responses	Percent	No. of Responses	Percent	No. of Responses	Percent
MRP	5	22.7	10	37.0	14	33.3	10	40.0
MRPII	4	18.2	8	29.6	12	28.6	3	12.0
JIT	3	13.6			4	9.5	2	8.0
ERP			3	11.1	3	7.1	3	12.0
Others	3	13.6	3	11.1	1	2.4	2	8.0
Total	15	68.2	24	88.9	34	81.0	20	80.0
Missing	7	31.8	3	11.1	8	19.0	5	20.0
Total	22	100.0	27	100.0	42	100.0	25	100.0

Table 9.30: Types of MPC Systems (By Miles and Snow's Strategic Archetypes)

Path 16 (complexity-purchasing): With the exceptions to low lean and high leagile performers, the environmental complexity has a significant and positive effect on purchasing performance. Similar to path 15, it is supposed that low lean and high leagile do not consider the complexity-purchasing path as important as other types of organizations do.

Path 17 (complexity-inventory management): With the exception for reactor, lean and high agile performing organizations, the result shows that environmental complexity has a significant and positive effect on the performance of inventory management.

Path 18 (complexity-forecasting): It is observed that the environmental complexity is positively related to the forecasting module for high defender, high analyzer, high lean, high agile and high leagile performers. Environmental complexity has no effect on forecasting module for high prospector, reactor, and low lean performing organizations.

Path 19 (operational environment-MPS): The operational environment has a significant and positive effect on MPS effectiveness for high prospector, high analyzer, low lean, high agile, and high leagile performers. The effect is not significant for other types of organizations.

Path 20 (operational environment-CRP): The operational environment has a significant and positive effect on MPS effectiveness for high prospector, high analyzer, high reactor, and high agile performers. The effect is not significant for other types of organizations.

Path 21 (operational environment-MRP): With the exception for high analyzer and low lean performing organizations, the result shows that operational environment has a significant and positive effect on the MRP performance.

Path 22 (operational environment-purchasing): The operational environment has a significant and positive effect on purchasing performance for all types of organizations except high reactor and low lean performing organizations.

Path 23 (operational environment-inventory management): High prospector, high analyzer, high agile and high leagile performers confirm the positive significant effect of operational environment on the performance of inventory management.

Path 24 (operational environment-forecasting): The results show that the operational environment is positively related to forecasting for all types of organizations except high analyzer and high agile performing organizations.

Path 25 (MPS-MPC performance): The effect of MPS on MPC system performance is insignificant for all types of organizations except low reactor performers.

Path 26 (CRP-MPC performance): The results show that the relationship between CRP and MPC system performance is not significant for all types of organizations.

Path 27 (MRP-MPC performance): Similar to path 25, the effect of MRP on MPC system performance is insignificant for all types of organizations except low reactor performers.

Path 28 (purchasing-MPC performance): Purchasing function has an inverse effect on MPC system performance for low reactor performers, whilst the effect is positive for high leagile performers. The effect is not significant for other types of organizations.

Path 29 (inventory management-MPC performance): Surprisingly, it is observed that the relationship between inventory management and MPC system performance is not significant for all types of organizations.

Path 30 (forecasting-MPC performance): Forecasting module has a significant and positive effect on MPC system performance for high defender performers. The effect is not significant for other types of organizations.

Table 9.31 (pp.258-9) presents the summary assessment of the paths 1 to 30 for MPC configurations. It shows that the networks of direct and indirect relationships for different sample groupings are not the same. It can be concluded that the configurations in MPC systems exist for different types of organizational and operational environments, competitive strategy and manufacturing strategy. Therefore, H5b is supported.

9.4 Discussion

(1) Correlations between Manufacturing Strategy and MPC System:

Of the 5 hypothesized relations for manufacturing strategy and MPC system (H1 to H1d) tested, there is evidence that manufacturing strategy has the positive relationship with MPC system, MPS, CRP and MRP modules. However, the assumption that manufacturing strategy has a direct effect on purchasing function is refuted. The extent of correlation effect is different for various types of organization. For example, in the context of manufacturing strategy-CRP relationship, strong correlation results are found for defender and analyser organizations, whilst moderate correlation is observed for reactor organizations.

(2) Correlations between Competitive Strategy and MPC System:

Another set of 6 hypothesized relations for competitive strategy and MPC system (H2 to H2e) are tested by correlation and regression analysis. It is observed that a moderate positive relationship between competitive strategy and MPC system are found for three types of organization, i.e. analyser, agile and leagile groupings. However, the correlation results between competitive strategy and individual MPC modules are not significant. It is probably due to the weak indirect effect of competitive strategy on individual MPC modules.

Paths	Defender	Prospector	Analyzer	Reactor	Lean Chain	Agile Chain	Leagile Chain	All Samples
1	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
2	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	-	n.s.
3	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
4	+	+	+	+	+	n.s.	+	+
5	+	+	+	+	+	+	+	+
6	+	+	+	+	n.s.	Zero	n.s.	+
7	+	-	+	n.s.	+	n.s.	-	n.s.
8	+	-	n.s.	n.s.	+	n.s.	-	-
9	+	+	+	+	+	n.s.	+	+
10	+	+	Zero	+	+	+	+	+
11	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	Zero	Zero
13	+	n.s.	n.s.	+	+	n.s.	+	+
14	n.s.	+	Zero	n.s.	+	n.s.	+	+
15	+	+	+	+	+	+	n.s.	+
16	+	+	+	+	+	+	n.s.	+
17	+	+	+	n.s.	n.s.	Zero	+	+
18	+	Zero	+	Zero	+	+	+	n.s.
19	n.s.	+	+	n.s.	n.s.	+	+	Zero

[Note: (a) Only high performing organizations are considered.
(b) Notation: +, positive relationship; -, negative relationship; n.s., not significant; Zero, zero relationship.]

Table 9.31: A Summary of the Test Results of the Path Models for Configurations in MPC Systems

Paths	Defender	Prospector	Analyzer	Reactor	Lean Chain	Agile Chain	Leagile Chain	All Samples
20	Zero	+	+	+	n.s.	+.	Zero	Zero
21	+	+	n.s.	+	+	+	+	+
22	+	+	+	Zero	n.s.	+	+	+
23	Zero	+	+	n.s.	Zero	+	+	Zero
24	+	+	Zero	+	+	Zero	+	+
25	Zero	n.s.	Zero	n.s.	n.s.	Zero	n.s.	n.s.
26	Zero	Zero	Zero	Zero	Zero	Zero	Zero	Zero
27	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+
28	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+	-
29	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+
30	+	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

[Note: (a) Only high performing organizations are considered.
(b) Notation: +, positive relationship; -, negative relationship; n.s., not significant; Zero, zero relationship.]

Table 9.31: A Summary of the Test Results of the Path Models for Configurations in MPC Systems (Continued)

(3) Correlations between operational environment and MPC system:

Hypotheses 3 to 3c are proposed to examine the relationship between operational environment and MPC system performance. The results are mixed. A moderate positive correlation is observed for reactor organizations. However, the correlation results for other types of groupings are insignificant. Different results are yielded for the tests undertaken for individual components of operational environment separately. Two hypotheses are mostly proven for the positive relationships of "product development strategy – MPC system performance" and "internal relationship – MPC system performance". The hypothesis of external relationship and MPC system performance is proven.

(4) Relationships between organizational environment, supply chain and organizational performance:

Hypotheses H4a to H4m are proposed to examine the aforementioned relationships. The tests for these hypotheses are based on the archival data, i.e. Hong Kong Government industrial statistics and published data of public-listed organizations. The inventory performance measurement is a longitudinal study in this thesis and it is observed that inventory performance has been continuously improved over time for high performers. It is proven that the inventory performance is positively related to the environmental complexity and dynamism. Further, the MPC system performance, in terms of inventory level, is dependent on the types of supply chain strategy they adopt. High performers tend to keep lower inventory level than low performers.

(5) Causal relationships between environment, strategy and MPC system:

Figures 9.1 to 9.20 show the causal relationships between MPC system, competitive strategy, manufacturing, organizational environment and operational environment (refer to Section 9.3.5). The test results reveal both differences and similarities in that the path models. The profiles for each MPC configuration are different and they are influenced, directly or indirectly, by different environments and strategies.

It is observed that there are some common features of these configurations. They are:

- Dynamism-competitive strategy (path 1), operational environment-competitive strategy (path 3), and CRP-MPC performance (path 26) have no significant relationships.
- Competitive strategy-manufacturing strategy (path 5) and dynamism-inventory management (path 11) have significant and positive relationships.

Two interesting observations are also detected. They are:

- MRP-MPC performance (path 27) and inventory management-MPC performance (path 29) have no significant relationship for all types of organizations, but unexpectedly, the result of the overall responding sample demonstrates a positive relationship.
- Leagile organizations are quite different from other six types of organizations. There are four particular features that illustrate the differences. First, complexity-competitive strategy (path 2) exhibits a negative relationship but it is non-significant for other types of organizations. Second, dynamism-forecasting (path 12) has a zero effect but it is positively related for other types of organizations. Third, complexity-MRP (path15) and complexity-purchasing (path 16) are not significant but others have shown a positive effect. Fourth, purchasing-MPC performance (path 28) is positively related but other organizations have a non-significant effect.

Based on the testing of 30 hypothesized relationships, the thesis has also concluded that: (a) the indirect effect of environmental dynamism on MPC system is not significant (b) the indirect effect of environmental complexity on MPC system is not significant; (c) the indirect effect of operational environment on MPC system is not significant; (d) with an exception of agile organizations, competitive strategy tends to shape operational environment for high performing organizations; and (e) the indirect effect of competitive strategy on MPC system is significant for groupings associated with Miles & Snow's strategic archetypes. The result of item (d) supports the theory of autopsies.

Model comparison between high and low performers demonstrate that poor MPC system performance can be attributed to factor such as lack of proper attention to integrate competitive strategy with manufacturing strategy (path 5) and overlooking of shaping the operational environment (path 4). As such, the thesis provides support for the role of

management plays in strategic planning and actions taken to shaping favorable environmental conditions for MPC system effectiveness.

9.5 Summary

A summary of the testing results for the thirty hypothesized relationships are presented in Table 9.32. The conclusion and further discussions are presented in Chapter 10.

Hypothesis	Result
H1: Manufacturing strategy will have a direct effect on the MPC system effectiveness.	Proven; moderate correlations are found: between decoupling point (end- item); ATS strategy and MRP; between ATS strategy and inventory management.
H1a: Manufacturing strategy will have a direct effect on the MPS performance.	Proven; strong correlation for defender and analyser organizations; moderate correlation for lean organizations.
H1b: Manufacturing strategy will have a direct effect on the CRP performance.	Proven; strong correlation for defender and analyser organizations; moderate correlation for reactor organizations.
H1c: Manufacturing strategy will have a direct effect on the MRP performance.	Proven; moderate correlation for all responding organizations: between MRP and decoupling point (sub-assembly); and between MRP and ATS strategies.
H1d: Manufacturing strategy will have a direct effect on the purchasing performance.	Not proven.
H2: Competitive strategy will have a direct effect on the MPC system effectiveness.	Proven; moderate positive correlations for analyzer, agile and leagile organizations.
H2a: Competitive strategy will have a direct effect on the MPS performance.	Not proven.
H2b: Competitive strategy will have a direct effect on the CRP performance.	Not proven.
H2c: Competitive strategy will have a direct effect on the MRP performance.	Not proven.

Table 9.32: A Summary of Test Results for 30 Hypothesized Relationships

Hypothesis	Result
H2d: Competitive strategy will have a direct effect on the purchasing performance.	Not proven.
H2e: Defender organizations will tend to keep a higher inventory level than analyzer organizations.	Not proven.
H3: Operational environment will have a direct effect on the MPC system effectiveness.	Proven; moderate positive relationship for reactor organizations.
H3a: Product development is positively associated with the MPC system effectiveness.	Proven; moderate positive correlation for prospector organizations; strong positive correlation for agile and leagile organizations.
H3b: External relationship is positively associated with the MPC system effectiveness.	Proven; moderate positive correlation for reactor, lean, agile and leagile organizations; strong correlation for defender organizations.
H3c: Internal relationship is positively associated with the MPC system effectiveness.	Proven; moderate positive correlation for lean and agile organizations; strong positive correlation for reactor organizations.
H4a: Inventory performance has been continuously improved over time for high performing organizations.	Proven.
H4b: In the context of inventory performance, high performing manufacturing organizations out-perform low performing organizations.	Mostly proven.
H4c: The inventory performance for the lean supply chain is better than the agile supply chain.	Partially proven.

Table 9.32: A Summary of Test Results for 30 Hypothesized Relationships (continued)

Hypothesis	Result
H4d: For organizations adopting extended supply chain, the inventory performance is better than their previous undertaking that operated as either an agile or a lean supply chain.	Unproven (for short-term performance).
H4e: For organizations employing (sub)contractors to execute a large proportion of manufacturing orders, the inventory performance would be better than the organizations undertaking most of the manufacturing themselves.	Proven.
H4f : The inventory level is positively related to the level of environmental munificence, i.e. the inventory investment is high under high environmental munificence, or otherwise.	Unproven
H4g:In the condition of low environmental munificence, organizations operating as lean supply chain will have better inventory performance than organizations operating as agile supply chain, or otherwise.	Unproven
H4h: The inventory level is positively related to the level of environmental dynamism, i.e. the inventory investment is high under high environmental dynamism, or otherwise.	Proven

Table 9.32: A Summary of Test Results for 30 Hypothesized Relationships (continued)

Hypothesis	Result
H4i: In condition of high environmental dynamism, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.	No conclusion at this stage
H4j: The inventory level is positively related to the level of environmental complexity, i.e. the inventory investment is high under high environmental complexity, or otherwise.	Proven
H4k:In the condition of high environmental complexity, organizations operating as agile supply chain will have better inventory performance than organizations operating as lean supply chain, or otherwise.	No conclusion at this stage
H4l:Organizations adopting IT have their improvement rates in inventory performance faster than organizations not adopting IT.	Partially proven
H4m: In condition of high environmental dynamism or high complexity, organizations adopting IT have the faster rates of improvement in inventory performance than organizations not adopting IT.	Unproven
H5a:The manufacturing and competitive strategies have a moderating effect between organizational environment, operational environment and MPC system.	Mostly proven particularly for the moderating effect of environmental complexity on MPC system.
H5b:The configurations in MPC systems are related to particular organizational and operational environment.	Proven.

Table 9.32: A Summary of Test Results for 30 Hypothesized Relationships (continued)

Chapter 10 Conclusions

10.1 Introduction

The literature study has suggested that the infrastructures such as manufacturing planning and control (MPC) can become a competitive weapon[2] if implemented and managed properly. The study on the environment influences and strategic decisions on MPC system can help unlocking the complex intercorrelations among the MPC system variables that subject to specific manufacturing conditions and organizational strategies. This can be useful for greater understanding of the choice of an appropriate MPC system in a range of organizational environments.

There are a number of shortcomings for the bulk of the research study in MPC systems. For example, few studies extend beyond the MPC system boundary to include strategic issues, decision support framework, and manufacturing environments. Some studies are based on the qualitative reasoning without conducting an empirical proof. A number of quantitative studies have been carried out within a limited scope of MPC variables while ignoring the whole complexity of the problems. Some empirical studies contend the impact of organization environments but omit the quantitative assessment.

The researches on the content of MPC practices are relatively under-explored. Issues such as competitive strategy, manufacturing strategy, MPC system performance, and organizational environment are seldom addressed. It is not known yet about the environmental influences on the system and their relationships. Therefore, there is a need to clear the uncertainties about the relationship between MPC system, manufacturing strategy, competitive strategy, operational and organizational environments. With this in mind, this thesis attempts to investigate rigorously and comprehensively the environmental impact on the configurations of MPC systems. The main thrust of this thesis is to inquire into a wider scope of MPC system.

However, the study of the relationship between MPC system and its environments is often difficult. First, despite a number of contributions from various authors, the operationalized measures for environments and organizational strategies are

controversial and remain unclear. This thesis shows that the definition of organization strategies and the development of environment construct are critical for the research study. Since the environment and strategic issues are multi-dimensional, they should be defined prudently. Second, the 3-dimensional environments proposed by Dess and Beard[239] seems appropriate for the study, but it requires a significant amount of effort to construct it. Third, most researches on organization configurations have been advanced more at the corporate strategy level. The literature on environment and strategy at the manufacturing system level is relatively few. Fourth, the development of the configurations of MPC systems is a big issue since it embraces a larger and complex scope of study. Special care must also be exercised in order to control the efficiency of the experiment.

The configurations research in MPC system is still in its infancy. The findings of this thesis cover only a small portion of the complex phenomenon of manufacturing system and the relations with organizational environments. They are discussed in the following sections.

10.2 Research Outcomes

As discussed earlier in Section 1.3 of Chapter 1, there are four main research objectives for this study. This section briefly describes the outcomes of the study in achieving these objectives.

Research outcome for objective 1 (environmental constructs):

The first research objective dealt with the development of the environmental constructs that would be used as a useful platform for the following research objectives 3 and 4. Based on the literature study, the Dess and Beard's[239] 3-dimensional construct of the organizational environment was proposed (refer to Chapter 4). Several measures of various attributes of the organizational environment were designed (see Section 7.5.2, Chapter 7). The result of the classification of the organizational environments, based on archival method, was presented (see Table 9.1, Chapter 9). It was then validated by comparing the scores and ranks of environmental complexity and

dynamism with perceptual data ((see Table 9.3, Chapter 9). The first objective is achieved.

Research outcome for objective 2 (reference model of MPC system):

The second research objective examined the components of the MPC reference model of MPC system, which is derived from the literature study (refer to Sections 8.1 – 8.8, Chapter 8). A reference model was then proposed and it was subjected to a number of "face-validity" checks to test its logic and reasonableness (refer to Section 8.9, Chapter 8). The reference model (refer to Figure 8.6, Chapter 8) provided a generic representation of the MPC system in a defined range of environmental conditions. The model was one of the references for the design of the survey questionnaire. The second objective is attained.

Research outcome of objective 3 (configurations in MPC systems):

The third research objective investigated the configurations in MPC systems. In order to carry out the research inquiry, a questionnaire for the study of the configurations was designed (refer to Appendix 1 and Sections 7.4 – 7.5, Chapter 7). As mentioned earlier, the research questionnaire was based on the literature review and the proposed MPC reference model (research objective 2, above). Two path models were proposed (see Figures 6.4 and 6.5 of Section 6.4.5, Chapter 6). The configurations of MPC systems were then tested and derived from path model analysis of empirical data based on multiple dimensions referring to Miles & Snow strategic archetypes and supply chain strategies (refer to Section 9.3.5, Chapter 9). Operational and organizational environments were also taken into consideration for the study of various configurations in MPC systems. Besides, selected measures of organization performance and MPC system performance were also incorporated into the configurations research (refer to Section 7.5.3 of Chapter 7 and Section 9.3.5 of Chapter 9). The third objective was done.

Research outcome of objective 4 (validation):

The fourth research objective validated the reference model and configurations in MPC systems. Quantitative techniques such as Pearson correlation, regression, and path model analysis were used to test 30 hypothesized relationships (see Chapter 6). The correlations between organization environment, operational environment, competitive strategy, manufacturing strategy and MPC system with performance implications were observed (refer to Section 9.4). These data were then used to test the hypothesized relationships. A summary of the testing results for the hypothesized relationships were presented in Table 9.32 of Chapter 9. The MPC reference model was validated by the field visits (refer to Sections 8.9.1 to 8.9.6, Chapter 9) and the configurations in MPC systems were proved by path model analysis (refer to Section 9.3.5, Chapter 9). A summary assessment of the 30 paths for MPC configurations was presented (see Table 9.31, Chapter 9). The configurations in MPC systems for different types of organizational and operational environments, competitive strategy, and manufacturing strategy were concluded. The fourth research objective is accomplished.

10.3 Conclusions on the Research Hypotheses

The findings for the 30 hypothesized relationships are summarized in Chapter 9. The results are varied. Six major issues are discussed and presented as follows:

(1) Consistent with the literature as discussed in Chapter 3, moderate to strong correlation results between manufacturing (positioning) strategy and MPC system are observed (refer to Section 9.3.1, Chapter 9). The correlation between manufacturing strategy and purchasing performance is not supported. One of the concerns in this study is that the majority of the responding organizations adopt MTO strategy (refer to Table 9.10, Chapter 9). It appears that there is the trend in Hong Kong manufacturing industries that move away from MTS into MTO strategy, whilst fewer organizations implement ETO and ATS strategies. The correlation results could be biased towards MTO strategy.

