The effects of collaborative supply chain solutions on strategic performance management

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This study is about the effects of workflow automation on strategic performance of supply chains in the discrete manufacturing industry. The findings of this study are based on field data collected at real world manufacturing companies. This study has been a challenging journey for me. Fortunately, I am not alone on this journey. There are those who stood by me. I would like to acknowledge this people for their guidance and support.

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Contents

Chapter 1: Introduction

"What are the effects of collaborative solutions on strategic performance management of supply chains?" This question states the research problem addressed here. Before attempting to provide an answer, the question first needs clarification and delineation. This chapter does so by putting the question into context, regarding both academic and managerial relevance as well as significant prior research in related areas. This then leads to the formulation of a specific research question and of expected contributions. A section on research method i.e. the approach taken to answer these questions, and an outline of this thesis concludes the chapter.

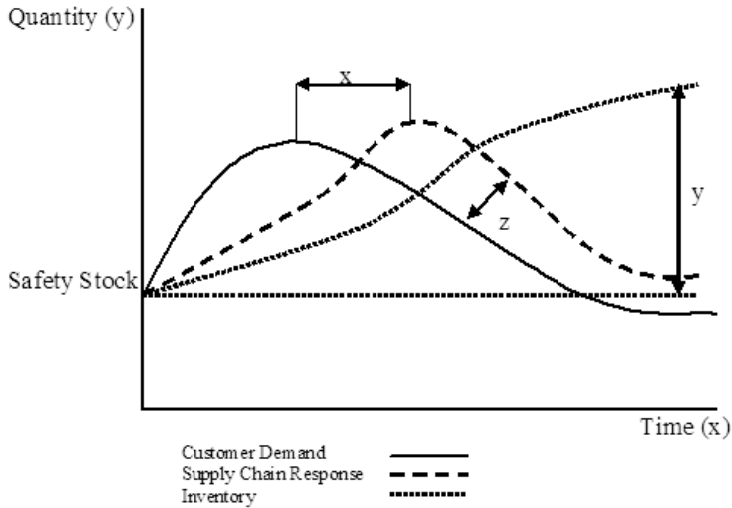
1.1. Research Problem and Relevance

Start by considering the supply chain performance plot in Fig. 1.1, below. This is a 'snap shot' representation of supply chain performance taken from the first Action Research (AR) cycle at the first study organization namely SAM. The x-axis is time in days and the y-axis quantity in units. Customer demand for an item is variable over time. The period-planning processes accumulate information based on SAM weekly Master Production Schedule (MPS), causing a time delay between the actual events and when the supply side responses to the changes in demand. As a result of these delays, planners at SAM make responses for adjustments based on what has already happened and anticipating what the planners think is likely to happen next. Typically SAM ends up with an incorrect forecast that is over or under planning the supply.

What distorts the supply chain performance so badly is response time i.e. the lengthy delay between the event that creates the change i.e. demand shift in the form of a message or signal and the time when the factory i.e. supply side finally responds to this message or signal (Schroeder & Flynn, 2001). These delays are caused by delays in workflow i.e. information flow. Essentially this response time delay problem can be restated as an interaction dynamics problem. This includes but is not limited to delays and disruptions in supply chain transactions, communications and coordination. Goldratt (1986) described this as a 'scheduling problem' mainly from a production perspective of supply chains. Hau (1997) described this as a 'Bullwhip effect' from a distribution standpoint of supply chains. The bullwhip phenomenon was

first noted by Forrester (1958), and has since been observed in many diverse settings.

Fig 1.1: A 'snap shot' of supply chain performance at SAM



x: Time Delay (Response is delayed by the period planning cycle)
y: Inventory Oscillation (Demand is variable causing inventory buildup)
z: Inaccuracy (Planning overreacts based on inaccurate information)

Some examples of problems created by response time delays affecting supply chain performance:

a) Large inventory swings or oscillations,
b) Excessive inventory i.e. the result of building up 'protection or safety' stock. This creates additional inventory holding costs; however if safety stock is not provided there is a risk of stock outs,
c) Wrong inventory i.e. the result of overstocking some items and depleting inventory of others,
d) Poor customer service level and lost sales, and
e) Remedy of the above problems will require a costly investment of time and money.