(2) A positive relationship between competitive strategy and MPC system is proven for three groupings such as analyser, agile and leagile organizations (refer to Section 9.3.2). This illustrates that the competitive strategy of an organization may have an

effect on the MPC system effectiveness. However, the correlation results between competitive strategy and individual MPC functions are insignificant. Presumably the effect of competitive strategy has a stronger impact on the whole organizations rather than an individual module at lower hierarchical levels.

(3) Section 9.3.3 examines the hypothesized relations between operational environment and MPC system based on the theory of autopoiesis[58], in which the systems enact their environment. The results demonstrate that product development strategy, internal relationship and external relationship are directly related to MPC system performance. This confirms to the view that organization shapes and trades with the environment, contrary to the traditional concept of one-way environment-organization interactions to which MPC system responds to the environmental demands. The findings in Section 9.3.5 also verify this new organization view (see Figures 9.1 – 9.9, Chapter 9). Competitive strategy shapes the operational environment for all high performers, except agile organizations. The non-significant relationship between competitive strategy and the operational environment is not known.

(4) Sections 9.3.4 demonstrates that manufacturing organizations achieving high financial performance will also accomplish a high inventory performance, while the reverse is not true. In other word, inventory performance is only a necessary condition for financial performance (hypothesis 4a, being proven). The finding provides an insight that modern organization should not sacrifice inventory performance while emphasizing only on competitive priorities such as agility, flexibility, responsiveness etc. Inventory management must also be regarded as one of the important organizational objectives, no matter a company adopts a lean or agile supply chain strategy. Concerning the environmental dimensions, it is found that dynamism and complexity have a significant impact upon inventory performance. For instance, the inventory investment would be high under high dynamism (Hypothesis 4h, being proven) or high complexity (Hypothesis 4j, being proven). However, the effect of munificence on inventory performance will be small (Hypothesis 4f, unproven). This indicates that the manufacturing environment of an organization has inventory performance implications. Whether

environmental dynamism and environmental complexity have a direct impact or moderating effect on inventory performance or not is a subject for further research study.

(5) One of the tenets of the study is that the success of a manufacturing organization depends on its adoption of appropriate supply chain mechanism in order to cope with the relevant environmental forces. In addition to the study of inventory performance implications, the thesis extends the investigation to the environment-supply chain paradigm. The following points are drawn:

(a) The improvement rate in inventory performance for a lean supply chain is faster than the agile supply chain (Hypothesis 4c, partially proven). The reasons for holding a larger inventory level for an agile supply chain could probably due to the environment of unpredictable market demand, innovative products, high product variety, and different supply chain focuses[230]. However, there is no evidence in this empirical study that a lean supply chain is superior to an agile supply chain in the context of inventory performance under low munificence (Hypothesis 4g), nor an agile supply chain better than a lean supply chain under high dynamism (Hypothesis 4i) and high complexity (Hypothesis 4k). At the present stage, the differences in supply chain focus could probably be the major cause of inventory performance differences. A lean supply chain with prime focuses on cost and quality will apply rigorously the continuous improvement programmes to minimize inventory costs.

(b) As noted earlier, high inventory performance should be one of the main organizational goals for all business organizations since it is one of the necessary conditions for a higher financial performance. The prime focuses on speed, flexibility and quality for an agile supply chain would be parsimonious to pursue. It is recommended that manufacturing organizations adopting agile supply chain strategy should also include cost-effectiveness as one of the prime focuses. In this regard, the movement of transforming an agile supply chain to a leagile chain would be a solution for competitive advantage or survival. The design of a leagile chain would be another subject worth for further research study.

(c) The movement of supply chain reengineering processes witnesses the trend in developing an extended supply chain via the formation of various partnerships within the supply chain. In this study, one of the findings is that the core firms of an extended supply chain transferring a large proportion of manufacturing orders would improve the inventory performance (Hypothesis 4e). However, the inventory performance implications for applying an extended supply chain remains unproven (Hypothesis 4d). Perhaps it is necessary to take a longer time to reflect the benefits rather than a snapshot of two years' performance. The subject of an extended supply chain is expected to draw considerable research interests.

(d) The results on the impact of IT investment are mixed and in contradiction. One of the findings provides evidence that the adoption of IT has a positive effect on inventory performance improvement (Hypothesis 4l, partially proven). However, surprisingly, the effect of IT investment on inventory performance was not proven in the condition of high environmental dynamism or high complexity (Hypothesis 4m, unproven). Thus, no conclusion can be drawn at this stage on whether there will be a positive impact of IT investment on supply chains in the context of inventory performance. One probable reason is that the benefits of IT application on a supply chain may take place after a considerable period of time (Keen, 1988) and thus the hypothesized relationship could not be proven for the present study.

(6) In Section 9.3.5, a summary of the path models for different types of organizations is presented (refer to Table 9.31, Chapter 9). It demonstrates that the configurations in MPC systems are existed in a defined range of environmental conditions. This finding provides an insight that organizations must seek for an appropriate model (configuration) that fits with the environment. The following points are drawn:

(a) For all types of organizations, environmental dynamism and operational environment have no significant effect on competitive strategy (Figure 9.1, Chapter 9). In addition, with the exception of high leagile performers, environmental complexity and competitive strategy has no significant relationship. This suggests that, unlike traditional organization-environment

thinking, the strategic responses of an organization are independent of organizational and operational environments. Presumably, manufacturing organizations tend to perform according to their own interpretation of the environment (theory of autopoiesis).

(b) With the exception for all low performing organizations and high agile performers, the competitive strategy has a direct and positive effect on the operational environment (see Figures 9.1 – 9.9, Chapter 9). Therefore, for organizations classified by Miles & Snow strategic archetypes, the theory of autopoiesis is proven. However, for organizations classified by the three types of supply chain strategies, the theory of autopoiesis is only partially proven. It demonstrates that competitive strategy is a key variable in an organization that enacts the environment. Therefore, the importance of competitive strategy in shaping favorable environmental conditions for high organizational performance is demonstrated.

(c) Contrary to expectations, the findings show that most of the MPC modules such as MPS, CRP, MRP, purchasing, inventory and forecasting have no impact on MPC system performance. There are only a few exceptions such as, a positive forecasting-MPC relationship for high defender performers and a positive purchasing-MPC relationship for high leagile performers. There are several probable reasons. First, the respondents in this study are not satisfied with their existing MPC systems and thus reflect in the survey the non-significant effects. Second, the tangible and intangible performance measurements for MPC system and its modules are enormous. The perceived performance cannot reflect accurately the actual outcome and thus leading to inaccurate findings. Third, the benefits of each MPC module could only be exploited for a fully integrated MPC system. The measurement of performance of each MPC module could result in research errors. It is worth for further research to explore the critical success factors for MPC system effectiveness.

(d) With the exception of low performers, competitive strategy of an organization has a direct and positive effect on manufacturing strategy. It implies that the design of a set of competitive strategies for high performing manufacturing

organization is important. It is not only laid down competitive strategic focus for shaping favorable environmental conditions (refer to 6(b) of Section 10.3), but also assists the organization to position the manufacturing strategies.

(e) The MPC configuration for leagile organizations is quite different from six other types of organizations (see Section 9.4, Chapter 9). Since leagile supply chain has been suggested recently, it is worth to carry out future research to explore more about it.

(f) The study presents an interesting finding that the effect of manufacturing strategy on MPC system is insignificant for organizations classified by supply chain strategies, but significant for organizations classified by Miles & Snow's strategic archetypes (see Section 9.3.5, Chapter9).

10.4 Research Contributions

The main contributions of this thesis are:

(1) The scores and categories on three environmental dimensions – munificence, dynamism and complexity, for 20 major Hong Kong manufacturing industries are developed. This manufacturing environment classification framework provides a useful construct to improve the conceptualization and measurement of the empirical relationship among supply chain, manufacturing environment and organizational performance. Both archival-based and perceptual-based data were collected to gauge the reliability of this measurement. In addition, it could be a useful platform for future research studies related to manufacturing environment in Hong Kong.

(2) The thesis is unique in that it focuses a wider scope of study that links dynamism, complexity, operational environment, competitive strategy, manufacturing strategy, MPC system and its modules. The knowledge on the relations between manufacturing environment, organization strategies, supply chains and MPC system has been expanded.

(3) This thesis applies the path modelling technique to investigate the network relationships between MPC system and the environment. This method is rarely used in this discipline.

(4) It attempts to challenge the traditional view of environment-organization interactions. This study adopts the theory of autopoiesis and enacted environment. Such an attempt provides a new insight to structure the MPC system that takes into account of developing a favorable operational environment such as internal relationship and external relationship etc.

(5) The development of a modified reference MPC model in Chapter 8 is also a contribution of this research that adds to the body of knowledge in this field. The reference model provides a generic representation of the MPC systems, which clarifies the linkages between manufacturing strategy, competitive strategy, organizational environment and various functions relating to the MPC system.

(6) A summary listing of the causal relationships of MPC-Environment paradigm (Table 9.30) is another contribution of this research. Similar to the framework of environmental construct, this listing could also be used for further research.

10.5 Limitations

There are several limitations. First, the measures by questionnaire survey are cross-sectional in nature, that is, taken at only one point in time. This limits the reliability of the study to capture the MPC system variables that may lag behind today's situation. Second, the study is undertaken in Hong Kong and therefore, the findings of the MPC system behaviour may represent the particular aspects of Hong Kong manufacturing environment. Third, nowadays most of the Hong Kong managers refuse to respond to the questionnaire. That limits the size of the search samples. Fourth, most of the respondents adopt the standard MPC systems such as MRP, MRPII etc., no sample organizations implement OPT nor CONWIP systems (see Table 9.17). The results of the research may be epitomized by a sample of Hong Kong manufacturing managers who preferred the popular Western techniques.

10.6 Future Research Direction

This research is only a preliminary study in MPC configurations. Therefore, more research can be done within the context of the path model developed in this thesis. First, the manufacturing strategy of the decision model could be involved so that the research paradigm could be expanded. Second, a longitudinal study by extending the length of research horizon as a factor that may generate valuable findings about the transformation processes from one point of time to another. Third, the theory of autopoiesis and enacted environment could be an important research issue for the study of relationships between organization and environment. For example, managers nowadays adopt the best practice strategy in order to enact the environment and to achieve manufacturing competitiveness (refer to Section 3.3.6, Chapter 3). It is worth to study how the best practice strategy relates with the MPC system, organizational environment and strategy. Fourth, further research can be carried out in a different region such as UK by adopting the similar methodology. Testing on the MPC-Environment relationship in different countries may generate interesting results that can provide more insights to the MPC configurations. Fifth, the study reveals that MPC configuration for leagile organizations is quite different and therefore the design of a leagile chain would be another subject worth for further research study. Sixth, the non-significant effect of individual functions on MPC system performance is observed and it is worth for further research to explore the critical factors leading to MPC system effectiveness.

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Questionnaire on the Configurations in MPC Systems

I. Company Profile

1. Company Name: _____

2. Ownership structure:
   Independent ☐ Subsidiary ☐
   (Kindly provide an ownership structure of your company.)

3. Number of employees:_____

4. Age of the company:_____

5. Business Sectors:
   Electrical appliance ☐ Metal products ☐
   Plastics ☐ Electronics ☐
   Toys ☐ Watches & Clocks ☐
   Others:_____

6. Nature of market:
   Home_____% Export_____%

7. Company headquarters:
   Hong Kong ☐ China ☐ Singapore ☐
   Others:_____

8. Production base:
   China ☐ Hong Kong ☐ Both HK & China ☐
   Others:_____

9. Revenues of company in 1998 (in HK$):_____

10. OEM/ODM business:
    OEM (Original Equipment Manufacture)_____%
    ODM (Original Design Manufacture)_____%

11. Products:_____
    _____
    _____

12. Characteristics of products:
    Number of main products:_____
    Number of product ranges:_____

Total number of raw materials/components:_____

The average number of components per product: _____

The average number of item levels per product:_____

The average rate of new product introduction:_____products/year

Product families can be formed. Yes ☐ No ☐

Level of common parts: High ☐ Medium ☐ Low ☐

II. Positioning Strategy and Organizational Environment

13. Types of your positioning strategy:

Make-to-order (MTO) ☐ Make-to-stock (MTS) ☐

Assemble-to-stock (ATO) ☐ Engineer-to-order (ETO) ☐

Others:_____

(For questions 14 through 18, please circle the number in the scale below to indicate the changes in your company's organizational environment over the past 3 years.)

14. Changes in customer demands:

1	2	3	4	5	6	7
Stable						Changing rapidly (hard to forecast)

15. Rate of new products introduced:

1	2	3	4	5	6	7
Dramatically decreased			No change			Dramatically increased

16. Rate of product getting obsolete:

1	2	3	4	5	6	7
Very slow			No change			Very high

17. Changes in marketing practices:

1	2	3	4	5	6	7
Rarely changed						Extremely frequently

18. Changes in production methods:

1	2	3	4	5	6	7
Rarely changed						Extremely frequently

III. Competitive Strategy

(For questions 19 and 20, please circle the number in the scale below to indicate the competitive strategy/preference of senior executive in your company over the past 3 years.)

19. Senior management has strong emphasis on the following function:

	Highly likely			Neutral			Highly unlikely
a) Marketing	1	2	3	4	5	6	7
b) Product design & Development	1	2	3	4	5	6	7
c) Manufacturing	1	2	3	4	5	6	7
d) Quality	1	2	3	4	5	6	7
e) Financial Management	1	2	3	4	5	6	7

20. Risk taking by senior executives:

1	2	3	4	5	6	7
Avoiding			Netrual			Taking high risks

IV. Forecasting

21. Is forecasting function necessary in your company?

a) For finished goods Yes ☐ No ☐

b) For modularized items Yes ☐ No ☐

c) For raw materials/components Yes ☐ No ☐

22. If answer for question 21 is yes, please comment the extent of forecasting errors. If no, please go to question 23.

	Extremely accurate						Extremely inaccurate
a) For finished goods	1	2	3	4	5	6	7
b) For modularized items	1	2	3	4	5	6	7
c) For raw materials	1	2	3	4	5	6	7

V. Master Production Schedule (MPS)

23. Is MPS necessary in your company?

Yes ☐ No ☐

(If yes, please answer questions 24 – 25. If no, please go to question 26.)

24. MPS items of your company:

Finished goods ☐ Modularized BOM ☐

Customer orders ☐ Others:_____

25. Time considerations:

MPS time horizon _____months;

MPS replanning interval _____months;

MPS frozen interval _____months.

(Please go to question 27.)

26. Please state reasons why MPS is not necessary.

Reasons:_____

_____

_____

VI. Capacity Planning (CRP)

27. Is CRP necessary in your company?

Yes ☐ No ☐

(If yes, please answer questions 28 – 31. If no, please answer 32.)

28. The planning horizon for CRP: _____months.

29. When order requirements are expected to exceed capacity, what actions are taken?

Decline orders ☐ Subcontracting ☐ Work overtime ☐

Others:_____

30. Please state the number of subcontractors in your organization:_____

31. (a) How do you rate the relationship between subcontractors with your company.

1 2 3 4 5 6 7

Excellent Poor

(b) How do you rate the level of interactions with your subcontractors?

1 2 3 4 5 6 7

Extremely Low Extremely High

(Please go to question 33.)

32. Please state reasons why CRP is not necessary.

Reasons:_____

_____

_____

VII. Materials Planning

33. Is materials planning used in your company?

Yes ☐ No ☐

(If yes, please answer questions 34 – 36. If no, please answer 37.)

34. It is used to determine:

Vendor order ☐ Shop order ☐ Both ☐

35. Which type of materials planning system does your company apply?

MRP ☐ MRPII ☐ OPT ☐ JIT ☐

CONWIP ☐ ERP ☐ Others:_____

Please name of software package:_____

36. The planning horizon is _____weeks.

(Please go to question 38.)

37. Please state reasons why MRP is not necessary.

Reasons:_____

_____

_____

VIII. Purchasing

38. Please state the number of suppliers:_____.

39. Nature of supplies

Local supplies_____% Overseas supplies_____%

40. (a) How do you rate the relationship between suppliers with your company.

1	2	3	4	5	6	7
Excellent						Poor

(b) How do you rate the level of interactions with your suppliers?

1	2	3	4	5	6	7
Extremely Low						Extremely High

IX. Capacity control

41. How does your company adjust the plant capacity?

Orders postponed ☐ Working overtime ☐ Subcontracting ☐

X. Purchasing control

42. Which strategy does your company used?

Multiple sources of supplies ☐ Few sources of supplies ☐

XI. Inventory control

43. State which decoupling point of inventory does you used.

End-item ☐ Sub-assembly ☐ Component ☐

44. (a) How does your company decide the level of inventories?

EOQ ☐ Forecasting ☐ Value of items ☐

Economic situation ☐ Actual customer order ☐ Demand fluctuation ☐

Management skills ☐ ABC control ☐ Others:_____

(b) How do you rate the level of inventory in your organization?

1	2	3	4	5	6	7
Extremely Low						Extremely High

45. How frequent does your company taking the physical count of inventory?

Once in every _____ months.

XII. Information Technology

46. (a) Does your company computerize your operations?

Yes ☐ No ☐

(If yes, please answer questions 46(a), 47 and 48. If no, please answer 49.)

47. State which areas your computer(s) is/are on site:

Forecasting ☐ MPS ☐ Purchasing control ☐

Data control ☐ Purchasing orders ☐ Shop order planning ☐

CRP ☐ Capacity control ☐ Shop floor control ☐

MRP ☐ Inventory control ☐ Change control ☐

Documentation control ☐ Performance measurement ☐

48. How would your company describe the role of software and hardware suppliers for the effectiveness of MPC system?

_____

_____

_____(Please go to question 50.)

49. State reasons why computerization is not used for manufacturing planning and control?
Reasons:_____

_____

_____

XIII. Interdepartmental relationships

50. Are interdepartmental relationships important for the effectiveness of manufacturing system?

Yes ☐ No ☐

Reasons: _____

_____

_____

51. How do you rate the interdepartmental relationships in your organization?

1 2 3 4 5 6 7

Excellent Poor

XIV. Inter-site Communication

52. If your company has offices/plants in two or more locations, please indicate the communication channels:

Internet ☐ E-mail ☐ Fax ☐ EDI ☐

Phone ☐ Telex ☐ Others:_____

XV. Customer Profile

53. (a) Please state the number of customers in your organization:_____.

(b) How do you rate the level of interactions with your customers?

1 2 3 4 5 6 7

Extremely Low — Extremely High

54. Nature of customers:

Local orders:_____% Overseas orders:_____%

55. Please state the percentage of the following types of orders:

strangers:_____% repeaters:_____% runners:_____%

(Definitions:
Strangers: Customers are rarely placing orders.
Repeaters: Customers are occasionally placing orders.
Runners: Customers are regularly placing orders.)

56. Average delivery time per order:_____week(s).

57. By what means does your customers place their orders.

Internet	☐	E-mail	☐	Fax	☐	EDI	☐
Phone	☐	Telex	☐	Post	☐		

Others:_____

XVI. Performance rating

58. How do you rate the priorities of the following critical success factors (for the past 3 years)?

	Top priority						Lowest priority
a) Manufacturing cost	1	2	3	4	5	6	7
b) Product development	1	2	3	4	5	6	7
c) Product quality	1	2	3	4	5	6	7
d) Goods delivery	1	2	3	4	5	6	7
e) Sales revenues	1	2	3	4	5	6	7
f) Sales growth rate	1	2	3	4	5	6	7
g) Information flow	1	2	3	4	5	6	7
h) Gross profit margin	1	2	3	4	5	6	7

59. How do you rate the performance of the following critical success factors relative to your competitors (for the past 3 years)?

	Excellent						Poor
a) Manufacturing cost	1	2	3	4	5	6	7
b) Product development	1	2	3	4	5	6	7
c) Product quality	1	2	3	4	5	6	7
d) Goods delivery	1	2	3	4	5	6	7
e) Sales revenues	1	2	3	4	5	6	7
f) Sales growth rate	1	2	3	4	5	6	7
g) Information flow	1	2	3	4	5	6	7
h) Gross profit margin	1	2	3	4	5	6	7

60. How do you rate the performance of the following MPC modules and the overall MPC performance of your organization (for the past 3 years)?