It is evident from the above listed problems that the nature of these problems caused by response time delays, are partly operational i.e. inventory levels and holding cost are partly strategic i.e. inability to react quickly to shifting customer demands and poor customer service level.

According to Porter (1996), various management tools like total quality management, benchmarking, time-based competition, outsourcing, partnering, reengineering, that are used today, do enhance and dramatically improve the operational performance of a company, but fail to provide the company with sustainable profitability. Thus the root cause of the problem seems to be failure of management to distinguish between operational excellence and strategy. A visionary strategy that is not linked to operational performance and governance processes cannot be implemented. Conversely, operational excellence may lower cost, improve quality and reduce lead times, but without strategy's vision and guidance, a company is not likely to enjoy sustainable success from its operational improvements alone (Kaplan & Norton, 2008).

Although both operational excellence and strategy are necessary for the sustainable, profitable performance of an organization, they operate in different ways:

a) **Operational Excellence** i.e. performing similar activities better than rivals perform them and,
b) **Strategy** i.e. performing different activities from rivals' or performing similar activities in different ways.

According to Kaplan & Norton (1996), there are four strategic goal perspectives:

a) Financial,
b) Customer,
c) Internal Process and
d) Learning.

All successful strategic plans should cover at least the four critical perspectives listed above to be effective in driving the company towards long term success. Supply chain has much to offer in 'strategic' terms for achieving performance, competitiveness and sustainable profitability. Further supply chain scope covers all four critical goal perspectives listed above. Therefore, supply chain becomes the focus of our study as representing strategic performance.

Strategic performance in supply chain is about delivery of the right product, the right quantity, at the right price, to the right place, on time (Srakis & Talluri, 2008). The 'right' refers to what the customer wants. To meet the customer 'wants' the supply chain has to be 'in sync with customer' i.e. in synchronization with customer. The term synchronization *may* be somewhat misleading since synchronization usually implies simultaneity: 'Synchronization: occur at the same time;

coincide in point in time; be contemporary or simultaneous' (Brown, 1993). Since, in supply chain context, synchronization enforces ***ordered actions*** rather than simultaneous actions. Therefore, 'in sync with customer' does not provide synchronization according to this definition. However, there is a long-standing tradition in computer science to interpret the term *synchronization* more broadly so that it is concerned with '***correct order'*** rather than 'same time' (Svend, 1996). Rather than invent terminology, I have chosen to be consistent with the computer science literature and use of *synchronization* in this broader sense.

Often software solutions to support supply chain operations are installed on top of other enterprise software or legacy systems, requiring an array of interfaces to be developed. Linking different applications requires a profound level of understanding about the data that is passed back and forth between them. I begin by asking myself, which aspects of supply chain do I want to focus on?

I begin by focusing my attention on supply chain interaction dynamics. These interactions encompass supply chain transactions, communications and coordination activities within and between autonomous entities in the supply chain. The supply chain transaction, communications and coordination activities defines customer synchronization effectiveness and efficiency in strategic performance management of supply chains.

Workflow of the supply chain then becomes the key means of studying the interaction dynamics, with the objective towards strategic performance. Information flow can be seen as a common denominator of the four strategic goal perspectives outlined above. Information flow is also a precursor of workflow. Therefore, instead of targeting the four individual strategic goal perspectives, I will target improvements in information flow of supply chains. Further, I want to achieve this performance improvement using flexible, open technology that works unobtrusively with the existing infrastructure in the study organization. Such systems are far more likely to deliver positive intervention, remain flexible enough to accommodate future changes, and offer a less risky investment to organizations seeking to leverage technology and deliver real bottom-line improvements. I align my focus on workflow automation as a means to improve information flow in supply chains.

Although there is a substantial volume of literature on the topic of Supply Chain Management, as will be discussed in the literature review in Chapter 2, the major concentration is on operational initiatives such as Zero Inventory, JIT (Just-In-Time), SMED (Single Minute Exchange of

Die/Mould), ERP Software and Scheduling using Computer software. There is sufficient coverage of the strategic aspects of supply chain performance in terms of 'Agility' and need for 'Service Level' capability. However, there is hardly any evidence of the two working together. I will therefore concentrate my study on whether and how workflow automation can fill this gap by connecting the operational and strategic aspect of supply chain performance. Consequently, my research focus is narrowed down to the study of workflow automation effects on strategic performance management of supply chains.