	Excellent						Poor
a) MPS	1	2	3	4	5	6	7
b) CRP	1	2	3	4	5	6	7
c) MRP	1	2	3	4	5	6	7
d) Purchasing	1	2	3	4	5	6	7
e) Inventory management	1	2	3	4	5	6	7
f) Overall MPC performance	1	2	3	4	5	6	7

<u>ABBREVIATION (for MPC system)</u>

MPC = Manufacturing Planning & Control

MRP = Materials Requirements Planning

MRPII = Manufacturing Resources Planning

OPT = Optimized Production technology

JIT = Just-in-time Production

CONWIP = Constant Work-in-Process

ERP = Enterprise Resources Planning

MPS = Master Production Schedule

CRP = Capacity Requirement Planning

EOQ = Economic Order Quantity

XVII. Please tick as appropriate which strategic archetype your organization is adopted:

☐ A "defender" organization tends to create a stable domain. Its target is to produce a limited set of products and maintain a small niche within the industry. It emphasizes technological efficiency by continuous reduction in distribution, production and administration costs.

☐ A "prospector" organization strives to be an innovator in product and market development. Its environment is neither stable nor predictable because of the new market domains. A strong orientation in technological and administrative flexibility is necessary in response to a rapidly changing environment, but production and distribution efficiency is hardly achieved because of the under-utilization or mis-utilization of physical, financial, and human resources.

☐ An "analyser" organization has good adaptation capabilities endeavouring to minimize risk and maximize opportunities for profit. It tends to imitate the successful prospector products and modifies them for the market. The strategic orientation is a combination of defender and prospector types.

☐ A "reactor" organization has no clear strategic focus. It responds to its organizational environment ineffectively and is forced to adjust its strategy-structure by pressures. The type of organization lacks clear articulated strategy and it has a rigid strategy-structure despite the changes in environmental conditions.

XVIII. Please tick as appropriate which supply chain your organization is adopted:

☐ Lean supply chain is aimed at supplying functional products efficiently at the lowest possible cost with the prime focus on cost and quality.

☐ Agile supply chain is aimed at supplying innovative products with the prime focus on speed, flexibility and quality.

☐ Leagile supply chain combines the lean and agile paradigms for effective and efficient manufacturing. On the upstream side of decoupling point, lean manufacturing is adopted in order to achieve cost-effectiveness. On the downstream side, agile manufacturing is applied in order to achieve a high service level for the end-users.

One-Sample Statistics

Variable	N	Mean	Std. Deviation	Std. Error Mea
Miles & Snow's archetype	11	2.47	1.0	9.60E-0
Supply chain strategy	11	1.72	.82	7.63E-0
Ownership structure	11	1.35	.48	4.46E-0
No. of employees	11	2151.48	3427.0	318.20
Age of company	11	20.996	15.509	1.44
Business sector	11	4.43	2.0	.19
Nature of market:home	11	23.307	32.869	3.05
Nature of market:export	11	84.374	91.824	8.52
Company headquarters	11	1.81	1.3	.12
Production location	11	1.55	.96	8.94E-0
Revenues (HK$ in million)	11	850.0429	1818.307	171.8139
OEM %	9	47.42	40.2	4.11
ODM %	9	54.16	40.1	4.05
No. of main products	10	96248.162	975849.31	95233.14
Product ranges	9	10780.298	100520.98	10102.73
No. of raw mat'l	9	22572.68	132070.0	13695.03
No. of components per product	9	292.167	1137.50	114.323
No. of item levels per product	9	63.300	273.793	28.860
Rate of new product introduction	10	184.87	1001.24	99.1
Product families	11	1.05	.26	2.42E-0
Level of common parts	11	1.96	.64	6.03E-0
ordering profile: Make-to-order	11	1.13	.34	3.15E-0
ordering profile: Make-to-stock	11	1.75	.44	4.07E-0
ordering profile: assemble-to-stock	11	1.97	.18	1.72E-0
ordering profile: Engineer-to-order	11	1.90	.30	2.75E-0
Change in customer demands	11	4.57	1.5	.14
Rate of new products introducted	11	5.29	1.0	9.41E-0
Rate of product getting obsolete	11	3.92	1.4	.14
Change in marketing practices	11	4.42	1.2	.12
Change in production methods	11	3.51	1.4	.14
Marketing-oriented	11	2.53	1.5	.14
Product development focus	11	2.63	1.5	.14
Manaufacturing focus	11	2.97	1.3	.12
Quality focus	11	2.49	1.2	.11
Finance focus	11	2.70	1.2	.12
Risk taking	11	3.83	1.2	.12
Finished goods forecast	11	1.25	.43	4.08E-0
Modularized items forecast	10	1.51	.50	4.81E-0
Raw materials forecast	11	1.21	.41	3.81E-0
Forecast erros:Finished goods	9	3.59	1.3	.14
Forecast errors: Modularized items	5	3.64	1.1	.14
Forecast errors: Raw materials	9	3.62	1.3	.13
MPS	11	1.17	.38	3.52E-0
MPS items: Finished goods	9	1.29	.46	4.66E-0
MPS items: Modularized BOM	9	1.71	.46	4.66E-0
MPS items: Customer orders	9	1.48	.54	5.54E-0
MPS time horizon	8	3.736	3.48	.373
MPS replanning interval	7	1.4166	1.6217	.184
MPS frozen interval	5	1.4105	1.7386	.234
CRP	11	1.25	.43	4.05E-0
CRP planning horizon	8	5.062	4.58	.509

Subcontracting	9	1.41	.50	5.16E-0
No. of subcontractors	8	148.784	1072.69	114.349
Subcontracting relationship	7	3.20	1.1	.13
Materials planning	11	1.10	.30	2.75E-0
MRP order	10	2.11	.94	9.26E-0
Types of materials planning	9	2.65	2.1	.22
MRP planning horizon	7	6.706	10.620	1.20
No. of suppliers	10	1187.86	9786.88	955.10
Local supplies	10	50.37	30.7	2.98
Oversas supplies	10	48.89	30.9	3.00
Supplier relationship	10	3.32	1.1	.11
Plant capacity:subcontracting	11	1.52	.50	4.76E-0
Purchasing control	11	1.46	.50	4.73E-0
Decoupling point: End-item	11	1.70	.46	4.33E-0
Decoupling point: Sub-assembly	11	1.76	.43	4.03E-0
Decoupling point: Component	11	1.37	.49	4.57E-0
Inventory Management	11	1.59	1.1	.11
Physical count	10	6.17	4.3	.43
Computerization	11	1.13	.34	3.13E-0
Level of Compuertization	10	2.23	.75	7.43E-0
Interdepartmental relationship	11	1.07	.26	2.40E-0
Interdepartmental relationship rating	11	3.66	1.2	.12
Interdepartmental communication channel	11	1.23	.42	3.95E-0
No. of customers	11	271798.25	2847344.0	270257.9
Local orders	11	28.23	34.0	3.20
Overseas orders	11	72.65	33.4	3.14
Strangers	11	12.02	17.1	1.63
Repeaters	11	34.09	26.9	2.57
Runners	11	54.58	31.5	2.98
Delivery time per order	10	8.109	13.070	1.25
Communication channel: Customers	11	1.36	.48	4.49E-0
Competitive strategy: cost	11	2.32	1.1	.10
Competitive strategy: Product development	11	2.48	1.4	.13
Competitive strategy: Product quality	11	2.34	1.2	.11
Competitive strategy: Goods delivery	11	2.69	1.2	.11
Competitive strategy: Sales revenues	11	2.42	1.1	.10
Competitive strategy: Sales growth rate	11	2.84	1.1	.11
Compeitive strategy: Information flow	11	3.43	1.3	.12
Competitive strategy: Gross profit margin	11	2.72	1.1	.11
Performance: Cost	11	3.11	1.38	.13
Performance: Product development	11	3.10	1.4	.13
Performance: Product quality	11	2.82	1.2	.11
Performance: Goods delivery	11	3.10	1.3	.12
Performance: Sales revenues	11	2.85	1.1	.11
Performance: Sales growth rate	11	3.03	1.1	.11
Performance: Information flow	11	3.51	1.2	.12
Performance: Profit margin	11	3.22	1.1	.11
Overall performance	11	3.03	1.0	9.56E-0

One-Sample Test

	t	df	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
Miles & Snow's archetype	25.774	11	2.4	2.28	2.66
Supply chain strategy	22.491	11	1.7	1.56	1.87
Ownership structure	30.362	11	1.3	1.27	1.44
No. of employees	6.76	11	2151.4	1521.20	2781.77
Age of company	14.580	11	20.99	18.143	23.848
Business sector	23.902	11	4.4	4.06	4.80
Nature of market: home	7.63	11	23.30	17.262	29.352
Nature of market: export	9.89	11	84.37	67.487	101.262
Company headquarters	14.791	11	1.8	1.57	2.05
Production location	17.351	11	1.5	1.37	1.73
Revenues (HK$)	4.94	11	850.042	509.5822	1190.503
OEM %	11.543	9	47.4	39.26	55.5
ODM %	13.360	9	54.1	46.12	62.2
No. of main products	1.01	10	96248.16	-92602.733	285099.05
Product ranges	1.06	9	10780.29	-9268.259	30828.85
No. of raw materials	1.64	9	22572.6	-4626.83	49772.19
No. of components per product	2.55	9	292.16	65.296	519.037
No. of item levels per product	2.19	8	63.30	5.955	120.645
Rate of new product introduction	1.86	10	184.8	-11.79	381.53
Product families	43.452	11	1.0	1.00	1.10
Level of common parts	32.461	11	1.9	1.84	2.08
ordering profile: Make-to-order	35.839	11	1.1	1.07	1.19
ordering profile: Make-to-stock	42.973	11	1.7	1.67	1.83
ordering profile: assemble-to-stock	114.517	11	1.9	1.93	2.0
ordering profile: Engineer-to-order	69.133	11	1.9	1.85	1.96
Change in customer demands	32.825	11	4.5	4.29	4.84
Rate of new products introduced	56.271	11	5.2	5.11	5.48
Rate of product getting obsolete	28.298	11	3.9	3.65	4.20
Change in marketing practices	37.495	11	4.4	4.18	4.65
Change in production methods	25.896	11	3.5	3.24	3.78
Marketing-oriented	17.992	11	2.5	2.25	2.80
Product development focus	18.201	11	2.6	2.34	2.91
Manufacturing focus	24.107	11	2.9	2.72	3.21
Quality focus	22.267	11	2.4	2.27	2.71
Finance focus	23.073	11	2.7	2.47	2.93
Risk taking	32.035	11	3.8	3.60	4.07
Finished goods forecast	30.587	11	1.2	1.17	1.33
Modularized items forecast	31.475	10	1.5	1.42	1.61
Raw materials forecast	31.757	11	1.2	1.13	1.28
Forecast erros: Finished goods	25.875	9	3.5	3.32	3.87
Forecast errors: Modularized items	25.109	5	3.6	3.35	3.93
Forecast errors: Raw materials	26.851	9	3.6	3.36	3.89
MPS	33.284	11	1.1	1.10	1.24
MPS items: Finished goods	27.698	9	1.2	1.20	1.38
MPS items: Modularized BOM	36.633	9	1.7	1.62	1.80
MPS items: Customer orders	26.715	9	1.4	1.37	1.59
MPS time horizon	10.015	8	3.73	2.995	4.47
MPS replanning interval	7.66	7	1.416	1.0485	1.7847
MPS frozen interval	6.01	5	1.410	.9405	1.8805
CRP	30.761	11	1.2	1.17	1.33
CRP planning horizon	9.94	8	5.06	4.049	6.07

Subcontracting	27.376	9	1.4	1.31	1.52
No. of subcontractors	1.30	8	148.78	-78.498	376.066
Subcontracting relationship	24.135	7	3.2	2.93	3.46
Materials planning	39.775	11	1.1	1.04	1.15
MRP order	22.743	10	2.1	1.92	2.29
Types of materials planning	12.154	9	2.6	2.21	3.08
MRP planning horizon	5.57	7	6.70	4.311	9.10
No. of suppliers	1.24	10	1187.8	-706.14	3081.86
Local supplies	16.932	10	50.3	44.48	56.2
Overseas supplies	16.321	10	48.8	42.95	54.8
Supplier relationship	29.059	10	3.3	3.09	3.55
Plant capacity: Subcontracting	31.969	11	1.5	1.43	1.62
Purchasing control	30.933	11	1.4	1.37	1.56
Decoupling point: End-item	39.206	11	1.7	1.61	1.78
Decoupling point: Sub-assembly	43.705	11	1.7	1.68	1.84
Decoupling point: Component	30.039	11	1.3	1.28	1.46
Inventory Management	15.067	11	1.5	1.38	1.80
Physical count	14.318	9	6.1	5.31	7.02
Computerization	36.092	11	1.1	1.07	1.19
Level of Computerization	29.981	10	2.2	2.08	2.38
Interdepartmental relationship	44.535	11	1.0	1.02	1.12
Interdepartmental relationship rating	31.505	11	3.6	3.43	3.89
Interdepartmental communication	31.113	11	1.2	1.15	1.31
No. of customers	1.00	11	271798.2	-263789.54	807386.0
Local orders	8.82	11	28.2	21.89	34.5
Overseas orders	23.103	11	72.6	66.42	78.8
Strangers	7.37	11	12.0	8.79	15.2
Repeaters	13.273	10	34.0	29.00	39.1
Runners	18.325	11	54.5	48.68	60.4
Delivery time per order	6.44	10	8.10	5.616	10.602
Communication channel: Customers	30.239	11	1.3	1.27	1.45
Competitive strategy: cost	22.382	11	2.3	2.11	2.52
Competitive strategy: Product develop	18.602	11	2.4	2.21	2.74
Competitive strategy: Product quality	20.519	11	2.3	2.12	2.57
Competitive strategy: Goods delivery	24.197	11	2.6	2.47	2.91
Competitive strategy: Sales revenues	23.791	11	2.4	2.22	2.62
Competitive strategy: Sales growth	25.906	11	2.8	2.62	3.05
Competitive strategy: Information flow	28.131	11	3.4	3.19	3.67
Competitive strategy: Profit margin	24.631	11	2.7	2.51	2.94
Performance: Cost	24.370	11	3.1	2.86	3.37
Performance: Product development	23.605	11	3.1	2.84	3.36
Performance: Product quality	25.332	11	2.8	2.60	3.04
Performance: Goods delivery	25.685	11	3.1	2.86	3.34
Performance: Sales revenues	25.853	11	2.8	2.63	3.07
Performance: Sales growth rate	27.899	11	3.0	2.81	3.24
Performance: Information flow	29.478	11	3.5	3.27	3.74
Performance: Profit margin	30.162	11	3.2	3.00	3.43
Overall performance	31.749	11	3.0	2.85	3.22

Runs Test

	Miles & Snow's archetype	Supply chain strategy	No. of employees	Age of company	Business sector
Test Value	2.00	1.00[b]	1000.00	17.000	4.0
Cases < Test Value	22	0	5	57	2
Cases >= Test Value	94	116	6	59	9
Total Cases	116	116	11	116	11
Number of Runs	41	1[c]	5	58	3
Z	1.325		-1.48	-.183	-1.16
Asymp. Sig. (2-tailed)	.185		.13	.855	.24

a Median
b All values are greater than or less than the cutoff. Runs Test cannot be performed.
c Only one run occurs. Runs Test cannot be performed.

Runs Test

	Nature of market: home	Nature of market: export	Revenues (HK$)	OEM %	ODM %
Test Value	5.000	95.000	190.000	30.00	70.0
Cases < Test Value	53	57	5	42	4
Cases >= Test Value	63	59	5	54	5
Total Cases	116	116	11	96	9
Number of Runs	58	64	5	37	2
Z	-.107	.936	-1.13	-2.346	-4.25
Asymp. Sig. (2-tailed)	.915	.349	.25	.019	.00

Runs Test

	No. of main products	Product ranges	No. of raw materials	No. of components per product	No. of item levels per product
Test Value	4.000	10.000	300.00	40.000	4.00
Cases < Test Value	38	44	4	49	3
Cases >= Test Value	67	55	4	50	6
Total Cases	105	99	9	99	9
Number of Runs	49	54	4	49	3
Z	-.105	.841	.32	-.302	-.47
Asymp. Sig. (2-tailed)	.916	.400	.74	.763	.633

Runs Test

	Rate of new product introduction	Product families	Level of common parts	Ordering profile: Make-to-order	Ordering profile: Make-to-stock
Test Value	15.00	1.00	2.0	1.00[b]	2.0
Cases < Test Value	50	1	2	0	2
Cases >= Test Value	52	114	8	115	8
Total Cases	102	115	11	115	11
Number of Runs	50	3	3	1[c]	3
Z	-.394	.133	-1.11		-1.33
Asymp. Sig. (2-tailed)	.693	.894	.26		.18

Runs Test

	Ordering profile: assemble-to-stock	Ordering profile: Engineer-to-order	Change in customer demands	Rate of new products introduced	Rate of product getting obsolete
Test Value	2.0	2.0	5.00	5.0	4.0
Cases < Test Value	4	1	48	1	4
Cases >= Test Value	11	10	68	9	6
Total Cases	11	11	116	11	11
Number of Runs	9	2	63	2	5
Z	.41	.05	1.101	-1.22	-1.45
Asymp. Sig. (2-tailed)	.68	.95	.271	.22	.14

Runs Test

	Change in marketing practices	Change in production methods	Marketing-oriented	Product development focus	Manufacturing focus
Test Value	5.00	4.00	2.0	2.0	3.00
Cases < Test Value	57	53	3	3	4
Cases >= Test Value	58	61	8	8	7
Total Cases	115	114	11	11	11
Number of Runs	55	68	5	4	5
Z	-.655	1.944	.21	.64	-.20
Asymp. Sig. (2-tailed)	.513	.052	.83	.51	.83

Runs Test

	Quality focus	Finance focus	Risk taking	Finished goods forecast	Modularized items forecast
Test Value	2.00	3.00	4.0	1.00[b]	2.0
Cases < Test Value	26	55	3	0	5
Cases >= Test Value	90	61	7	113	5
Total Cases	116	116	11	113	10
Number of Runs	46	69	5	1[c]	5
Z	1.253	1.899	1.46		-.47
Asymp. Sig. (2-tailed)	.210	.058	.14		.63

Runs Test

	Raw materials forecast	Forecast errors: Finished goods	Forecast errors: Modularized items	Forecast errors: Raw materials	MPS items: Finished goods
Test Value	1.00[b]	4.00	4.0	4.00	1.00[b]
Cases < Test Value	0	44	2	45	0
Cases >= Test Value	115	47	3	48	9
Total Cases	115	91	5	93	9
Number of Runs	1[c]	45	3	47	1[c]
Z		-.306	.88	-.094	
Asymp. Sig. (2-tailed)		.759	.37	.925	

Runs Test

	MPS items: Modularized BOM	MPS items: Customer orders	MPS time horizon	MPS replanning interval	CRP planning horizon
Test Value	2.00	1.00[b]	2.00	1.0000	3.00
Cases < Test Value	28	0	3	22	3
Cases >= Test Value	68	96	5	55	5
Total Cases	96	96	8	77	8
Number of Runs	43	1[c]	3	26	3
Z	.581		-1.74	-1.812	-2.19
Asymp. Sig. (2-tailed)	.561		.08	.070	.02

Runs Test

	No. of subcontractors	Subcontracting relationship	MRP order	Types of materials planning	MRP planning horizon
Test Value	5.00	3.00	2.50	2.00	4.00
Cases < Test Value	3	21	52	39	3
Cases >= Test Value	4	55	52	54	4
Total Cases	8	76	104	93	7
Number of Runs	4	30	49	38	3
Z	-.52	-.404	-.788	-1.775	-1.36
Asymp. Sig. (2-tailed)	.59	.686	.431	.076	.17

Runs Test

	Local supplies	Overseas supplies	Supplier relationship	Plant capacity: subcontracting	Purchasing control
Test Value	50.00	50.00	3.0	2.00	1.00[b]
Cases < Test Value	47	50	3	53	0
Cases >= Test Value	60	57	7	58	11
Total Cases	107	107	10	111	11
Number of Runs	41	41	4	58	1[c]
Z	-2.507	-2.589	-1.08	.308	
Asymp. Sig. (2-tailed)	.012	.010	.27	.758	

Runs Test

	Decoupling point: End-item	Decoupling point: Sub-assembly	Decoupling point: Component	Inventory Management	Physical count
Test Value	2.00	2.00	1.00[b]	2.00	6.0
Cases < Test Value	34	27		55	3
Cases >= Test Value	79	86	11	56	6
Total Cases	113	113	11	111	10
Number of Runs	52	39	1[c]	55	4
Z	.779	-.807		-.285	.08
Asymp. Sig. (2-tailed)	.436	.419		.775	.93