This research emerges from an interest in applying Information & Communication Technology (ICT) based solution to the 'response time' delays problem. Seen here as a supply chain interaction dynamics problem. As will be discussed in section 1.2.4 in this chapter, workflow is a class of collaborative solution of the ICT domain. The Strategic Inhibitors Model (SPI), as will be discussed in Chapter 2, will be operationalized by deployment of workflow automation to support supply chain interactions and studying the effects this would have on organizations and individuals. I have therefore formulated my central research question as follows:

How are efforts to manage strategic performance of supply chains affected by workflow automation?

Gates (2000) in Business @ the speed of Thought says "*The twenty-first century will be about velocity: the speed of business and the speed of change"*. He argues that an improved information flow is imperative to be able to react quickly to changing customer demands.

During evaluation, an organization's capability to respond to changes is compared with an abstract entity called "agile organization" (Paterson et. al., 2003). An agile organization socio-technical system supports agility to respond quickly to change in an uncertain business environment. For an organization to be agile it has to be capable of operating profitably in a competitive environment of continual and unpredictable change, especially in customer demands. The most important characteristics of agile organizations, within the context of our research, is being responsive to changes in plans, schedules, market demands, product options and service levels.

It is important to note that quick reactions to changing environments are not only relevant from an operational logistical supply chain perspective, in terms of inventory levels and costs. Reacting quickly is also crucial to

allow organizations to be customer centric in their process orientation. The concept of a process-oriented organization (Tennant, 2001) is a way of focusing the activities of an organization towards the customer wants, also called 'customer orientation'. These activities are oriented towards and validated by customers both internal and external i.e. "in-sync with customers".

A process-oriented organization tackles inter-functional and inter-departmental conflicts by creating structures and taking ownership of their customer wants e.g. vendor managed inventories (VMI) and postponement strategies. In process-oriented organizations, it is mandatory that adaptation to changes is responsive, so that the customer wants are continuously met. This necessity favors the continuous improvement of every aspect of the enterprise, being it process, product or people related. Information technologies are among the principal factors to permit a process-based restructuring of a given organization (Rosemann, et al., 2003; Willcocks, et al., 2002).

In order to operationalize this research question, I need to harness a model to sharpen our focus and put this research into the context of current knowledge in the field of strategic performance of supply chains. Where, Chapter 2 is reserved for a more in-depth grounding of the concepts applied for the development of SPI. The next section focuses on some of the relevant anchors from significant prior research and some key concepts in areas of direct relevance to SPI and the research topic.

1.2. Key Concepts & Significant Prior Research

In order to operationalize the research question, it is first necessary to obtain an understanding of key supply chain concepts, models and interfaces. Particularly, relating to strategic performance of supply chains. It is then necessary to delineate workflow automation in the collaborative solutions landscape. These key supply chain concepts, models and interfaces, together with workflow automation as a means of collaboration, have sound implications for theory development on strategic performance management of supply chains.

1.2.1. Inventory Management in Supply Chains

The bullwhip effect: refers to the observation that the variability of orders in supply chains increases as one move closer to the source of production (Hau, 1997). The effect is costly because it causes excessive inventories, unsatisfactory customer service, and uncertain production planning.

According to Lewis & Slack (2003), several industry studies such as Efficient Consumer Response (ECR) and Efficient Foodservice Response (EFR), report the bullwhip effect as most harmful to the strategic performance of supply chains. The bullwhip phenomenon was first noted by Forrester (1958), and has since been observed in many diverse settings.

Lead-time (or Safety Stock) Syndrome: Firms deal with two types of flows i.e. information and materials (Shaw, 2001). The “bullwhip effect” is exposing only the top layer of problems production companies face today in managing these flows. Functional silos within each company affect the flow of information and materials; just as autonomous entities do in the supply chain. Batch processing of information generates effects of the "bullwhip effect" within the organization. Distorted demand data and delayed information become commonplace eliciting a reaction typical of purchasing personnel and production planners. This reaction is referred to as the "Lead-time (or Safety Stock) Syndrome".