Runs Test

	Level of Computerization	Interdepartmental relationship rating	No. of customers	Local orders	Overseas orders
Test Value	2.0	3.00	30.0	10.0	90.0
Cases < Test Value	1	19	4	4	5
Cases >= Test Value	8	95	6	6	5
Total Cases	10	114	11	11	11
Number of Runs	3	32	5	5	4
Z	1.03	-.227	.10	-1.08	-1.78
Asymp. Sig. (2-tailed)	.30	.820	.92	.27	.07

Runs Test

	Strangers	Repeaters	Runners	Delivery time per order	Competitive strategy: cost
Test Value	10.00	27.50	60.0	4.000	2.0
Cases < Test Value	52	55	4	38	3
Cases >= Test Value	59	55	6	70	8
Total Cases	111	110	11	108	11
Number of Runs	48	64	5	60	4
Z	-1.585	1.533	-.63	2.067	-.81
Asymp. Sig. (2-tailed)	.113	.125	.52	.039	.41

Runs Test

	Competitive strategy: Product development	Competitive strategy: Product quality	Competitive strategy: Goods delivery	Competitive strategy: Sales revenues	Competitive strategy: Sales growth rate
Test Value	2.00	2.00	3.0	2.00	3.0
Cases < Test Value	34	32	5	25	4
Cases >= Test Value	81	84	6	91	7
Total Cases	115	116	11	116	11
Number of Runs	49	46	5	39	5
Z	.024	-.315	-.13	-.339	.09
Asymp. Sig. (2-tailed)	.981	.753	.89	.735	.92

Runs Test

	Competitive strategy: Information flow	Competitive strategy: Gross profit margin	Performance: Cost	Performance: Product development	Performance: Product quality
Test Value	3.00	3.00	3.0	3.00	3.0
Cases < Test Value	26	51	3	45	5
Cases >= Test Value	90	65	7	70	6
Total Cases	116	116	11	115	11
Number of Runs	38	55	5	57	5
Z	-.900	-.597	.61	.239	-1.12
Asymp. Sig. (2-tailed)	.368	.550	.53	.811	.26

Runs Test

	Performance: Goods delivery	Performance: Sales revenues	Performance: Sales growth rate	Performance: Information flow
Test Value	3.00	3.0	3.00	4.0
Cases < Test Value	41	5	41	5
Cases >= Test Value	75	6	75	6
Total Cases	116	11	116	11
Number of Runs	57	6	52	5
Z	.609	.40	-.412	.01
Asymp. Sig. (2-tailed)	.542	.68	.680	.99

Runs Test

	Performance: Profit margin	Overall performance
Test Value	3.00	3.0
Cases < Test Value	26	3
Cases >= Test Value	90	7
Total Cases	116	11
Number of Runs	37	5
Z	-1.169	-.08
Asymp. Sig. (2-tailed)	.242	.93

Education of Respondents

Ranks

	Education (2nd sample)	N	Mean Rank	Sum of Ranks
Education	Degree	29	20.36	590.50
	HD	10	18.95	189.50
	Total	39		

Test Statistics

	Education
Mann-Whitney U	134.500
Wilcoxon W	189.500
Z	-.389
Asymp. Sig. (2-tailed)	.697
Exact Sig. [2*(1-tailed Sig.)]	.740

a Not corrected for ties.
b Grouping Variable: Education (2nd sample)

Age of Respondents

Ranks

	Age of Respondents (2nd sample)	N	Mean Rank	Sum of Ranks
Range of age	20-30	28	20.29	568.00
	31-40	11	19.27	212.00
	Total	39		

Test Statistics

	Range of age
Mann-Whitney U	146.000
Wilcoxon W	212.000
Z	-.266
Asymp. Sig. (2-tailed)	.791
Exact Sig. [2*(1-tailed Sig.)]	.818

a Not corrected for ties.
b Grouping Variable: range of age (2nd sample)

Age of Company

Ranks

	Age of company (2nd sample)	N	Mean Rank	Sum of Ranks
Age of the Company	1-9	16	14.78	236.50
	10-19	12	14.13	169.50
	Total	28		

Test Statistics

	Age of the Company
Mann-Whitney U	91.500
Wilcoxon W	169.500
Z	-.226
Asymp. Sig. (2-tailed)	.821
Exact Sig. [2*(1-tailed Sig.)]	.837

a Not corrected for ties.

b Grouping Variable: Age of company (2nd sample)

Number of Employees of Company

Ranks

	Size of company (2nd sample)	N	Mean Rank	Sum of Ranks
Size of the company	1-500	21	19.31	405.50
	501-1500	14	16.04	224.50
	Total	35		

Test Statistics

	Size of the company
Mann-Whitney U	119.500
Wilcoxon W	224.500
Z	-1.030
Asymp. Sig. (2-tailed)	.303
Exact Sig. [2*(1-tailed Sig.)]	.359

a Not corrected for ties.

b Grouping Variable: Size of company (2nd sample)

Location of Headquarters

Ranks

	Headquarters (2nd sample)	N	Mean Rank	Sum of Ranks
Headquarters	Hong Kong	29	15.47	448.50
	China	1	16.50	16.50
	Total	30		

Test Statistics

	Headquarters
Mann-Whitney U	13.500
Wilcoxon W	448.500
Z	-.149
Asymp. Sig. (2-tailed)	.881
Exact Sig. [2*(1-tailed Sig.)]	.933

a Not corrected for ties.

b Grouping Variable: Headquarters (2nd sample)

Make-to-order Strategy

Ranks

	Ordering profile: MTO (2nd sample)	N	Mean Rank	Sum of Ranks
Ordering profile: Make-to-order	Yes	33	19.91	657.00
	No	6	20.50	123.00
	Total	39		

Test Statistics

	Ordering profile: Make-to-order
Mann-Whitney U	96.000
Wilcoxon W	657.000
Z	-.141
Asymp. Sig. (2-tailed)	.888
Exact Sig. [2*(1-tailed Sig.)]	.924

a Not corrected for ties.

b Grouping Variable: ordering profile: MTO (2nd sample)

Make-to-stock Strategy

Ranks

	Ordering profile: Make-to-stock	N	Mean Rank	Sum of Ranks
Ordering profile: MTS (2nd sample)	Yes	21	19.62	412.00
	No	17	19.35	329.00
	Total	38		

Test Statistics

	Ordering profile: MTS (2nd sample)
Mann-Whitney U	176.000
Wilcoxon W	329.000
Z	-.109
Asymp. Sig. (2-tailed)	.913
Exact Sig. [2*(1-tailed Sig.)]	.954

a Not corrected for ties.

b Grouping Variable: ordering profile: Make-to-stock

Assemble-to-stock Strategy

Ranks

	Ordering profile: assemble-to-stock	N	Mean Rank	Sum of Ranks
Ordering profile: ATS (2nd sample)	Yes	7	19.79	138.50
	No	31	19.44	602.50
	Total	38		

Test Statistics

	Ordering profile: ATS (2nd sample)
Mann-Whitney U	106.500
Wilcoxon W	602.500
Z	-.119
Asymp. Sig. (2-tailed)	.905
Exact Sig. [2*(1-tailed Sig.)]	.941

Engineering-to-order Strategy

Ranks

	Ordering profile: Engineer-to-order	N	Mean Rank	Sum of Ranks
Ordering profile: ETO (2nd sample)	Yes	11	20.00	220.00
	No	27	19.30	521.00
	Total	38		

Test Statistics

	Ordering profile: ETO (2nd sample)
Mann-Whitney U	143.000
Wilcoxon W	521.000
Z	-.638
Asymp. Sig. (2-tailed)	.523
Exact Sig. [2*(1-tailed Sig.)]	.874

a Not corrected for ties.
b Grouping Variable: ordering profile: Engineer-to-order

Job Title

Ranks

	Job title (2nd sample)	N	Mean Rank	Sum of Ranks
Job title	Top management	8	10.63	85.00
	Senior Management	13	11.23	146.00
	Total	21		

Test Statistics

	Job title
Mann-Whitney U	49.000
Wilcoxon W	85.000
Z	-.233
Asymp. Sig. (2-tailed)	.816
Exact Sig. [2*(1-tailed Sig.)]	.860

a Not corrected for ties.
b Grouping Variable: Job title (2nd sample)

Product Family

Ranks

	Product families (2nd sample)	N	Mean Rank	Sum of Ranks
Product families	Yes	35	19.60	686.00
	No	3	18.33	55.00
	Total	38		

Test Statistics

	Product families
Mann-Whitney U	49.000
Wilcoxon W	55.000
Z	-.224
Asymp. Sig. (2-tailed)	.823
Exact Sig. [2*(1-tailed Sig.)]	.879

Level of Common Components

Ranks

	Level of common parts (2nd sample)	N	Mean Rank	Sum of Ranks
Level of common parts	High	7	11.07	77.50
	Medium	24	17.44	418.50
	Total	31		

Test Statistics

	Level of common parts
Mann-Whitney U	49.500
Wilcoxon W	77.500
Z	-1.754
Asymp. Sig. (2-tailed)	.079
Exact Sig. [2*(1-tailed Sig.)]	.104

a Not corrected for ties.
b Grouping Variable: Level of common parts (2nd sample)

Implementation of MRP System

Ranks

	MRP (2nd Sample)	N	Mean Rank	Sum of Ranks
MRP	Yes	30	18.80	564.00
	No	9	24.00	216.00
	Total	39		

Test Statistics

	MRP
Mann-Whitney U	99.000
Wilcoxon W	564.000
Z	-1.389
Asymp. Sig. (2-tailed)	.165
Exact Sig. [2*(1-tailed Sig.)]	.241

a Not corrected for ties.

b Grouping Variable: MRP (2nd Sample)

MPS Planning Horizon

Ranks

	MPS time (2nd sample)	N	Mean Rank	Sum of Ranks
MPS time	1-6	37	19.66	727.50
	7-12	2	26.25	52.50
	Total	39		

Test Statistics

	MPS time
Mann-Whitney U	24.500
Wilcoxon W	727.500
Z	-1.197
Asymp. Sig. (2-tailed)	.231
Exact Sig. [2*(1-tailed Sig.)]	.456

a Not corrected for ties.

b Grouping Variable: MPS time (2nd sample)

Education of Respondents

Frequencies

	Education (2nd sample)	N
Education	Degree	29
	HD	10
	Total	39

Test Statistics

		Education
Most Extreme Differences	Absolute	.114
	Positive	.062
	Negative	-.114
Kolmogorov-Smirnov Z		.310
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: Education (2nd sample)

Age of Respondents

Frequencies

	Range of age (2nd sample)	N
Range of age	20-30	28
	31-40	11
	Total	39

Test Statistics

		Range of age
Most Extreme Differences	Absolute	.084
	Positive	.013
	Negative	-.084
Kolmogorov-Smirnov Z		.237
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: range of age (2nd sample)

Age of Company

Frequencies

	Age of company (2nd sample)	N
Age of the Company	1-9	16
	10-19	12
	Total	28

Test Statistics

		Age of the Company
Most Extreme Differences	Absolute	.104
	Positive	.021
	Negative	-.104
Kolmogorov-Smirnov Z		.273
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: Age of company (2nd sample)

Number of Employees of Company

Frequencies

	Size of company (2nd sample)	N
Size of the company	1-500	21
	501-1500	14
	Total	35

Test Statistics

		Size of the company
Most Extreme Differences	Absolute	.190
	Positive	.000
	Negative	-.190
Kolmogorov-Smirnov Z		.552
Asymp. Sig. (2-tailed)		.921

a Grouping Variable: Size of company (2nd sample)

Location of Headquarters

Frequencies

	Headquarters (2nd sample)	N
Headquarters	Hong Kong	27
	China	3
	Total	30

Test Statistics

		Headquarters
Most Extreme Differences	Absolute	.222
	Positive	.000
	Negative	-.222
Kolmogorov-Smirnov Z		.365
Asymp. Sig. (2-tailed)		.999

a Grouping Variable: Headquarters (2nd sample)

Make-to-order Strategy

Frequencies

	Ordering profile: MTO (2nd sample)	N
Ordering profile: Make-to-order	Yes	33
	No	6
	Total	39

Test Statistics

		Ordering profile: Make-to-order
Most Extreme Differences	Absolute	.121
	Positive	.121
	Negative	.000
Kolmogorov-Smirnov Z		.273
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: ordering profile: MTO (2nd sample)

Make-to-stock Strategy

Frequencies

	Ordering profile: MTS (2nd sample)	N
Ordering profile: Make-to-stock	Yes	31
	No	7
	Total	38

Test Statistics

		Ordering profile: Make-to-stock
Most Extreme Differences	Absolute	.023
	Positive	.000
	Negative	-.023
Kolmogorov-Smirnov Z		.055
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: ordering profile: MTS (2nd sample)

Assemble-to-stock Strategy

Frequencies

	Ordering profile: ATS (2nd sample)	N
Ordering profile: assemble-to-stock	Yes	6
	No	32
	Total	38

Test Statistics

		Ordering profile: assemble-to-stock
Most Extreme Differences	Absolute	.021
	Positive	.021
	Negative	.000
Kolmogorov-Smirnov Z		.047
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: ordering profile: ATS (2nd sample)

Engineering-to-order Strategy

No test result.

Job Title

Frequencies

	Job title (2nd sample)	N
Job title	Top management	8
	Senior Management	13
	Total	21

Test Statistics

		Job title
Most Extreme Differences	Absolute	.269
	Positive	.221
	Negative	-.269
Kolmogorov-Smirnov Z		.599
Asymp. Sig. (2-tailed)		.865

a Grouping Variable: Job title (2nd sample)

Product Family

Frequencies

	Product families (2nd sample)	N
Product families	Yes	35
	No	3
	Total	38

Test Statistics

		Product families
Most Extreme Differences	Absolute	.067
	Positive	.000
	Negative	-.067
Kolmogorov-Smirnov Z		.111
Asymp. Sig. (2-tailed)		1.000

a Grouping Variable: Product families (2nd sample)

Level of Common Components

Frequencies

	Level of common parts (2nd sample)	N
Level of common parts	High	7
	Medium	24
	Total	31

Test Statistics

		Level of common part
Most Extreme Differences	Absolute	.333
	Positive	.000
	Negative	-.333
Kolmogorov-Smirnov Z		.776
Asymp. Sig. (2-tailed)		.584

a Grouping Variable: Level of common parts (2nd sample)

Implementation of MRP System

Frequencies

	MRP (2nd Sample)	N
MRP	Yes	30
	No	9
	Total	39

Test Statistics

		MRP
Most Extreme Differences	Absolute	.267
	Positive	.267
	Negative	.000
Kolmogorov-Smirnov Z		.702
Asymp. Sig. (2-tailed)		.708

a Grouping Variable: MRP (2nd Sample)

MPS Planning Horizon

Frequencies

	MPS time (2nd sample)	N
MPS time	1-6	37
	7-12	2
	Total	39

Test Statistics

		MPS time
Most Extreme Differences	Absolute	.338
	Positive	.338
	Negative	.000
Kolmogorov-Smirnov Z		.465
Asymp. Sig. (2-tailed)		.982

a Grouping Variable: MPS time (2nd sample)

Correlation Matrix (For All Responding Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.	.																						
	N	116																						
MPS	Cor.	-.055	1.000																					
	Sig.	.634																						
	N	77	77																					
CRP	Cor.	-.175	**.420	1.000																				
	Sig.	.119	.001																					
	N	81	63	81																				
MRP	Cor.	.156	.125	.026	1.000																			
	Sig.	.137	.333	.842																				
	N	93	62	63	93																			
Purchase	Cor.	.138	-.165	.073	.058	1.000																		
	Sig.	.140	.150	.519	.584	.																		
	N	116	77	81	93	116																		
Inventory	Cor.	-.071	-.157	.006	-.179	.005	1.000																	
	Sig.	.458	.181	.956	.092	.955																		
	N	113	74	78	90	113	113																	
MPC	Cor.	-.150	-.072	-.016	-.114	-.004	.015	1.000																
	Sig.	.107	.535	.886	.278	.969	.876																	
	N	116	77	81	93	116	113	116																
comput	Cor.	**-.286	-.106	.037	.081	-.138	-.001	*.227	1.000															
	Sig.	.002	.358	.743	.437	.138	.991	.014	.															
	N	116	77	81	93	116	113	116	116															
extrel	Cor.	.149	-.086	.068	-.069	.106	.091	**.361	.049	1.000														
	Sig.	.122	.465	.553	.528	.272	.353	.000	.613															
	N	110	74	79	87	110	107	110	110	110														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	*.221	.116	.035	**.296	.143	.176	.111	-.086	**.536	1.000													
	Sig.	.017	.315	.757	.004	.127	.062	.236	.357	.000														
	N	116	77	81	93	116	113	116	116	110	116													
comstrg	Cor.	-.178	-.062	.000	.002	-.014	-.070	**.372	*.227	*.244	.142	1.000												
	Sig.	.057	.591	.999	.982	.879	.464	.000	.014	.010	.127													
	N	116	77	81	93	116	113	116	116	110	116	116												
invlevel	Cor.	.032	*-.265	-.036	-.171	.000	**.694	.003	.022	.062	.100	-.110	1.000											
	Sig.	.737	.023	.755	.106	.999	.000	.979	.818	.528	.292	.248												
	N	113	74	78	91	113	112	113	113	107	113	113	113											
dynamism	Cor.	.057	.115	.172	-.101	.156	.065	-.131	**-.329	.038	**.364	.011	-.058	1.000										
	Sig.	.544	.321	.124	.337	.094	.495	.160	.000	.696	.000	.909	.543	.										
	N	116	77	81	93	116	113	116	116	110	116	116	113	116										
compro	Cor.	-.108	.112	.079	-.031	-.097	-.053	**.250	**.249	.038	-.023	**.455	-.060	-.019	1.00									
	Sig.	.250	.334	.486	.767	.299	.578	.007	.007	.696	.808	.000	.530	.837	.									
	N	116	77	81	93	116	113	116	116	110	116	116	113	116	116									
Invdp1	Cor.	-.052	.074	.160	-.089	.003	.003	*.222	-.082	.098	.080	*.231	**-.249	.033	.137	1.000								
	Sig.	.586	.527	.161	.403	.973	.972	.018	.390	.317	.397	.014	.009	.728	.149									
	N	113	75	78	91	113	110	113	113	107	113	113	110	113	113	113								
Invdp2	Cor.	.080	.199	.107	.180	.072	-.081	.014	-.033	.062	.088	.072	-.121	.027	-.034	.040	1.000							
	Sig.	.399	.087	.352	.088	.451	.402	.880	.728	.524	.356	.449	.208	.778	.717	.677								
	N	113	75	78	91	113	110	113	113	107	113	113	110	113	113	113	113							
Invdp3	Cor.	.073	-.174	-.065	-.056	.003	.058	-.091	.137	-.091	-.067	-.083	-.018	.085	-.002	**-.454	**-.342	1.000						
	Sig.	.444	.136	.571	.598	.979	.547	.340	.149	.349	.483	.382	.849	.372	.980	.000	.000							
	N	113	75	78	91	113	110	113	113	107	113	113	110	113	113	113	113	113						
mto	Cor.	*.208	.066	.066	.108	.098	-.131	-.038	-.058	-.152	-.081	.070	-.109	-.096	.008	-.064	.009	*.188	1.000					
	Sig.	.026	.569	.558	.306	.299	.169	.685	.539	.113	.392	.456	.252	.309	.933	.503	.927	.048	.					
	N	115	76	81	92	115	112	115	115	110	115	115	112	115	115	112	112	112	115					
mts	Cor.	-.138	-.153	.016	-.054	-.093	.011	.097	-.024	.005	-.035	.161	-.046	-.076	.037	*.202	-.084	*-.203	**-.251	1.000				
	Sig.	.140	.186	.884	.612	.322	.905	.300	.797	.960	.709	.086	.634	.419	.695	.033	.376	.032	.007					
	N	115	76	81	92	115	112	115	115	110	115	115	112	115	115	112	112	112	115	115				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	-.033	.186	-.009	*.218	-.087	*-.215	.006	.057	-.007	-.031	-.022	-.121	.020	.001	-.127	.116	-.054	*-.208	.108	1.000			
	Sig.	.723	.107	.934	.037	.354	.023	.946	.547	.939	.744	.815	.205	.829	.995	.182	.221	.575	.025	.249	.			
	N	115	76	81	92	115	112	115	115	110	115	115	112	115	115	112	112	112	115	115	115			
eto	Cor.	*-.194	.026	-.091	-.029	.020	.174	-.046	.109	.026	-.004	.010	.137	-.152	.095	-.002	*.190	.043	**-.313	.015	.100	1.000		
	Sig.	.038	.823	.418	.780	.833	.067	.622	.247	.791	.963	.912	.151	.106	.315	.980	.045	.653	.001	.870	.289			
	N	115	76	81	92	115	112	115	115	110	115	115	112	115	115	112	112	112	115	115	115	115		
err	Cor.	-.003	-.140	-.063	.079	-.031	*.248	.150	-.024	**.260	**.564	.088	**.280	.179	.017	-.093	-.129	.119	-.065	-.064	-.134	.123	1.00	
	Sig.	.972	.237	.594	.476	.749	.011	.124	.803	.008	.000	.371	.004	.066	.866	.352	.194	.229	.512	.517	.173	.210	.	
	N	106	73	75	84	106	103	106	106	102	106	106	103	106	106	103	103	103	103	105	105	105	105	106
intersh	Cor.	-.010	.054	-.062	-.117	.108	*.241	**.348	.017	**.489	**.422	**.264	*.208	.020	.095	*.196	.066	-.161	-.079	-.011	-.131	.014	.133	1.000
	Sig.	.917	.643	.588	.266	.252	.011	.000	.860	.000	.000	.004	.028	.833	.315	.038	.489	.089	.408	.908	.168	.885	.180	
	N	114	76	79	92	114	111	114	114	108	114	114	111	114	114	11	11	11	113	11	113	11	104	11