The Inventory Reduction Syndrome: Eventually, the overload is relieved since increased capacity floods the supply chain causing the second effect from distorted demand data. This effect, labeled "The Inventory Reduction Syndrome", is the result of the organization addressing the excess inventory created by the first syndrome. Without process changes, these two syndromes feed each other in a continuous loop.

Shortcomings: The bullwhip effect, Lead-time (or Safety Stock) Syndrome, and the Inventory Reduction Syndrome concepts focus on material flow of the supply chain. While the concepts mentioned above are relevant and valid for evaluation of strategic performance in supply chains. The associated biases of past data, inventory and supply-side have serious implications on strategic performance management of supply chains.

- ***Past Data Bias****:* Customer Orders are recognized in the supply chain as a plan i.e. simply a set of actions attempted at a particular time. Therefore, planning becomes the task of navigating from present to the future along a temporal tree in an effort to attain a world-history in which the goal condition i.e. delivery of the customer order is satisfied. But all planning is based on past and current events data, typically resulting in an incorrect forecast that is over or under planning the supply.

- ***Hedging Bias***: Uncertainty is a risk brought about by a lack of information about a future event. The objective is to reduce uncertainty. One approach to reduce uncertainty is to place inventory in the supply chain e.g. safety stock. However, this approach has cost implications such as cost of storage, depreciation, currency fluctuation, obsolescence, insurance and handling cost.

- ***Supply Side Bias***: Arguably one of the most important management tasks in manufacturing is Master Production Scheduling (MPS). This is also the seat of complexity in manufacturing. In MPS there are two types of complexity: i) Detail Complexity i.e. when there are many variables. ii) Dynamic Complexity i.e. situations where cause and effect are subtle, and where the effects over time of interventions are not obvious. (Peterson, Mannix, Tuttle & Day, 2003). Detail complexity can be overcome by use of computer software. Dynamic complexity is typically managed by setting planning time fence to create time zone e.g. 'firm zone' typically from 1st week to 4th week, 'trading zone' from 5th week to 8th week and 'open zone' from 9th week onwards. In the firm zone changes to the MPS are resisted, making changes – particularly on the supply side are very difficult and can be expensive. In the trading zone changes to mix are allowed but some restrictions are set for volume changes. In the open zone both mix and volume changes are practical. This planning time fence although necessary to manage dynamic complexity have implications for strategic performance management of supply chains.

1.2.2. Process Orientation in Supply Chain

Value Chain Model: In his well-known book Competitive Advantage, Michael E. Porter (1985) takes what is essentially a process view. He looks at the main business of an enterprise as a single process and divides it into a number of sub processes. He then looks at how each sub process adds value to the overall process. Suppose a restaurant turns raw materials into food to satisfy customers. Based on the cost of raw materials and what is paid for the final dishes, the value added by the restaurant can be determined.

In principle this added value can now be divided among the activities such as purchasing materials, taking orders, preparing ingredients, cooking, presentation, delivery to table and collecting payment.

Peripheral activities such as decorating the room also add value, since people are prepared to pay more for the same food served in a better ambience. Having assigned values to the activities we now have a "value chain".

To help establish value chains in complex organizations, Porter has defined a number of typical key activities. Primary activities i.e. inbound logistics, operations, outbound logistics, marketing & sales, service. Support activities i.e. Procurement, technology development, human resource management, maintaining infrastructure for planning, accounting, finance, legal matters, government liaison, quality.

Enterprise Integration model: It combines basic tenets of linking generic i.e. structural strategies with functional i.e. prescriptive strategies (Wu, 2002), proposed an integrated framework to manage a supply chain. Its building blocks are availability, supply and demand, for inventory; and a planning unit that coordinates marketing and production of inventory. Relationships between these are expressed in traditional 'inventory-balance' equations, as follows: *Inventory level + Supply level = Demand level*

Shortcomings: The Value Chain Model and Enterprise Integration Model have been well received by the industry and practitioners. However, the models are static in nature and do not provide a means to capture the dynamics of supply chain interactions and transactions. These supply chain interactions and transactions in the form of messages and responses are vital to the evaluation of strategic performance management of supply chains. Also, the associated variation in process over time and Information System disconnect with action have serious implications for strategic performance management of supply chains.

- ***Variation in process over time***: Delivery is a key representation of an ***output*** of a production process or system (Keller & Ludwig, 2002). All processes and systems produce variation in output. No system is perfect. This applies to all systems, natural or man-made. Hence the importance of continuous improvement cycles (Dalcher, 2003). A good example of such improvement cycle is PDCA – Plan, Do, Check and Act. It is like an autopilot of an aircraft. Small and frequent adjustments are needed to keep the aircraft on the right path, due to influence of factors both internal and external. It is obvious then, that variation is the enemy of performance. The less of it we have, the more reliable our process or product and the greater the value. But at the same time, we can never eliminate

variation. So an important question is how much variation can be tolerated from a value or economic perspective? Therefore, understanding variation is the key to understanding strategic performance management of supply chains.

- ***Schedule disconnect with Action***: A perfect schedule is of no use if the shop floor is not able to execute according to the schedule. A closed loop mechanism is needed to ensure feedback from shop floor to schedule. This connection is achieved through a concept of 'pull replenishment' (Wallace, 2003). This 'pull replenishment' is based on a visual scheduling technique called Kanban. In Japanese, the word Kan means 'visual' and the word ban means 'card'. So Kanban refers to 'visual cards'. The visual signal used for Kanban could be a card, a flag, a ball, an empty tray, an empty rack, an empty truck or an electronic signal. Making this connection between the schedule and the shop floor by visual means has implications for strategic performance management of supply chains.

1.2.3. Communication and Coordination in Supply Chains

Interfacing aspects of strategic performance of supply chains have received attention of researches and practitioners. What emerges from this empirical research is a fairly consistent and robust picture of the processes for transactions, communication and coordination in supply chains.

SCOR Model: SCOR (Supply Chain Operation Reference) is a process reference model that provides a language for communicating among intra-company functions and inter-company supply chain partners (Bolstorf & Rosenbaum, 2003).

Buyer-Supplier Interface: The buyer-supplier interface includes all activities and processes associated with the transfer of goods or services from one firm to another. It includes order placement, billing and payment, inventory management of finished goods at the supplier and purchased parts at the buyer and transportation and external logistics. Increasing the efficiency of the buyer-supplier interface, from a supply chain cost perspective, deals with reducing the cost associated with these activities and processes. The primary ways that the interface can be made more efficient are by lowering transaction-processing costs and by reducing uncertainty (Cooper & Schlamuder, 1999)

Shortcomings: The SCOR model focus is on the design of Supply chain based on the four core processes i.e. plan, source, make and deliver. The 'Buyer-Supplier Interface model' focuses on transactions. While SCOR model has been well received by the Industry and the practitioner and the Buyer-Supplier Interface has been the subject of much academic attention. The associated biases listed below have serious implications for strategic performance management of supply chains.

- ***Interpretation Bias***: The ambiguity, confusion, lack of understanding, or the existence of multiple and conflicting interpretations (Smargt, 2000) about a message is what is defined as 'Equivocality' in the supply chain. Although a piece of information i.e. message is received at the right time and at right place by the right person. If there is a lack of understanding or clarity and a need for more information becomes necessary to resolve this ambiguity, a delay in response could occur. Reducing equivocality has implications for strategic performance management of supply chains.

- ***Interface Bias***: Verbal communication i.e. face-to-face or remote through telecommunication means, if not supported by written documentation is then dependent on ones memory. Atkinson and Shiffrin (1971) proposed a theory of memory that emphasizes the interaction among the sensory store, *short-term memory i.e. verbal and long-term memory i.e. written*. The label *short-term memory* indicates that information is lost rapidly unless it is preserved through rehearsal. The rapid rate of forgetting, from memory was established by Peterson and Peterson (1959) at Indiana University. The interface by which data on interactions and transactions is collected, stored and retrieve has implications for strategic performance management of supply chains.

- **Expediting Bias**: People are paid based on the amount of time spent on the job i.e. the more time, the more money. Expediting becomes necessary due to equivocality i.e. response time delays coupled with inaccurate messages and responses. Expediting is a waste of people's time (Imai, 1997). This communication and coordination involving different people over diverse geography has implications for strategic performance management of supply chains.