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Correlation Matrix (For Defender Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.																							
	N	22																						
MPS	Cor.	-.169	1.000																					
	Sig.	.619																						
	N	11	11																					
CRP	Cor.	-.423	.355	1.000																				
	Sig.	.103	.284																					
	N	16	11	16																				
MRP	Cor.	.175	.531	.230	1.000																			
	Sig.	.518	.176	.522																				
	N	16	8	10	16																			
Purchase	Cor.	.166	-.291	-.307	.119	1.000																		
	Sig.	.461	.385	.247	.660																			
	N	22	11	16	16	22																		
Inventory	Cor.	.208	-.056	.178	-.104	.014	1.000																	
	Sig.	.352	.869	.510	.701	.950																		
	N	22	11	16	16	22	22																	
MPC	Cor.	-.016	.169	.077	-.189	.169	.005	1.000																
	Sig.	.943	.619	.778	.484	.453	.984																	
	N	22	11	16	16	22	22	22																
comput	Cor.	.120	-.216	-.299	-.048	.126	.066	.155	1.000															
	Sig.	.595	.524	.260	.859	.575	.769	.490																
	N	22	11	16	16	22	22	22	22															
extrel	Cor.	.120	-.271	-.291	.079	.332	-.026	**.595	-.037	1.000														
	Sig.	.595	.420	.274	.771	.131	.907	.004	.869															
	N	22	11	16	16	22	22	22	22	22														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	.097	.027	-.097	*.619	.403	.230	.098	.057	**.566	1.000													
	Sig.	.669	.937	.720	.011	.063	.304	.666	.802	.006														
	N	22	11	16	16	22	22	22	22	22	22													
comstrg	Cor.	-.334	-.097	-.047	-.090	.243	-.045	.257	.304	.260	.341	1.000												
	Sig.	.129	.777	.863	.740	.276	.842	.248	.169	.244	.121													
	N	22	11	16	16	22	22	22	22	22	22	22												
invlevel	Cor.	.084	-.153	.182	-.038	.106	**.845	-.196	.070	-.191	.225	.051	1.000											
	Sig.	.709	.653	.500	.888	.640	.000	.382	.756	.395	.314	.820												
	N	22	11	16	16	22	22	22	22	22	22	22	22											
dynamism	Cor.	**-.568	.156	.400	.040	.135	.220	.056	.185	.038	*.428	.366	.215	1.000										
	Sig.	.006	.647	.125	.883	.550	.326	.806	.410	.865	.047	.094	.337											
	N	22	11	16	16	22	22	22	22	22	22	22	22	22										
compro	Cor.	-.316	.269	.296	.177	-.196	.151	-.098	.207	.065	.411	*.509	.301	.383	1.000									
	Sig.	.151	.425	.265	.513	.381	.504	.665	.356	.772	.057	.015	.174	.079										
	N	22	11	16	16	22	22	22	22	22	22	22	22	22	22									
invdp1	Cor.	.053	.557	.176	.135	-.242	-.013	.372	.051	.132	.047	.123	-.223	.021	.000	1.000								
	Sig.	.825	.094	.547	.632	.304	.957	.106	.830	.578	.844	.605	.344	.929	1.000									
	N	20	10	14	15	20	20	20	20	20	20	20	20	20	20	20								
invdp2	Cor.	.129	-.093	-.149	.259	.175	-.397	.043	.021	.204	-.029	-.101	-.337	-.121	-.155	.068	1.000							
	Sig.	.587	.799	.610	.352	.459	.083	.856	.930	.388	.904	.673	.146	.611	.513	.776								
	N	20	10	14	15	20	20	20	20	20	20	20	20	20	20	20	20							
invdp3	Cor.	.082	-.557	-.203	-.088	.350	*.479	-.205	.227	-.083	.194	.030	*.449	.277	-.078	**-.698	-.369	1.000						
	Sig.	.730	.094	.486	.755	.130	.033	.386	.336	.727	.414	.899	.047	.238	.743	.001	.110							
	N	20	10	14	15	20	20	20	20	20	20	20	20	20	20	20	20	20						
mto	Cor.	.206	.541	.027	.331	.137	-.087	.009	-.052	-.168	.086	-.085	.008	-.105	-.203	-.229	.140	.183	1.000					
	Sig.	.358	.086	.922	.211	.543	.700	.969	.820	.455	.702	.705	.971	.641	.365	.332	.556	.440	.					
	N	22	11	16	16	22	22	22	22	22	22	22	22	22	22	20	20	20	22					
mts	Cor.	.077	*-.702	-.027	-.331	-.358	-.050	.089	.123	.089	-.277	.085	-.190	-.242	-.006	.357	-.167	-.302	*-.482	1.000				
	Sig.	.733	.016	.922	.211	.102	.826	.695	.587	.693	.213	.705	.396	.277	.978	.122	.482	.196	.023					
	N	22	11	16	16	22	22	22	22	22	22	22	22	22	22	20	20	20	22	22				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats[a]	Cor.	.	.	.	.	.	.		.		.	.	.	.	.			.	.	.	.	.	.	
	Sig.	.	.	.	.	.	.		.		.	.	.	.	.			.	.	.	.	.	.	
	N	22	11	16	16	22	22	22	22	22	22	22	22	22	22	20	20	20	22	22	22			
eto	Cor.	-.313	a	*-.475	-.345	.049	.190	-.090	-.094	.167	.134	.285	.181	.230	.240	-.187	-.076	.208	**-.583	-.171	a	1.000		
	Sig.	.157	a	.048	.191	.830	.397	.689	.677	.458	.551	.199	.421	.302	.282	.429	.749	.380	.004	.445	a	.		
	N	22	11	16	16	22	22	22	22	22	22	22	22	22	22	20	20	20	22	22	22	22		
err	Cor.	-.253	-.022	.305	.287	.060	.407	-.074	-.052	.023	*.569	.132	**.598	**.618	.374	-.080	*-.489	.312	.213	-.213	a	-.100	1.000	
	Sig.	.297	.951	.288	.341	.806	.084	.762	.833	.926	.011	.591	.007	.005	.115	.759	.046	.223	.382	.382	a	.684	.	
	N	19	10	14	13	19	19	19	19	19	19	19	19	19	19	17	17	17	19	19	19	19	19	
intersh	Cor.	.263	.066	.013	-.063	.141	**.420	-.042	-.067	.393	**.497	.051	.315	-.083	-.279	.025	.105	-.140	.062	-.020	*-.331	.063	.037	1.000
	Sig.	.093	.750	.946	.723	.372	.007	.794	.673	.015	.001	.749	.047	.602	.074	.877	.515	.381	.699	.900	.035	.696	.828	.
	N	42	26	29	34	42	40	42	42	38	42	42	40	42	42	41	41	41	41	41	41	41	38	42

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

a Cannot be computed because at least one of the variables is constant.

Correlation Matrix (For Prospector Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.																							
	N	42																						
MPS	Cor.	*-.457	1.000																					
	Sig.	.019																						
	N	26	26																					
CRP	Cor.	*-.389	.327	1.000																				
	Sig.	.037	.137																					
	N	29	22	29																				
MRP	Cor.	.240	-.063	-.226	1.000																			
	Sig.	.172	.792	.300																				
	N	34	20	23	34																			
Purchase	Cor.	.204	-.273	-.028	.151	1.000																		
	Sig.	.195	.178	.886	.394																			
	N	42	26	29	34	42																		
Inventory	Cor.	-.183	-.113	.122	-.173	-.043	1.000																	
	Sig.	.260	.598	.546	.343	.794																		
	N	40	24	27	32	40	40																	
MPC	Cor.	-.012	.024	-.028	-.116	.007	-.030	1.000																
	Sig.	.939	.907	.885	.512	.965	.852																	
	N	42	26	29	34	42	40	42																
comput	Cor.	-.292	.020	.091	.169	-.133	-.024	.063	1.000															
	Sig.	.061	.923	.637	.339	.401	.885	.691																
	N	42	26	29	34	42	40	42	42															
extrel	Cor.	.312	-.148	.232	-.017	.265	.019	.182	.121	1.000														
	Sig.	.057	.481	.235	.929	.108	.912	.273	.469															
	N	38	25	28	30	38	36	38	38	38														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	*.341	-.012	.060	.299	.121	.079	.004	.070	*.475	1.000													
	Sig.	.027	.954	.759	.086	.446	.627	.978	.660	.003														
	N	42	26	29	34	42	40	42	42	38	42													
comstrg	Cor.	.130	-.045	-.156	.308	-.139	-.173	.157	.191	.022	-.056	1.000												
	Sig.	.411	.827	.419	.077	.381	.287	.320	.226	.894	.725													
	N	42	26	29	34	42	40	42	42	38	42	42												
invlevel	Cor.	-.025	-.238	.111	*-.378	.094	**.778	-.020	-.257	.101	.034	-.280	1.000											
	Sig.	.879	.262	.583	.030	.563	.000	.902	.110	.556	.833	.080												
	N	40	24	27	33	40	39	40	40	36	40	40	40											
dynamism	Cor.	.140	-.016	.081	-.134	.215	-.046	*-.309	**-.467	-.156	.061	*-.367	.010	1.000										
	Sig.	.377	.940	.677	.450	.171	.779	.046	.002	.349	.700	.017	.950											
	N	42	26	29	34	42	40	42	42	38	42	42	40	42										
compro	Cor.	-.049	.127	-.248	.062	.028	-.267	*.353	-.054	-.152	-.235	*.388	-.086	-.023	1.000									
	Sig.	.760	.538	.195	.727	.862	.095	.022	.736	.363	.134	.011	.596	.883										
	N	42	26	29	34	42	40	42	42	38	42	42	40	42	42									
invdp1	Cor.	.138	-.129	-.025	-.037	.055	-.009	.204	-.096	-.043	-.101	.072	-.186	-.194	-.034	1.000								
	Sig.	.388	.540	.900	.837	.732	.956	.201	.548	.801	.529	.653	.257	.224	.832									
	N	41	25	28	33	41	39	41	41	37	41	41	39	41	41	41								
invdp2	Cor.	.073	.107	.104	.175	.169	-.006	.071	-.148	-.157	.107	.094	-.036	.065	-.059	.035	1.000							
	Sig.	.650	.610	.598	.330	.292	.973	.658	.355	.353	.507	.558	.827	.685	.713	.829								
	N	41	25	28	33	41	39	41	41	37	41	41	39	41	41	41	41							
invdp3	Cor.	-.003	.129	-.057	-.128	-.183	-.219	-.019	.248	-.090	-.020	-.113	-.244	.156	-.072	**-.521	-.009	1.000						
	Sig.	.985	.540	.774	.477	.252	.180	.906	.117	.597	.899	.481	.135	.331	.654	.000	.954							
	N	41	25	28	33	41	39	41	41	37	41	41	39	41	41	41	41	41						
mto	Cor.	**.431	.027	-.071	.269	-.080	-.242	-.028	-.011	.039	.039	.233	-.076	-.195	-.078	.010	.142	-.010	1.000					
	Sig.	.005	.898	.715	.130	.617	.138	.863	.946	.815	.809	.143	.647	.221	.630	.951	.381	.951						
	N	41	25	29	33	41	39	41	41	38	41	41	39	41	41	40	40	40	41					
mts	Cor.	-.134	.107	.079	-.007	-.088	.230	.118	.209	.013	.007	-.039	.172	*-.339	.066	-.019	-.120	-.232	-.304	1.000				
	Sig.	.404	.610	.683	.967	.586	.160	.464	.190	.938	.966	.809	.295	.030	.680	.908	.462	.149	.054					
	N	41	25	29	33	41	39	41	41	38	41	41	39	41	41	40	40	40	41	41				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	-.130	.199	-.109	.090	-.114	-.154	-.061	.009	-.220	*-.314	.005	-.091	-.182	.165	-.168	-.115	.168	.064	**.427	1.000			
	Sig.	.419	.341	.573	.620	.478	.349	.705	.956	.185	.045	.977	.582	.254	.302	.299	.481	.299	.693	.005	.			
	N	41	25	29	33	41	39	41	41	38	41	41	39	41	41	4	4	4	4	4	41			
eto	Cor.	-.256	.155	-.005	-.170	.057	-.074	-.089	.057	-.073	-.120	.007	-.040	-.141	-.095	.105	.042	.070	-.223	.223	.307	1.000		
	Sig.	.106	.461	.978	.344	.723	.654	.582	.725	.661	.454	.966	.811	.378	.553	.520	.799	.668	.161	.161	.051	.		
	N	41	25	29	33	41	39	41	41	38	41	41	39	41	41	4	4	4	4	4	41	41		
err	Cor.	.062	-.306	-.184	.221	.090	-.102	.066	.055	.207	**.570	.130	.000	.019	-.103	-.271	-.159	.154	-.079	-.165	-.282	-.072	1.000	
	Sig.	.710	.137	.358	.232	.591	.553	.693	.741	.226	.000	.436	.998	.912	.538	.105	.348	.364	.641	.329	.090	.670	.	
	N	38	25	27	31	38	36	38	38	36	38	38	36	38	38	3	3	3	3	3	37	37	38	
intersh	Cor.	-.206	-.104	-.236	*-.444	.142	.067	.323	.153	.321	-.003	*.413	.171	-.138	.151	.349	.093	-.245	.019	.028	-.255	-.066	-.047	1.00
	Sig.	.302	.636	.361	.030	.479	.744	.101	.447	.118	.989	.032	.402	.492	.452	.074	.646	.218	.924	.888	.199	.745	.823	.
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	2	2	2	2	2	27	27	25	27

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Correlation Matrix (For Analyzer Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.																							
	N	27																						
MPS	Cor.	.110	1.000																					
	Sig.	.619																						
	N	23	23																					
CRP	Cor.	.054	.437	1.000																				
	Sig.	.835	.080																					
	N	17	17	17																				
MRP	Cor.	-.113	.264	.475	1.000																			
	Sig.	.599	.247	.063																				
	N	24	21	16	24																			
Purchase	Cor.	.101	-.128	**.662	.369	1.000																		
	Sig.	.615	.561	.004	.076																			
	N	27	23	17	24	27																		
Inventor.	Cor.	.120	-.039	-.378	-.006	-.058	1.000																	
	Sig.	.561	.864	.148	.977	.780																		
	N	26	22	16	23	26	26																	
MPC	Cor.	-.145	*-.439	-.287	-.237	.216	.225	1.000																
	Sig.	.471	.036	.264	.264	.278	.269																	
	N	27	23	17	24	27	26	27																
comput	Cor.	-.223	-.177	-.081	-.026	-.004	.057	.123	1.000															
	Sig.	.264	.418	.758	.903	.983	.781	.540																
	N	27	23	17	24	27	26	27	27															
extrel	Cor.	.130	.079	.283	*-.473	.015	.311	.235	.103	1.000														
	Sig.	.536	.732	.288	.026	.945	.140	.257	.624															
	N	25	21	16	22	25	24	25	25	25														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	.125	.385	.319	.092	.078	.348	.020	-.294	.372	1.000													
	Sig.	.534	.070	.211	.669	.697	.081	.923	.136	.067														
	N	27	23	17	24	27	26	27	27	25	27													
comstrg	Cor.	-.218	-.247	.072	-.369	.192	.172	*.480	.031	.340	.294	1.000												
	Sig.	.275	.256	.783	.076	.337	.400	.011	.880	.097	.136													
	N	27	23	17	24	27	26	27	27	25	27	27												
invlevel	Cor.	.061	-.412	-.426	.032	.056	**.590	.273	*.416	.069	-.169	.146	1.000											
	Sig.	.768	.057	.100	.886	.786	.002	.178	.034	.749	.410	.477	.											
	N	26	22	16	23	26	26	26	26	24	26	26	26											
dynamism	Cor.	.263	.272	.328	.061	-.091	-.080	.074	*-.477	.125	**.643	.095	*-.472	1.000										
	Sig.	.184	.209	.199	.778	.651	.699	.714	.012	.551	.000	.639	.015											
	N	27	23	17	24	27	26	27	27	25	27	27	26	27										
compro	Cor.	.168	*-.433	-.113	-.200	.093	.204	.305	.095	.304	-.047	-.040	.219	-.172	1.000									
	Sig.	.404	.039	.666	.348	.645	.317	.121	.639	.139	.815	.844	.283	.390										
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27									
Invdp1	Cor.	-.228	.226	.108	-.215	-.111	-.113	.072	*-.385	.065	.279	.237	**-.514	.270	.224	1.000								
	Sig.	.252	.301	.681	.312	.583	.584	.722	.047	.756	.160	.234	.007	.172	.262									
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	27								
Invdp2	Cor.	.276	**.607	*.489	.247	.133	.087	*-.389	-.003	.015	.097	-.061	-.081	.007	-.184	.047	1.000							
	Sig.	.163	.002	.046	.245	.508	.671	.045	.989	.945	.632	.764	.694	.974	.357	.816								
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	27	27							
Invdp3	Cor.	.192	*-.484	-.119	-.070	.078	.306	.222	-.019	.131	.009	-.124	.063	.045	*.416	-.301	*-.457	1.000						
	Sig.	.338	.019	.648	.746	.700	.129	.267	.923	.532	.965	.536	.759	.824	.031	.128	.017							
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	27	27	27						
mto	Cor.	.200	-.230	-.053	-.047	.160	-.089	.111	-.019	-.222	-.168	-.007	-.041	-.075	.189	-.112	-.112	**.503	1.000					
	Sig.	.316	.291	.839	.829	.427	.666	.580	.924	.287	.402	.970	.843	.709	.345	.578	.578	.007						
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	27	27	27	27					
mts	Cor.	-.341	-.195	-.039	.000	-.111	-.113	.256	*-.385	-.083	.157	.237	-.121	.270	.142	**.524	*-.429	-.145	-.112	1.000				
	Sig.	.082	.372	.883	1.000	.583	.584	.197	.047	.692	.434	.234	.556	.172	.480	.005	.025	.472	.578					
	N	27	23	17	24	27	26	27	27	25	27	27	26	27	27	27	27	27	27	27				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	.085	.380	*.507	.348	.237	-.245	-.288	-.040	.058	.195	-.282	-.229	.317	*-.402	-.150	.256	-.237	-.470	-.150	1.000			
	Sig.	.673	.074	.038	.096	.235	.227	.145	.844	.782	.329	.155	.260	.108	.038	.454	.198	.235	.013	.454	.			
	N	27	23	17	24	27	26	27	27	2	27	27	26	27	27	27	27	27	27	27	27			
eto	Cor.	-.019	.234	.198	.315	.146	*.475	-.094	.105	-.004	-.021	-.051	.207	-.376	.279	-.027	*.461	.053	-.184	-.271	-.069	1.000		
	Sig.	.924	.283	.446	.133	.468	.014	.639	.604	.983	.918	.801	.311	.054	.159	.893	.016	.792	.357	.171	.731	.		
	N	27	23	17	24	27	26	27	27	2	27	27	26	27	27	27	27	27	27	27	27	27		
err	Cor.	.206	.066	-.245	-.090	-.133	**.726	.259	-.272	.367	**.561	.200	.350	.135	.235	.115	-.051	.173	-.113	.260	-.187	.313	1.000	
	Sig.	.324	.775	.361	.692	.526	.000	.211	.189	.085	.004	.337	.094	.519	.258	.583	.809	.408	.591	.210	.370	.128		
	N	25	21	16	22	25	24	25	25	2	25	25	24	25	25	25	25	25	25	25	25	25	25	
intersh	Cor.	-.206	-.104	-.236	*-.444	.142	.067	.323	.153	.321	-.003	*.413	.171	-.138	.151	.349	.093	-.245	.019	.028	-.255	-.066	-.047	1.000
	Sig.	.302	.636	.361	.030	.479	.744	.101	.447	.118	.989	.032	.402	.492	.452	.074	.646	.218	.924	.888	.199	.745	.823	
	N	27	23	17	24	27	26	27	27	2	27	27	26	27	27	27	27	27	27	27	27	27	25	27