- **Asynchronous Interaction**: The problem of actually operationalizing supply chains has remained challenging; supply

chains not only have a large number of concurrent components i.e. Suppliers, Entities, Plants, Distribution Centers, Shipment agencies and so on, but these components can interact asynchronously to create an exponential number of possible outcomes. There is no CEO who owns the supply chain from end-to-end like an enterprise. The need to coordinate the behavior of the autonomous entities to maintain coherence in the supply chain adds considerable complexity (Jung & Jeong, 2004). Such coordination involves dynamic temporal relations between events occurring at different entities resulting in a large number of messages and responses (Chinn & Madey, 2000)

It can be argued that the above 'shortcomings' or biases are particularly important where it concerns performance inhibitors i.e. uncertainty of plans, equivocality of interactions, complexity of scheduling and variability of production. Since, the objective of strategic performance management of supply chains is to reduce performance inhibitors in an integral manner, over time through continuous improvement cycles (Dalcher, 2003); the biases mentioned above will have serious implications on managing strategic performance of supply chains.

1.2.4. Collaborative Solutions

This section elaborates on the collaborative solutions and the aspects of workflow automation that will be the focus of this study, and its relevance to strategic performance management of supply chains. Collaborative solutions are classified according to three aspects of computer supported cooperative work (CSCW) i.e. in the context of supply chain, application for communication, coordination and collaboration. Taxonomy of collaborative solutions classifies applications according to synchronicity (i.e. time) on one dimension and geographical dispersion on the other dimension (Anderson, 2001).

Workflow automation is a primary CSCW class of collaborative solutions and has application for communication, coordination and collaboration in strategic performance management of supply chain. The importance of workflow automation is demonstrated by the fact that even in its most rudimentary form i.e. asynchronous text-based email system, it has made a significant impact on theorists from sociology (Thurlow et al., 2004), computer science (Greening, 2000), philosophy (Floridi, 2003), education (Moore & Anderson, 2003), and medicine (Buzug et al., 2001).
CSCW has been forecasted as a major socio-technological force leading to significant changes in human interaction. With somewhat less stature,

workflow automation has also become worthy of formal academic investigation. This is revealed through published work in Business Process Management (Reijers, 2003), Supply Chain Management (Handfield & Nichols, 2002), and ICT i.e. Information and Communication Technology (Kiel, 2001).

Workflow automation systems focus on the communication and coordination of people performing different tasks, at different times and different places to create the final work product. In the context of strategic performance management, information or knowledge gathered has to be retained or stored over long intervals i.e. days and weeks before being applied i.e. recalled. In the meantime, interference of other activities or external sources also comes to add to the already voluminous database of actions and interactions. Therefore, information has to be in the medium that allows for easy gathering, storage and retrieval i.e. recall without loss of data integrity. Verbal communication is not well suited for such application.

Workflow automation's main function is to enable managers to design and track the execution of interrelated activities (Luftman, 2003). Great importance has been given lately to workflow as it is closely related to the concept of process. As the awareness about this concept increased in the management community in the last few years, especially due to the business process reengineering (BPR) movement, several discussions have been taking place about technical and conceptual aspects associated with linking workflow automation systems to business process improvement (Scheer, 2000).

Workflows are categorized according to their value to business and their repetition (Miller & Berger, 2001). Workflows for strategic performance are characterized by having a high business value and a high repetition factor e.g. Order processing and fulfillment. It is the efficient execution of workflows that provides the company with a competitive edge. An additional distinctive dimension to the business value and the repetition factor is the "degree of automation of the workflow". A workflow with a high degree of automation does not necessarily mean that the workflow has no interaction with humans. But typically, a highly automated workflow is fragmented into sequences of activities, each of which is performed by a single user, intermixed with automatically performed sequences.

1.2.5. Supply Chains and Workflow Automation

While all the models studied in the literature review stage touched on both the operational and strategic aspects of the supply chain performance. None however made an explicit connection between the two. In order to operationalize the research question, it is imperative that a connection is made between the strategic and operational aspects of supply chain performance. Workflow automation provides the foundation to build a model that has elements to capture supply chain interactions and transactions dynamics.
The objective of the model is to reduce performance inhibitors through improved information flow that will enhance communication and coordination in the supply chain. Improved communication and coordination reduces uncertainty, equivocality, complexity and variability in supply chains (Chandra & Kamrani, 2004).