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Correlation Matrix (For Reactor Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	invtersh
Complex	Cor.	1.000																						
	Sig.	.																						
	N	25																						
MPS	Cor.	.226	1.000																					
	Sig.	.384																						
	N	17	17																					
CRP	Cor.	.102	.409	1.000																				
	Sig.	.677	.165																					
	N	19	13	19																				
MRP	Cor.	.239	-.181	-.009	1.000																			
	Sig.	.323	.555	.977																				
	N	19	13	14	19																			
Purchase	Cor.	-.002	.000	.301	-.307	1.000																		
	Sig.	.994	1.000	.211	.201																			
	N	25	17	19	19	25																		
Inventor.	Cor.	-.281	*-.537	-.283	-.295	.075	1.000																	
	Sig.	.174	.026	.240	.220	.721																		
	N	25	17	19	19	25	25																	
MPC	Cor.	-.222	.230	-.148	.169	-.193	-.093	1.000																
	Sig.	.285	.374	.546	.488	.356	.660																	
	N	25	17	19	19	25	25	25																
comput	Cor.	*-.436	-.246	.096	.207	-.363	-.049	.269	1.000															
	Sig.	.029	.341	.696	.394	.075	.818	.194																
	N	25	17	19	19	25	25	25	25															
extrel	Cor.	.008	.164	.200	.127	-.211	.049	*.438	-.019	1.000														
	Sig.	.969	.528	.412	.606	.312	.814	.029	.928															
	N	25	17	19	19	25	25	25	25	25														

		Complex	MPS	CRP	MRP	Purchas.	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	.211	.232	.022	.218	-.049	.104	*.427	-.126	**.683	1.000													
	Sig.	.312	.369	.928	.370	.814	.621	.033	.549	.000														
	N	25	17	19	19	25	25	25	25	25	25													
comstrg	Cor.	-.178	.436	.206	-.008	-.122	-.236	.254	-.015	.366	.194	1.000												
	Sig.	.394	.080	.398	.975	.560	.256	.221	.942	.072	.354													
	N	25	17	19	19	25	25	25	25	25	25	25												
invlevel	Cor.	-.018	-.230	-.051	.161	-.361	*.494	.123	.363	.157	.256	-.126	1.000											
	Sig.	.931	.375	.834	.510	.076	.012	.559	.074	.454	.218	.549												
	N	25	17	19	19	25	25	25	25	25	25	25	25											
dynamism	Cor.	.128	.000	.055	*-.481	.253	.222	-.136	-.271	.132	.392	.195	-.020	1.000										
	Sig.	.543	1.000	.822	.037	.222	.286	.517	.191	.531	.053	.350	.923											
	N	25	17	19	19	25	25	25	25	25	25	25	25	25										
compro	Cor.	-.227	.236	.124	-.148	.352	.016	.306	.112	-.116	.108	*.458	-.135	.137	1.000									
	Sig.	.276	.361	.614	.545	.084	.938	.137	.595	.580	.609	.021	.520	.514										
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25									
Invdp1	Cor.	-.090	.000	**.607	a	.324	.056	-.101	.027	.284	.247	.279	-.129	.231	.186	1.000								
	Sig.	.670	1.000	.006	a	.114	.791	.632	.897	.168	.233	.177	.538	.267	.373									
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25								
Invdp2	Cor.	-.229	.153	.125	-.031	-.115	-.145	.294	.028	.274	.193	.211	-.105	.139	.095	.144	1.000							
	Sig.	.271	.558	.611	.900	.586	.488	.153	.894	.186	.354	.310	.618	.506	.650	.491								
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25							
Invdp3	Cor.	-.010	-.170	-.053	.031	-.031	.093	-.294	.148	-.274	*-.413	.004	.038	-.139	-.010	-.144	**-.802	1.000						
	Sig.	.964	.514	.830	.900	.883	.659	.153	.481	.186	.040	.984	.858	.506	.961	.491	.000	.						
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25						
mto	Cor.	.057	.170	.331	-.278	.298	.003	-.341	*-.479	-.205	-.234	.173	-.257	.055	.061	.109	-.044	.044	1.000					
	Sig.	.786	.514	.167	.249	.148	.989	.095	.015	.325	.261	.408	.216	.794	.771	.604	.835	.835						
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25	25					
mts	Cor.	-.018	.153	.125	.084	.087	-.201	-.171	-.118	-.049	-.074	.291	-.181	.000	.268	-.147	.356	-.134	-.123	1.000				
	Sig.	.932	.558	.609	.732	.679	.335	.414	.573	.816	.725	.159	.386	1.000	.196	.482	.080	.524	.558	.				
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25				

		Complex	MPS	CRP	MRP	Purchas.	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	.029	.000	-.331	.336	-.276	-.324	.318	.220	.280	.297	.069	-.012	.046	-.164	-.060	.327	-.327	**-.553	-.102	1.000			
	Sig.	.890	1.000	.167	.159	.182	.115	.122	.290	.175	.149	.742	.953	.828	.434	.775	.110	.110	.004	.627				
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25			
eto	Cor.	-.221	-.402	-.181	.046	-.157	*.405	.039	*.415	.043	.065	-.257	*.428	-.264	.186	-.087	.144	-.144	-.345	.221	-.060	1.000		
	Sig.	.288	.109	.458	.852	.452	.045	.852	.039	.837	.756	.215	.033	.203	.373	.679	.491	.491	.091	.288	.775			
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25		
err	Cor.	-.169	-.353	-.201	.000	-.176	.369	.322	.099	*.415	**.620	-.048	**.572	.111	-.061	-.089	.010	-.092	-.233	-.152	.167	*.406	1.000	
	Sig.	.429	.165	.424	1.000	.410	.076	.125	.647	.044	.001	.823	.004	.607	.778	.678	.961	.668	.273	.478	.437	.049		
	N	24	17	18	18	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	
intersh	Cor.	-.168	*.524	.019	.139	-.136	-.055	**.697	.157	**.511	**.552	.234	.058	.103	.191	.021	.202	-.123	-.244	-.230	.376	-.110	.312	1.000
	Sig.	.421	.031	.939	.572	.517	.793	.000	.454	.009	.004	.261	.784	.624	.360	.921	.333	.558	.239	.268	.064	.602	.137	
	N	25	17	19	19	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	24	25

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

a Cannot be computed because at least one of the variables is constant.

Correlation Matrix (For Lean Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.																							
	N	60																						
MPS	Cor.	.132	1.000																					
	Sig.	.430																						
	N	38	38																					
CRP	Cor.	-.089	**.490	1.000																				
	Sig.	.566	.004	.																				
	N	44	32	44																				
MRP	Cor.	*.344	-.013	-.099	1.000																			
	Sig.	.015	.946	.572																				
	N	49	31	35	49																			
Purchase	Cor.	.133	-.028	-.022	-.144	1.000																		
	Sig.	.311	.866	.886	.325																			
	N	60	38	44	49	60																		
Inventor.	Cor.	-.069	-.272	.183	-.123	.017	1.000																	
	Sig.	.602	.104	.241	.405	.896																		
	N	59	37	43	48	59	59																	
MPC	Cor.	-.189	-.115	-.093	-.213	-.052	-.175	1.000																
	Sig.	.149	.492	.546	.142	.695	.186																	
	N	60	38	44	49	60	59	60																
comput	Cor.	**-.370	-.170	.084	.062	-.213	-.210	.134	1.000															
	Sig.	.004	.308	.587	.673	.102	.110	.307																
	N	60	38	44	49	60	59	60	60															
extrel	Cor.	.062	-.099	.236	-.145	.009	-.113	*.329	.022	1.000														
	Sig.	.642	.555	.128	.331	.944	.403	.012	.871															
	N	58	38	43	47	58	57	58	58	58														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	*.266	.136	.135	*.322	.092	.134	.029	-.199	**.423	1.000													
	Sig.	.040	.417	.381	.024	.485	.313	.827	.128	.001	.													
	N	60	38	44	49	60	59	60	60	58	60													
comstrg	Cor.	-.195	.027	.111	-.024	-.050	-.099	.178	.138	.201	.112	1.000												
	Sig.	.136	.873	.475	.868	.707	.457	.175	.293	.130	.394	.												
	N	60	38	44	49	60	59	60	60	58	60	60												
invlevel	Cor.	-.036	-.135	.279	-.029	-.129	**.576	-.203	-.204	-.174	.112	-.166	1.000											
	Sig.	.786	.425	.070	.847	.330	.000	.123	.121	.195	.397	.209	.											
	N	59	37	43	48	59	59	59	59	57	59	59	59											
dynamism	Cor.	-.010	.045	.008	-.141	.199	*.257	-.099	**-.369	.036	**.491	.093	.145	1.000										
	Sig.	.938	.790	.959	.334	.128	.049	.451	.004	.787	.000	.480	.273	.										
	N	60	38	44	49	60	59	60	60	58	60	60	59	60										
compro	Cor.	-.167	.097	.070	.096	.172	-.185	-.059	.186	.119	.075	**.529	-.284	-.017	1.000									
	Sig.	.202	.560	.649	.512	.188	.160	.652	.154	.372	.568	.000	.529	.897	.									
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60									
Invdp1	Cor.	-.012	.243	.195	-.081	.012	.034	.191	-.058	.125	.124	.185	*-.321	.062	*.277	1.000								
	Sig.	.929	.147	.210	.584	.928	.803	.148	.662	.354	.351	.160	.014	.641	.034	.								
	N	59	37	43	48	59	58	59	59	57	59	59	58	59	59	59								
Invdp2	Cor.	.115	.201	-.043	.140	.012	-.053	.121	-.119	.112	.172	.135	-.145	.062	.023	.091	1.000							
	Sig.	.385	.233	.785	.343	.928	.694	.362	.370	.405	.194	.308	.278	.641	.864	.493	.							
	N	59	37	43	48	59	58	59	59	57	59	59	58	59	59	59	59							
Invdp3	Cor.	.042	*-.357	-.074	-.075	.015	.064	-.147	.173	-.115	-.213	-.001	-.041	-.003	-.079	**-.361	**-.361	1.000						
	Sig.	.750	.030	.639	.611	.908	.631	.268	.190	.393	.105	.995	.762	.980	.550	.005	.005	.						
	N	59	37	43	48	59	58	59	59	57	59	59	58	59	59	59	59	59						
mto	Cor.	*.289	.244	.204	.080	.121	.028	-.164	-.215	-.120	-.019	.217	-.057	-.113	-.096	.059	.059	.017	1.000					
	Sig.	.025	.140	.184	.586	.356	.831	.210	.099	.369	.884	.096	.667	.389	.467	.656	.656	.898	.					
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60	59	59	59	60					
mts	Cor.	-.185	-.072	-.019	-.085	-.130	.083	.121	.212	.047	-.080	*.264	-.009	-.162	.232	.176	-.016	*-.261	-.169	1.000				
	Sig.	.156	.667	.901	.563	.321	.534	.356	.104	.728	.545	.042	.947	.217	.074	.183	.903	.046	.197	.				
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60	59	59	59	60	60				

		Complex	MPS	CRP	MRP	Purchas.	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	-.087	.161	-.238	.201	-.228	*-.260	-.055	.092	-.003	.012	.092	-.077	-.035	-.219	-.119	.088	-.049	*-.280	.152	1.000			
	Sig.	.511	.333	.120	.167	.080	.047	.677	.484	.984	.928	.485	.560	.792	.093	.369	.509	.711	.030	.246				
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60	59	59	59	60	60	60			
eto	Cor.	-.223	-.079	.000	.013	-.015	.096	-.024	.142	-.046	-.069	.062	.006	-.129	.171	.076	.185	.101	-.237	.194	.200	1.000		
	Sig.	.087	.637	1.000	.930	.912	.471	.853	.280	.731	.601	.639	.964	.327	.191	.567	.160	.448	.069	.137	.125	.		
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60	59	59	59	60	60	60	60		
err	Cor.	-.008	-.235	.086	.071	-.107	*.344	.135	-.038	.154	**.665	.083	**.378	*.312	.072	-.023	-.046	.044	-.213	.138	-.049	.097	1.000	
	Sig.	.952	.168	.597	.649	.444	.013	.337	.790	.277	.000	.553	.006	.023	.606	.873	.744	.758	.125	.323	.728	.489	.	
	N	53	36	40	43	53	52	53	53	52	53	53	52	53	53	52	52	52	53	53	53	53	53	
intersh	Cor.	.040	.206	.155	-.172	.088	.136	**.332	-.135	**.548	**.341	.222	.077	.100	.081	.165	.105	-.165	-.161	-.058	.025	-.026	.054	1.000
	Sig.	.760	.215	.315	.236	.505	.305	.009	.303	.000	.008	.088	.560	.446	.536	.212	.428	.211	.219	.662	.851	.842	.704	.
	N	60	38	44	49	60	59	60	60	58	60	60	59	60	60	59	59	59	60	60	60	60	53	60

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Correlation Matrix (For Agile Organizations)

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.	.																						
	N	29																						
MPS	Cor.	-.260	1.000																					
	Sig.	.282																						
	N	19	19																					
CRP	Cor.	-.374	.383	1.000																				
	Sig.	.115	.159																					
	N	19	15	19																				
MRP	Cor.	-.197	.034	.270	1.000																			
	Sig.	.357	.898	.295																				
	N	24	17	17	24																			
Purchase	Cor.	-.077	-.438	.373	*.499	1.000																		
	Sig.	.693	.061	.115	.013																			
	N	29	19	19	24	29																		
Inventory	Cor.	.007	.029	-.089	-.266	-.073	1.000																	
	Sig.	.974	.912	.735	.232	.716																		
	N	27	17	17	22	27	27																	
MPC	Cor.	-.231	.084	.108	.349	-.006	.152	1.000																
	Sig.	.229	.734	.660	.095	.976	.451	.																
	N	29	19	19	24	29	27	29																
comput	Cor.	*-.384	.283	.223	.224	-.155	-.126	.157	1.000															
	Sig.	.040	.240	.360	.293	.421	.531	.417																
	N	29	19	19	24	29	27	29	29															
extrel	Cor.	.040	-.046	.005	-.038	-.107	.220	*.383	-.267	1.000														
	Sig.	.838	.856	.985	.863	.586	.280	.044	.170															
	N	28	18	19	23	28	26	28	28	28														

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	.060	.098	.138	.178	.001	.198	.333	-.093	**.659	1.000													
	Sig.	.759	.690	.572	.405	.998	.323	.078	.633	.000														
	N	29	19	19	24	29	27	29	29	28	29													
comstrg	Cor.	-.339	.089	.099	.289	-.100	-.097	**.589	.274	.372	**.487	1.000												
	Sig.	.072	.718	.688	.171	.607	.632	.001	.150	.052	.007													
	N	29	19	19	24	29	27	29	29	28	29	29												
invlevel	Cor.	.145	-.188	-.198	-.259	.161	**.715	.149	-.146	.195	.036	-.146	1.000											
	Sig.	.461	.454	.430	.233	.414	.000	.448	.460	.330	.856	.459												
	N	28	18	18	23	28	27	28	28	27	28	28	28											
dynamism	Cor.	-.043	-.018	.245	.000	.030	.034	-.277	-.060	.046	.320	-.054	-.142	1.000										
	Sig.	.824	.943	.311	1.000	.875	.866	.146	.757	.816	.090	.781	.470											
	N	29	19	19	24	29	27	29	29	28	29	29	28	29										
compro	Cor.	-.160	-.078	-.035	.356	.089	.146	**.595	.181	.196	.252	**.659	.076	-.064	1.000									
	Sig.	.408	.751	.888	.088	.646	.466	.001	.349	.316	.187	.000	.699	.743										
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29									
Invdp1	Cor.	-.231	-.250	.061	-.061	-.107	-.051	.237	.122	.055	.031	*.403	-.250	-.277	.288	1.000								
	Sig.	.228	.302	.804	.778	.581	.802	.216	.528	.782	.874	.030	.199	.146	.130	.								
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29	29								
Invdp2	Cor.	-.127	.250	.370	.089	.152	-.165	-.126	.128	-.218	-.142	.148	-.343	.143	.175	-.080	1.000							
	Sig.	.511	.302	.119	.679	.432	.410	.516	.507	.265	.461	.442	.074	.461	.364	.681								
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29	29	29							
Invdp3	Cor.	.249	.048	.044	.059	.023	.094	-.157	-.045	-.055	.137	-.356	.000	*.456	-.213	**-.629	-.099	1.000						
	Sig.	.193	.846	.857	.784	.907	.639	.416	.817	.782	.480	.058	1.000	.013	.267	.000	.608							
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29	29	29	29						
mto	Cor.	.047	-.012	.397	.225	.241	-.067	.012	.167	-.220	-.267	-.101	-.028	-.110	.141	-.224	.141	.224	1.000					
	Sig.	.814	.963	.092	.301	.216	.745	.951	.397	.262	.169	.611	.889	.577	.473	.252	.473	.252						
	N	28	18	19	23	28	26	28	28	28	28	28	27	28	28	28	28	28	28					
mts	Cor.	-.030	-.265	.043	-.027	.108	-.139	.259	-.208	.100	.065	.204	.006	.147	.002	.164	.090	-.164	*-.431	1.000				
	Sig.	.882	.289	.861	.904	.584	.497	.183	.289	.613	.742	.299	.976	.455	.992	.406	.650	.406	.022					
	N	28	18	19	23	28	26	28	28	28	28	28	27	28	28	28	28	28	28	28				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	-.078	.082	-.037	.143	-.017		.372	.143	-.058	-.308	-.101		-.224	.126	-.143	-.079	.143	.067	.239	1.000			
	Sig.	.695	.746	.880	.516	.933		.051	.468	.770	.111	.611		.251	.523	.466	.691	.466	.736	.220	.			
	N	28	18	19	23	28	26	28	28	28	28	28	27	28	28	2	2	2	28	28	28			
Eto[a]	Cor.	.			.									.					.	.	.	.		
	Sig.	.			.									.					.	.	.	.		
	N	28	18	19	23	28	26	28	28	28	28	28	27	28	28	2	2	2	28	28	28	28		
err	Cor.	.141	-.187	-.397	.120	.127	.206	.078	-.291	**.498	**.579	.191	.274	-.010	.046	-.067	*-.392	-.01	-.102	-.206	-.276	.	1.000	
	Sig.	.465	.443	.093	.578	.512	.304	.686	.125	.007	.001	.321	.158	.957	.811	.729	.036	.934	.607	.292	.155	.	.	
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29	2	2	2	28	28	28	28	29	
intersh	Cor.	-.142	.001	.031	.200	.109	.277	**.492	.133	.407	**.567	**.640	.103	-.107	**.482	*.414	.097	-.218	-.127	.097	-.345	a	.253	1.000
	Sig.	.464	.996	.901	.349	.575	.162	.007	.492	.032	.001	.000	.601	.581	.008	.026	.618	.256	.520	.622	.072	a.	.186	.
	N	29	19	19	24	29	27	29	29	28	29	29	28	29	29	2	2	2	28	28	28	28	29	29

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

a Cannot be computed because at least one of the variables is constant.

Correlation Matrix (For Leagile Organizations)

		Complex	MPS	CRP	MRP	Purchae	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
Complex	Cor.	1.000																						
	Sig.																							
	N	27																						
MPS	Cor.	-.266	1.000																					
	Sig.	.256																						
	N	20	20																					
CRP	Cor.	-.149	.368	1.000																				
	Sig.	.556	.161	.																				
	N	18	16	18																				
MRP	Cor.	-.012	*.543	-.083	1.000																			
	Sig.	.958	.045	.808																				
	N	20	14	11	20																			
Purchase	Cor.	**.536	.014	-.124	.244	1.000																		
	Sig.	.004	.954	.623	.300																			
	N	27	20	18	20	27																		
Inventory	Cor.	-.108	-.129	-.214	-.262	-.019	1.000																	
	Sig.	.592	.587	.395	.265	.927																		
	N	27	20	18	20	27	27																	
MPC	Cor.	.121	-.075	.091	-.324	.111	.281	1.000																
	Sig.	.549	.754	.721	.163	.582	.156																	
	N	27	20	18	20	27	27	27																
comput	Cor.	-.026	-.288	-.161	.016	-.117	.372	*.484	1.000															
	Sig.	.898	.218	.524	.947	.560	.056	.011																
	N	27	20	18	20	27	27	27	27															
extrel	Cor.	**.546	-.111	-.216	.107	**.623	.378	*.432	.253	1.000														
	Sig.	.006	.660	.405	.683	.001	.068	.035	.233															
	N	24	18	17	17	24	24	24	24	24														

		Complex	MPS	CRP	MRP	Purchas.	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
operenvi	Cor.	.304	.166	-.260	.308	*.397	.220	.157	.032	**.711	1.000													
	Sig.	.123	.483	.297	.187	.040	.271	.433	.876	.000														
	N	27	20	18	20	27	27	27	27	24	27													
comstrg	Cor.	.230	-.109	-.303	-.166	.132	-.098	*.480	.309	.133	-.110	1.000												
	Sig.	.248	.647	.222	.485	.513	.628	.011	.116	.534	.585													
	N	27	20	18	20	27	27	27	27	24	27	27												
invlevel	Cor.	.073	*-.458	-.456	-.425	.060	**.896	.288	*.455	*.427	.099	-.048	1.000											
	Sig.	.722	.049	.066	.062	.772	.000	.154	.019	.042	.629	.814												
	N	26	19	17	20	26	26	26	26	23	26	26	26											
Dynamis.	Cor.	.273	.371	.460	-.071	.284	-.258	-.056	*-.388	.086	.183	-.063	-.364	1.000										
	Sig.	.169	.108	.055	.767	.151	.194	.780	.045	.690	.360	.753	.068											
	N	27	20	18	20	27	27	27	27	24	27	27	26	27										
compro	Cor.	-.007	-.026	.081	-.321	-.036	.002	**.620	.228	.047	-.117	.051	.077	-.015	1.000									
	Sig.	.972	.912	.750	.168	.858	.994	.001	.252	.828	.560	.799	.708	.942										
	N	27	20	18	20	27	27	27	27	24	27	27	26	27	27									
Invdp1	Cor.	.081	.253	.254	-.114	.197	.015	.310	-.293	.124	.086	.142	-.082	.246	.050	1.000								
	Sig.	.700	.297	.342	.641	.344	.945	.131	.155	.583	.681	.498	.704	.236	.812									
	N	25	19	16	19	25	25	25	25	22	25	25	24	25	25	25								
Invdp2	Cor.	.167	.116	.127	.306	.112	-.118	-.073	-.012	.124	-.052	-.050	.082	-.123	-.237	.067	1.000							
	Sig.	.424	.638	.639	.203	.596	.576	.729	.954	.583	.805	.813	.704	.559	.254	.751	.							
	N	25	19	16	19	25	25	25	25	22	25	25	24	25	25	25	25							
Invdp3	Cor.	-.060	-.238	-.185	-.156	-.080	.007	.145	.226	-.069	.069	.067	.000	-.031	.349	*-.460	**-.554	1.000						
	Sig.	.775	.326	.494	.524	.704	.974	.489	.276	.761	.742	.752	1.000	.882	.087	.021	.004							
	N	25	19	16	19	25	25	25	25	22	25	25	24	25	25	25	25	25						
mto	Cor.	.168	-.157	-.283	.094	.050	-.325	.247	.108	-.071	-.030	.273	-.192	-.139	*.392	-.134	-.187	*.458	1.000					
	Sig.	.402	.509	.255	.693	.804	.098	.214	.591	.742	.882	.169	.347	.489	.043	.524	.370	.021	.					
	N	27	20	18	20	27	27	27	27	24	27	27	26	27	27	25	25	25	27					
mts	Cor.	-.168	-.036	.079	.031	-.264	.062	-.247	-.229	-.125	.088	-.273	-.120	-.165	*-.392	.275	-.316	-.164	-.229	1.000				
	Sig.	.402	.882	.754	.896	.184	.760	.214	.251	.561	.664	.169	.559	.410	.043	.183	.124	.434	.251					
	N	27	20	18	20	27	27	27	27	24	27	27	26	27	27	25	25	25	27	27				

		Complex	MPS	CRP	MRP	Purchase	Inventory	MPC	comput	extrel	operenvi	compstrg	Invlevel	dynamism	compro	Invdp1	Invdp2	Invdp3	mto	mts	ats	eto	err	intersh
ats	Cor.	.119	.361	.311	.361	.196	-.241	-.274	-.076	.023	.144	-.231	-.272	.34	-.276	-.127	.363	-.272	-.331	-.11	1.000			
	Sig.	.556	.117	.210	.117	.328	.226	.167	.707	.915	.474	.246	.179	.07	.164	.544	.074	.188	.091	.56	.			
	N	27	20	18	20	27	27	27	27	24	27	27	26	2	27	25	25	25	27	2	27			
eto	Cor.	-.244	.112	-.311	-.199	.055	.360	-.090	.031	.153	.018	-.022	*.401	-.22	-.059	-.184	.180	-.086	**-.598	-.20	-.069	1.000		
	Sig.	.219	.638	.208	.400	.785	.065	.656	.878	.474	.929	.914	.042	.27	.772	.379	.391	.683	.001	.29	.731	.		
	N	27	20	18	20	27	27	27	27	24	27	27	26	2	27	25	25	25	27	2	27	27		
err	Cor.	-.158	.071	-.090	.053	-.085	.067	.359	.139	.240	.228	.135	.068	.06	*.445	-.258	-.229	.422	.165	-.18	-.202	.122	1.000	
	Sig.	.461	.779	.740	.840	.693	.755	.085	.516	.282	.283	.528	.756	.76	.029	.246	.306	.050	.442	.38	.344	.570		
	N	24	18	16	17	24	24	24	24	22	24	24	23	2	24	22	22	22	24	2	24	24	24	
intersh	Cor.	.064	-.141	**-.675	-.275	.113	*.425	.204	.161	.408	*.475	-.186	**.575	-.03	-.249	.027	-.087	-.091	.133	-.00	-.258	.118	.171	1.000
	Sig.	.763	.565	.004	.255	.590	.034	.328	.442	.060	.017	.374	.003	.88	.231	.899	.679	.664	.527	.96	.214	.576	.448	
	N	25	19	16	19	25	25	25	25	22	25	25	24	2	25	25	25	25	25	2	25	25	22	25

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

For H1.....

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.167	.028	.017	1.0207

a Predictors: (Constant), Decoupling Point:: End-item

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.805	1	2.805	2.692	.104
	Residual	97.935	94	1.042		
	Total	100.740	95			

a Predictors: (Constant), Decoupling Point:: End-item
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.462	.314		7.845	.000
	Decoupling Point:: End-item	.376	.229	.167	1.641	.104

a Dependent Variable: MPC system performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.218	.047	.037	1.80

a Predictors: (Constant), Assemble-to-stock strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.461	1	14.461	4.476	.037
	Residual	290.757	90	3.231		
	Total	305.217	91			

a Predictors: (Constant), Assemble-to-stock strategy
b Dependent Variable: MRP performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.566	2.084		-.271	.787
	Assemble-to-stock strategy	2.232	1.055	.218	2.116	.037

a Dependent Variable: MRP performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.215	.046	.037	1.78

a Predictors: (Constant), Assemble-to-stock strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.783	1	16.783	5.317	.023
	Residual	347.217	110	3.157		
	Total	364.000	111			

a Predictors: (Constant), Assemble-to-stock strategy
b Dependent Variable: Inventory mgt performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.731	2.059		4.241	.000
	Assemble-to-stock strategy	-2.398	1.040	-.215	-2.306	.023

a Dependent Variable: Inventory mgt performance

For H1a.....

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.702	.493	.437	1.25

a Predictors: (Constant), Make-to-stock Strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.636	1	13.636	8.766	.016
	Residual	14.000	9	1.556		
	Total	27.636	10			

a Predictors: (Constant), Make-to-stock Strategy
b Dependent Variable: MPS performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	7.500	1.506		4.980	.001
	Make-to-stock Strategy	-2.500	.844	-.702	-2.961	.016

a Dependent Variable: MPS performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.607	.368	.338	1.62

a Predictors: (Constant), Decoupling point: sub-assembly

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.311	1	32.311	12.241	.002
	Residual	55.429	21	2.639		
	Total	87.739	22			

a Predictors: (Constant), Decoupling point: sub-assembly
b Dependent Variable: MPS performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.571	1.167		.490	.629
	Decoupling: sub-assembly	2.429	.694	.607	3.499	.002

a Dependent Variable: MPS performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.484	.234	.198	1.79

a Predictors: (Constant), Decoupling point: component

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.570	1	20.570	6.431	.019
	Residual	67.169	21	3.199		
	Total	87.739	22			

a Predictors: (Constant), Decoupling point: component

b Dependent Variable: MPS performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.215	1.142		6.319	.000
	Decoupling point: component	-1.908	.752	-.484	-2.536	.019

a Dependent Variable: MPS performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.357	.128	.103	1.46

a Predictors: (Constant), Decoupling point (DP): component

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.924	1	10.924	5.122	.030
	Residual	74.643	35	2.133		
	Total	85.568	36			

a Predictors: (Constant), Decoupling point (DP): component

b Dependent Variable: MPS performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.650	.722		6.437	.000
	DP: component	-1.189	.525	-.357	-2.263	.030

a Dependent Variable: MPS performance

For H1b.....

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.475	.225	.170	1.76

a Predictors: (Constant), Engineer-to-order strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.604	1	12.604	4.072	.063
	Residual	43.333	14	3.095		
	Total	55.938	15			

a Predictors: (Constant), Engineer-to-order (ETO) strategy
b Dependent Variable: CRP performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.667	3.548		3.007	.009
	ETO strategy	-3.667	1.817	-.475	-2.018	.048

a Dependent Variable: CRP performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.489	.239	.188	1.56

a Predictors: (Constant), Decoupling point: sub-assembly

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.503	1	11.503	4.713	.046
	Residual	36.614	15	2.441		
	Total	48.118	16			

a Predictors: (Constant), Decoupling point: sub-assembly
b Dependent Variable: CRP performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.757	1.280		1.373	.190
	DP: sub-assembly	1.671	.770	.489	2.171	.046

a Dependent Variable: CRP performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.507	.257	.207	1.54

a Predictors: (Constant), Assemble-to-stock (ATS) strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.368	1	12.368	5.189	.038
	Residual	35.750	15	2.383		
	Total	48.118	16			

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.625	3.112		-.844	.412
	ATS strategy	3.625	1.591	.507	2.278	.038

a Dependent Variable: CRP performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.607	.369	.332	1.32

a Predictors: (Constant), Decoupling point: end-item

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.393	1	17.393	9.934	.006
	Residual	29.765	17	1.751		
	Total	47.158	18			

a Predictors: (Constant), Decoupling point (DP): end-item

b Dependent Variable: CRP performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.118	1.899		-1.115	.280
	DP: end-item	3.118	.989	.607	3.152	.006

a Dependent Variable: CRP performance

For H1c.....

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.180	.032	.021	1.79

a Predictors: (Constant), Decoupling point: sub-assembly

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.548	1	9.548	2.977	.088
	Residual	285.485	89	3.208		
	Total	295.033	90			

a Predictors: (Constant), Decoupling point: sub-assembly

b Dependent Variable: MRP performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.515	.763		3.295	.001
	DP: sub-assembly	.735	.426	.180	1.725	.048

a Dependent Variable: MRP performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.218	.047	.037	1.80

a Predictors: (Constant), Assemble-to-stock (ATS) strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.461	1	14.461	4.476	.037
	Residual	290.757	90	3.231		
	Total	305.217	91			

a Predictors: (Constant), Assemble-to-stock strategy

b Dependent Variable: MRP performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-.566	2.084		-.271	.787
	ATS strategy	2.232	1.055	.218	2.116	.037

a Dependent Variable: MRP performance

For H2.....

Model Summary (For All Sample Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.372	.138	.131	.9640

a Predictors: (Constant), Competitive strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.983	1	16.983	18.275	.000
	Residual	105.940	114	.929		
	Total	122.922	115			

a Predictors: (Constant), Competitive strategy

b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.701	.323		5.273	.000
	Competitive strategy	.499	.117	.372	4.275	.000

a Dependent Variable: MPC system performance

Model Summary (For Agile Supply Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.589	.347	.323	.8496

a Predictors: (Constant), Competitive strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	10.375	1	10.375	14.374	.001
	Residual	19.487	27	.722		
	Total	29.862	28			

a Predictors: (Constant), Competitive strategy
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.054	.520		2.028	.052
	Competitive strategy	.736	.194	.589	3.791	.001

a Dependent Variable: MPC system performance

Model Summary (For Analyzer Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.480	.230	.199	.7582

a Predictors: (Constant), Competitive strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.296	1	4.296	7.473	.011
	Residual	14.371	25	.575		
	Total	18.667	26			

a Predictors: (Constant), Competitive strategy
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.031	.655		1.573	.128
	Competitive strategy	.773	.283	.480	2.734	.011

a Dependent Variable: MPC system performance

Model Summary (For Leagile Supply Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.480	.231	.200	.7974

a Predictors: (Constant), Competitive strategy

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.771	1	4.771	7.503	.011
	Residual	15.896	25	.636		
	Total	20.667	26			

a Predictors: (Constant), Competitive strategy
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.162	.610		1.905	.068
	Competitive strategy	.704	.257	.480	2.739	.011

a Dependent Variable: MPC system performance

For H2e.....

Model Summary (For Analyzer Organization)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.273	.074	.036	.7226

a Predictors: (Constant), Inventory level

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.005	1	1.005	1.925	.178
	Residual	12.533	24	.522		
	Total	13.538	25			

a Predictors: (Constant), Inventory level
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.185	.392		5.571	.000
	Inventory level	.122	.088	.273	1.388	.178

a Dependent Variable: MPC system performance

Model Summary (For Defender Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.196	.038	-.010	1.23

a Predictors: (Constant), MPC system performance

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.203	1	1.203	.800	.382
	Residual	30.070	20	1.503		
	Total	31.273	21			

a Predictors: (Constant), MPC system performance
b Dependent Variable: Inventory level

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	3.850	.791		4.864	.000
	MPC system performance	-.210	.235	-.196	-.894	.382

a Dependent Variable: Inventory level

For H3.....

Model Summary (For Reactor Organization)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.427	.182	.147	.9935

a Predictors: (Constant), Operational environment

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.059	1	5.059	5.126	.033
	Residual	22.701	23	.987		
	Total	27.760	24			

a Predictors: (Constant), Operational environment
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.431	.570		4.265	.000
	Operational environment	.277	.123	.427	2.264	.033

a Dependent Variable: MPC system performance

For H3a.....

Model Summary (For All Sample Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.250	.063	.054	1.0054

a Predictors: (Constant), Product development

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.696	1	7.696	7.614	.007
	Residual	115.227	114	1.011		
	Total	122.922	115			

a Predictors: (Constant), Product development
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.575	.188		13.684	.000
	Product development	.181	.066	.250	2.759	.007

a Dependent Variable: MPC system performance

Model Summary (For Prospector Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.353	.124	.102	.8643

a Predictors: (Constant), Product development

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.240	1	4.240	5.676	.022
	Residual	29.879	40	.747		
	Total	34.119	41			

a Predictors: (Constant), Product development
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.076	.308		6.738	.000
	Product development	.434	.182	.353	2.382	.022

a Dependent Variable: MPC system performance

Model Summary (For Agile Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.595	.353	.330	.8456

a Predictors: (Constant), Product development

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.556	1	10.556	14.763	.001
	Residual	19.306	27	.715		
	Total	29.862	28			

a Predictors: (Constant), Product development
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.735	.349		4.974	.000
	Product development	.510	.133	.595	3.842	.001

Model Summary (For Leagile Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.620	.385	.360	.7133

a Predictors: (Constant), Product development

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	7.947	1	7.947	15.621	.001
	Residual	12.719	25	.509		
	Total	20.667	26			

a Predictors: (Constant), Product development
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardize Coefficient	Std. Error	Standardized Coefficient Bet	t	Sig.
1	(Constant)	1.52	.346		4.389	.000
	Product development	.404	.102	.620	3.952	.001

a Dependent Variable: MPC system performance

For H3b.....

Model Summary (For All Sample Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.361	.131	.123	.9815

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.636	1	15.636	16.231	.000
	Residual	104.037	108	.963		
	Total	119.673	109			

a Predictors: (Constant), External relationships
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.958	.288		6.806	.000
	External relationships	.317	.079	.361	4.029	.000

a Dependent Variable: MPC system performance

Model Summary (For Defender Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.595	.354	.321	.9389

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.642	1	9.642	10.938	.004
	Residual	17.631	20	.882		
	Total	27.273	21			

a Predictors: (Constant), External relationships
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.633	.509		3.206	.004
	External relationships	.480	.145	.595	3.307	.004

a Dependent Variable: MPC system performance

Model Summary (Reactor Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.438	.192	.157	.9876

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.325	1	5.325	5.459	.029
	Residual	22.435	23	.975		
	Total	27.760	24			

a Predictors: (Constant), External relationships

b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.252	.626		3.598	.002
	External relationships	.377	.161	.438	2.337	.029

a Dependent Variable: MPC system performance

Model Summary (For Lean Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.329	.108	.092	1.0476

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.459	1	7.459	6.797	.012
	Residual	61.455	56	1.097		
	Total	68.914	57			

a Predictors: (Constant), External relationships

b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.178	.412		5.294	.000
	External relationships	.290	.111	.329	2.607	.012

a Dependent Variable: MPC system performance

Model Summary (For Agile Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.383	.147	.114	.9750

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.248	1	4.248	4.469	.044
	Residual	24.716	26	.951		
	Total	28.964	27			

a Predictors: (Constant), External relationships

b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.626	.659		2.467	.021
	External relationships	.364	.172	.383	2.114	.044

a Dependent Variable: MPC system performance

Model Summary (For Leagile Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.432	.186	.149	.8457

a Predictors: (Constant), External relationships

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.600	1	3.600	5.034	.035
	Residual	15.733	22	.715		
	Total	19.333	23			

a Predictors: (Constant), External relationships

b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.762	.508		3.470	.002
	External relationships	.343	.153	.432	2.244	.035

a Dependent Variable: MPC system performance

For H3b.....

Model Summary (For All Sample Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.348	.121	.113	.9782

a Predictors: (Constant), Interdepartmental relationship

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.793	1	14.793	15.459	.000
	Residual	107.172	112	.957		
	Total	121.965	113			

a Predictors: (Constant), Interdepartmental relationship
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.950	.287		6.804	.000
	Interdepartmental relationship	.292	.074	.348	3.932	.000

a Dependent Variable: MPC system performance

Model Summary (For Reactor Organizations)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.697	.486	.463	.7879

a Predictors: (Constant), Interdepartmental relationship

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13.484	1	13.484	21.723	.000
	Residual	14.276	23	.621		
	Total	27.760	24			

a Predictors: (Constant), Interdepartmental relationship
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.985	.591		1.666	.109
	Interdepartmental relationship	.651	.140	.697	4.661	.000

a Dependent Variable: MPC system performance

Model Summary (For Lean Chain)

Model	R	R Square	Adjusted R Square	Std. Error of th Estimat
1	.332	.110	.095	1.0286

a Predictors: (Constant), Interdepartmental relationship

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.619	1	7.619	7.201	.009
	Residual	61.364	58	1.058		
	Total	68.983	59			

a Predictors: (Constant), Interdepartmental relationship
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.136	.412		5.179	.000
	Interdepartment al relationship	.286	.106	.332	2.684	.009

a Dependent Variable: MPC system performance

Model Summary (For Agile Chain)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.492	.242	.214	.9155

a Predictors: (Constant), Interdepartmental relationship

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.233	1	7.233	8.630	.007
	Residual	22.629	27	.838		
	Total	29.862	28			

a Predictors: (Constant), Interdepartmental relationship
b Dependent Variable: MPC system performance

Coefficients

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	1.371	.558		2.459	.021
	Interdepartment al relationship	.411	.140	.492	2.938	.007

a Dependent Variable: MPC system performance

Path Model Analysis Based on SEPATH (Model 1)

First Model Estimates (All Responding Organizations) – Low Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	-.002	4.561	-.000	1.000
(complexity)-2->(competitive str)	.000	45.667	.000	1.000
(operation envi)-3->(competitive str)	.004	3.896	.001	999
(competitive str)-4->(operation envir)	.675	.104	6.474	.000
(competitive str)-5->(mfg strategy)	1.642	.252	6.525	.000
(mfg strategy)-6->(MPC System)	1.482	.300	4.941	.000

First Model Estimates (All Responding Organizations) – Low Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	.034	.097	031	975
(complexity)-2->(competitive str)	.148	6.993	.021	.983
(operation envi)-3->(competitive str)	-.017	1.246	-.014	.989
(competitive str)-4->(operation envir)	.060	2.483	.024	.981
(competitive str)-5->(mfg strategy)	.171	86.660	.002	.998
(mfg strategy)-6->(MPC System)	.117	.372	.313	.754

First Model Estimates (Defender Organizations)

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	.000	40.148	.000	1.000
(complexity)-2->(competitive str)	.081	.142	.568	.570
(operation envi)-3->(competitive str)	-.044	.284	-.156	.876
(competitive str)-4->(operation envir)	.993	.306	3.242	.001
(competitive str)-5->(mfg strategy)	1.142	.350	3.259	.001
(mfg strategy)-6->(MPC System)	3.128	.957	3.268	.001

First Model Estimates (Prospector Organization) – High Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	-.000	230.904	-.000	1.000
(complexity)-2->(competitive str)	.000	138.730	.000	1.000
(operation envi)-3->(competitive str)	-.002	21.395	-.000	1.000
(competitive str)-4->(operation envir)	.513	.129	3.992	.000
(competitive str)-5->(mfg strategy)	1.457	.273	5.335	.000
(mfg strategy)-6->(MPC System)	.932	.234	3.978	.000

First Model Estimates (Analyzer Organizations) – High Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	.112	.104	1.069	.285
(complexity)-2->(competitive str)	.000	9345.798	.000	1.000
(operation envi)-3->(competitive str)	.000	4363.471	.000	1.000
(competitive str)-4->(operation envir)	.704	.214	3.295	.001
(competitive str)-5->(mfg strategy)	1.648	.483	3.413	.001
(mfg strategy)-6->(MPC System)	1.060	.434	2.441	.015

First Model Estimates (Reactor Organization)

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	.007	1.213	.006	.995
(complexity)-2->(competitive str)	.006	1.706	.004	.997
(operation envi)-3->(competitive str)	-.103	.117	-.886	.376
(competitive str)-4->(operation envir)	.842	.243	3.466	.001
(competitive str)-5->(mfg strategy)	1.295	.368	3.517	.000
(mfg strategy)-6->(MPC System)	2.336	.747	3.129	.002

First Model Estimates (Lean Organization) – High Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	.016	1.172	.014	.989
(complexity)-2->(competitive str)	.218	.118	1.841	.066
(operation envi)-3->(competitive str)	-.000	897.912	-.000	1.000
(competitive str)-4->(operation envir)	.846	.193	4.387	.000
(competitive str)-5->(mfg strategy)	1.423	.313	4.552	.000
(mfg strategy)-6->(MPC System)	.170	.404	.421	.673

First Model Estimates (Agile Organizations) – High Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	-.002	9.124	-.000	1.000
(complexity)-2->(competitive str)	-.001	43.689	-.000	1.000
(operation envi)-3->(competitive str)	.104	.167	.623	.533
(competitive str)-4->(operation envir)	.527	.160	3.302	.001
(competitive str)-5->(mfg strategy)	1.882	.558	3.370	.001
(mfg strategy)-6->(MPC System)	0.000	0.000		

First Model Estimates (Leagile Organization) – High Performance

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(competitive str)	-.000	79.887	-.000	1.000
(complexity)-2->(competitive str)	-.360	.165	-2.180	.029
(operation envi)-3->(competitive str)	-.000	1724.840	-.000	1.000
(competitive str)-4->(operation envir)	.739	.250	2.961	.003
(competitive str)-5->(mfg strategy)	1.587	.544	2.917	.004
(mfg strategy)-6->(MPC System)	.459	.271	1.694	.090

Path Model Analysis Based on SEPATH (Model 2)

Second Model Estimates (All Responding Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.155	.087	-1.790	.073
(dynamism)-2->(crp)	-.366	.117	-3.127	.002
(dynamism)-3->(mrp)	1.740	.115	15.147	.000
(dynamism)-4->(purchasing)	.514	.064	8.057	.000
(dynamism)-5->(inventory)	1.218	.155	7.842	.000
(dynamism)-6->(forecasting)	0.000	0.000		
(complexity)-7->(mps)	2.573	.213	12.075	.000
(complexity)-8->(crp)	2.064	.218	9.488	.000
(complexity)-9->(mrp)	1.575	.241	6.525	.000
(complexity)-10->(purchasing)	1.843	.162	11.393	.000
(complexity)-11->(inventory)	1.732	.240	7.206	.000
(complexity)-12->(forecasting)	.237	.163	1.451	.147
(operation envi)-13->(mps)	0.000	0.000		
(operation envi)-14->(crp)	0.000	0.000		
(operation envi)-15->(mrp)	.951	.214	4.446	.000
(operation envi)-16->(purchasing)	.283	.060	4.752	.000
(operation envi)-17->(inventory)	0.000	0.000		
(operation envi)-18->(forecasting)	1.492	.183	8.168	.000
(mps)-19->(mpc)	1.887	.304	6.202	.000
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	1.106	.142	7.785	.000
(purchasing)-22->(mpc)	-3.612	.538	-6.714	.000
(inventory)-23->(mpc)	.169	.084	2.021	.043
(forecasting)-24->(mpc)	.004	.050	.071	.944

Second Model Estimates (All Responding Organizations) – Low Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.969	.126	-7.706	.000
(dynamism)-2->(crp)	-.462	.185	-2.493	.013
(dynamism)-3->(mrp)	1.689	.175	9.679	.000
(dynamism)-4->(purchasing)	.030	.092	.327	.744
(dynamism)-5->(inventory)	.921	.202	4.571	.000
(dynamism)-6->(forecasting)	0.000	0.000		
(complexity)-7->(mps)	1.149	.267	4.296	.000
(complexity)-8->(crp)	2.068	.397	5.204	.000
(complexity)-9->(mrp)	.758	.241	3.145	.002
(complexity)-10->(purchasing)	.609	.241	2.531	.011
(complexity)-11->(inventory)	.332	.306	1.082	.279
(complexity)-12->(forecasting)	2.107	.321	6.560	.000
(operation envi)-13->(mps)	.646	.151	4.283	.000
(operation envi)-14->(crp)	.534	.378	1.414	.157
(operation envi)-15->(mrp)	1.339	.278	4.818	.000
(operation envi)-16->(purchasing)	.755	.245	3.080	.002
(operation envi)-17->(inventory)	1.054	.281	3.749	.000
(operation envi)-18->(forecasting)	2.222	.381	5.830	.000
(mps)-19->(mpc)	0.000	0.000		

(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	-.096	.100	-.958	.338
(purchasing)-22->(mpc)	.038	.191	.198	.843
(inventory)-23->(mpc)	.048	.105	.452	.651
(forecasting)-24->(mpc)	.010	.093	.104	.917

Second Model Estimates (Defender Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	.879	.291	3.024	.002
(dynamism)-2->(crp)	1.437	.331	4.338	.000
(dynamism)-3->(mrp)	1.412	.323	4.375	.000
(dynamism)-4->(pur)	.711	.294	2.422	.015
(dynamism)-5->(inv)	1.114	.389	2.866	.004
(dynamism)-6->(fore)	.594	.235	2.528	.011
(complex)-7->(mps)	2.551	.531	4.809	.000
(complex)-8->(crp)	.218	.549	.397	.691
(complex)-9->(mrp)	3.329	.823	4.045	.000
(complex)-10->(pur)	1.689	.398	4.248	.000
(complex)-11->(inv)	.958	.460	2.084	.037
(complex)-12->(fore)	1.546	.346	4.470	.000
(operenvi)-13->(mps)	.084	.152	.557	.578
(operenvi)-14->(crp)	0.000	0.000		
(operenvi)-15->(mrp)	2.431	.755	3.221	.001
(operenvi)-16->(pur)	1.277	.436	2.926	.003
(operenvi)-17->(inv)	0.000	0.000		
(operenvi)-18->(fore)	1.173	.378	3.107	.002
(mps)-19->(mpc)	0.000	0.000		
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	-.190	.264	-.721	.471
(pur)-22->(mpc)	-2.939	0.000		
(inv)-23->(mpc)	.009	.170	.054	.957
(fore)-24->(mpc)	3.984	.934	4.268	.000

Second Model Estimates (Prospector Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.374	.134	-2.781	.005
(dynamism)-2->(crp)	-.532	.198	-2.682	.007
(dynamism)-3->(mrp)	1.120	.198	5.657	.000
(dynamism)-4->(pur)	.384	.105	3.646	.000
(dynamism)-5->(inv)	1.305	.277	4.713	.000
(dynamism)-6->(fore)	1.085	.207	5.234	.000
(complex)-7->(mps)	.471	.250	1.883	.060
(complex)-8->(crp)	1.439	.335	4.301	.000
(complex)-9->(mrp)	1.917	.340	5.644	.000
(complex)-10->(pur)	.810	.233	3.469	.001
(complex)-11->(inv)	1.837	.414	4.440	.000
(complex)-12->(fore)	0.000	0.000		
(operenvi)-13->(mps)	.368	.085	4.341	.000
(operenvi)-14->(crp)	1.472	.325	4.525	.000
(operenvi)-15->(mrp)	1.014	.415	2.441	.015
(operenvi)-16->(pur)	1.015	.259	3.914	.000

(operenvi)-17->(inv)	.815	.373	2.187	.029
(operenvi)-18->(fore)	2.525	.319	7.918	.000
(mps)-19->(mpc)	.070	.086	.807	.420
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.001	.100	.005	.996
(pur)-22->(mpc)	.083	.144	.573	.567
(inv)-23->(mpc)	.053	.076	.691	.489
(fore)-24->(mpc)	-.002	.055	-.041	.968

Second Model Estimates (Analyzer Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	.952	.132	7.201	.000
(dynamism)-2->(crp)	-.021	.239	-.086	.931
(dynamism)-3->(mrp)	.485	.214	2.269	.023
(dynamism)-4->(pur)	0.000	0.000		
(dynamism)-5->(inv)	1.257	.269	4.664	.000
(dynamism)-6->(fore)	1.444	.289	4.994	.000
(complex)-7->(mps)	.216	.422	.513	.608
(complex)-8->(crp)	0.000	0.000		
(complex)-9->(mrp)	1.128	.322	3.503	.000
(complex)-10->(pur)	.518	.237	2.188	.029
(complex)-11->(inv)	1.773	.309	5.744	.000
(complex)-12->(fore)	1.689	.296	5.702	.000
(operenvi)-13->(mps)	.221	.094	2.347	.019
(operenvi)-14->(crp)	3.440	.475	7.242	.000
(operenvi)-15->(mrp)	.560	.360	1.556	.120
(operenvi)-16->(pur)	1.035	.269	3.849	.000
(operenvi)-17->(inv)	.648	.306	2.116	.034
(operenvi)-18->(fore)	0.000	0.000		
(mps)-19->(mpc)	0.000	0.000		
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.050	.161	.313	.754
(pur)-22->(mpc)	.389	.231	1.682	.093
(inv)-23->(mpc)	-.199	.497	-.401	.688
(fore)-24->(mpc)	.208	.420	.495	.621

Second Model Estimates (Reactor Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	.344	.282	1.221	.222
(dynamism)-2->(crp)	.326	.323	1.009	.313
(dynamism)-3->(mrp)	.887	.370	2.396	.017
(dynamism)-4->(pur)	.899	.321	2.804	.005
(dynamism)-5->(inv)	1.310	.385	3.406	.001
(dynamism)-6->(fore)	1.485	.374	3.965	.000
(complex)-7->(mps)	1.507	.561	2.685	.007
(complex)-8->(crp)	1.113	.593	1.878	.060
(complex)-9->(mrp)	2.309	.567	4.072	.000
(complex)-10->(pur)	1.855	.499	3.714	.000

(complex)-11->(inv)	.589	.499	1.181	.238
(complex)-12->(fore)	0.000	0.000		
(operenvi)-13->(mps)	.141	.088	1.604	.109
(operenvi)-14->(crp)	1.699	.606	2.805	.005
(operenvi)-15->(mrp)	1.702	.662	2.571	.010
(operenvi)-16->(pur)	0.000	0.000		
(operenvi)-17->(inv)	.043	.535	.080	.936
(operenvi)-18->(fore)	1.498	.514	2.914	.004
(mps)-19->(mpc)	.084	.142	.590	.555
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.139	.186	.748	.454
(pur)-22->(mpc)	-.244	.289	-.843	.399
(inv)-23->(mpc)	.027	.148	.183	.855
(fore)-24->(mpc)	-.095	.147	-.647	.517

Second Model Estimates (Reactor Organizations) – Low Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.839	.195	-4.298	.000
(dynamism)-2->(crp)	.705	.289	2.441	.015
(dynamism)-3->(mrp)	1.845	.272	6.775	.000
(dynamism)-4->(pur)	.251	.131	1.909	.056
(dynamism)-5->(inv)	.765	.300	2.547	.011
(dynamism)-6->(fore)	0.000	0.000		
(complex)-7->(mps)	.990	.277	3.575	.000
(complex)-8->(crp)	1.636	.543	3.013	.003
(complex)-9->(mrp)	0.000	0.000		
(complex)-10->(pur)	1.401	.367	3.817	.000
(complex)-11->(inv)	0.000	0.000		
(complex)-12->(fore)	.549	.386	1.423	.155
(operenvi)-13->(mps)	0.000	0.000		
(operenvi)-14->(crp)	0.000	0.000		
(operenvi)-15->(mrp)	1.159	.369	3.138	.044
(operenvi)-17->(inv)	.255	.291	.877	.380
(operenvi)-18->(fore)	2.158	.449	4.805	.000
(mps)-19->(mpc)	1.061	.453	2.344	.019
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.494	.220	2.241	.025
(pur)-22->(mpc)	-.199	.111	-1.799	.200

Second Model Estimates (Lean Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	.505	.147	3.438	.001
(dynamism)-2->(crp)	1.247	.193	6.460	.000
(dynamism)-3->(mrp)	.795	.211	3.771	.000
(dynamism)-4->(pur)	.628	.146	4.291	.000
(dynamism)-5->(inv)	1.355	.235	5.759	000
(dynamism)-6->(fore)	1.299	.241	5.386	.000
(complex)-7->(mps)	2.421	.318	7.619	.000
(complex)-8->(crp)	1.567	.325	4.820	.000

(complex)-9->(mrp)	3.164	.403	7.857	.000
(complex)-10->(pur)	2.084	.262	7.958	.000
(complex)-11->(inv)	.176	.288	.609	.542
(complex)-12->(fore)	1.125	.356	3.157	.002
(operenvi)-13->(mps)	.126	.140	.899	.369
(operenvi)-14->(crp)	.363	.340	1.068	.286
(operenvi)-15->(mrp)	1.208	.423	2.860	.004
(operenvi)-16->(pur)	.202	.237	.853	.394
(operenvi)-17->(inv)	0.000	0.000		
(operenvi)-18->(fore)	1.574	.310	5.076	.000
(mps)-19->(mpc)	.097	.380	.256	.798
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.549	.399	1.373	.170
(pur)-22->(mpc)	-.877	.673	-1.303	.193
(inv)-23->(mpc)	.086	.100	.860	.390
(fore)-24->(mpc)	-.291	.242	-1.203	.229

Second Model Estimates (Lean Organizations) – Low Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.965	.169	-5.695	.000
(dynamism)-2->(crp)	-.048	.238	-.201	.840
(dynamism)-3->(mrp)	1.187	.242	4.910	.000
(dynamism)-4->(pur)	039	.124	.314	.754
(dynamism)-5->(inv)	1.088	.284	3.834	.000
(dynamism)-6->(fore)	1.031	.273	3.779	.000
(complex)-7->(mps)	.657	.255	2.576	.010
(complex)-8->(crp)	1.640	.358	4.584	.000
(complex)-9->(mrp)	1.195	.312	3.836	.000
(complex)-10->(pur)	.441	.289	1.528	.127
(complex)-11->(inv)	.211	.441	.479	.632
(complex)-12->(fore)	0.000	0.000		
(operenvi)-13->(mps)	.305	.102	2.991	.003
(operenvi)-14->(crp)	.353	.370	.953	.340
(operenvi)-15->(mrp)	.144	.370	.389	.697
(operenvi)-16->(pur)	.391	.285	1.372	.170
(operenvi)-17->(inv)	1.009	.369	2.732	.006
(operenvi)-18->(fore)	2.939	.413	7.120	.000
(mps)-19->(mpc)	0.000	0.000		
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	-.185	.097	-1.910	.056
(pur)-22->(mpc)	-.061	.148	-.414	.679
(inv)-23->(mpc)	.006	.080	.074	.941
(fore)-24->(mpc)	.050	.057	.866	.386

Second Model Estimates (Agile Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.140	.142	-.988	.323
(dynamism)-2->(crp)	.456	.325	1.404	.160
(dynamism)-3->(mrp)	.046	.137	.335	.738

(dynamism)-4->(pur)	.496	.134	3.700	.000
(dynamism)-5->(inv)	2.112	.282	7.485	.000
(dynamism)-6->(fore)	.400	.111	3.601	.000
(complex)-7->(mps)	.554	.452	1.224	.221
(complex)-8->(crp)	.910	.803	1.134	.257
(complex)-9->(mrp)	1.362	.431	3.158	.002
(complex)-10->(pur)	1.044	.340	3.069	.002
(complex)-11->(inv)	0.000	0.000		
(complex)-12->(fore)	1.226	.234	5.244	.000
(operenvi)-13->(mps)	.353	.115	3.067	.002
(operenvi)-14->(crp)	3.182	.548	5.812	.000
(operenvi)-15->(mrp)	1.271	.486	2.614	.009
(operenvi)-16->(pur)	.959	.385	2.489	.013
(operenvi)-17->(inv)	.879	.444	1.978	.048
(operenvi)-18->(fore)	.000	0.000		
(mps)-19->(mpc)	0.000	0.000		
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.088	.135	.654	.513
(pur)-22->(mpc)	.144	.188	.765	.444
(inv)-23->(mpc)	.114	.070	1.622	.105
(fore)-24->(mpc)	-.210	.201	-1.042	.297

Second Model Estimates (Leagile Organizations) – High Performers

	Parameter Estimate	Standard Error	T Statistic	Prob. Level
(dynamism)-1->(mps)	-.355	.165	-2.150	.032
(dynamism)-2->(crp)	-.927	.239	-3.883	.000
(dynamism)-3->(mrp)	1.888	.219	8.607	.000
(dynamism)-4->(pur)	.473	.137	3.455	.001
(dynamism)-5->(inv)	1.172	.305	3.835	.000
(dynamism)-6->(fore)	0.000	0.000		
(complex)-7->(mps)	2.414	.402	6.002	.000
(complex)-8->(crp)	1.371	.395	3.473	.001
(complex)-9->(mrp)	.396	.430	.922	.357
(complex)-10->(pur)	.270	.273	.989	.323
(complex)-11->(inv)	1.281	.455	2.817	.005
(complex)-12->(fore)	1.668	.304	5.492	.000
(operenvi)-13->(mps)	.285	.106	2.693	.007
(operenvi)-14->(crp)	0.000	0.000		
(operenvi)-15->(mrp)	1.348	.401	3.361	.001
(operenvi)-16->(pur)	.985	.277	3.559	.000
(operenvi)-17->(inv)	1.232	.373	3.305	.001
(operenvi)-18->(fore)	2.017	.385	5.245	.000
(mps)-19->(mpc)	.142	.095	1.498	.134
(crp)-20->(mpc)	0.000	0.000		
(mrp)-21->(mpc)	.055	.088	.622	.534
(pur)-22->(mpc)	.359	.137	2.627	.009
(inv)-23->(mpc)	.062	.103	.605	.545
(fore)-24->(mpc)	-.061	.104	-.587	.557