Where this discussion of strategic performance management of supply chain and workflow automation suffices for the purpose of delineating and clarifying the research question, a detailed explanation on the model development is postponed until Chapter 2

1.3. Research Objectives and Expected Contributions

This study should lead to a better understanding of the effects of workflow automation on strategic performance management of supply chains by improving information flow leading to enhancements in supply chain interactions. By the deployment of workflow automation in real life companies and studying the effects it has on organizations and individuals, from order taking process through delivery to customer, by means of action research intervention in the organization, the link can be made between operational aspects and strategic aspect of supply chain performance.

The response time delays problem has been restated as an interaction dynamics problem (Section 1.1, above) affecting strategic performance management of supply chains. “Strategic performance inhibitors” and “Focus events” will be identified and observed along the AR iterations together with the research variables. There are four Strategic performance inhibitors relating to the respective focus event (detail discussion postponed until Chapter 2) i.e. Uncertainty of Plans, Equivocality of Communication, Complexity of Scheduling and Variability of Actions. The objective of the workflow automation is to reduce all Strategic performance inhibitors together in an integrated manner. However, the

magnitude of reduction is allowed to be different amongst the Strategic performance inhibitors.

Given the relative breadth of the research topic and the associated diversity of the related areas, the findings of this research are expected to be considerably lengthy. Therefore, I decide to summarize the findings according to two classification schemes:

a) **Degree of Reliability** i.e. by apparent degree of intensity (i.e. the strength of the computer supported workflow automation effects observed),
b) **Degree of Applicability i.e.** by apparent degree of external validity (i.e. how likely are the computer supported workflow automation effects to be observed in other organizations)

It is important to note that a distinction is made between the types of contributions arising from this research. Knowledge contributions (Leithwood et al., 2000) relate to the developing theory of the field, while value contributions (Cowan et al., 2000) relate to the use of the new knowledge in practice. Gowin's Vee heuristics provides the supporting links that warrants these claims.

Knowledge Contributions: This study attempts to understand the effects of improving information flow will have on organizations and individuals in a supply chain. Its aim is exploratory, building towards constructive guidance for managers to support communication and coordination improvement in supply chains. It should be clear that since I am dealing with a diverse problem in a real and difficult to control environment caution should be taken in assessing the results. Given the restraints of the exploratory design, this research leads to the following list of expected contributions:

a) Better understanding of communication and coordination aspects of strategic performance management of supply chains,
b) The assessed relation of performance inhibitor and the focus event in supply chain may include a grouping of 'typical' problems or issues, possibly affecting strategic and operational performance,
c) Tabulation of effects of workflow automation on strategic performance management of supply chains by degree of Reliability (i.e. internal validity) and degree of applicability (external validity) and
d) Built explanatory causal models in the form of causal diagrams aimed at building and structuring knowledge as sets of causal relationships between research variables. This static type of representation is used in a descriptive, rather than predictive, way (Stebbins, 2001).

Value Contributions: As stated earlier, this study should eventually lead to a better understanding of the effects collaborative solutions have on strategic performance management of supply chains. As wide as possible applicability is, however, as modest the claim to a direct managerial contribution should be. An exploratory study cannot directly result in normative prescriptions for situations in the real world, regardless of the degree of realism of the study. The reason for this is that intervention (AR) studies in principle can only establish the existence of a relation but not its direction (what causes what). Therefore, the findings in this study should be seen as descriptive and preliminary.

The contribution of this current study can best be described as the unraveling of the factors and relations that link different aspects of workflow automation in strategic performance management of supply chains.

The world of organization is about application. Organizations cannot be contended with adding knowledge. This knowledge must be applied. Competitive advantage does not come just from knowing, but from doing (Willcocks, Petherbridge & Olson, 2002). This means that I should not only be concerned with a deeper understanding of the processes *per se*, but also be primarily interested in aspects that may be translated to the real world with some degree of adaptation. To give a few examples:

a) The SPI Model (i.e. supply chain inhibitors model, please refer to Chapter 2) will enable an integrated approach to (i) problem structuring (ii) problem solving and (iii) learning for managers on potential threats and problem to strategic performance management of supply chains,
b) The SPI Model classification will provide a systematic and structured manner of addressing (i.e. communicating) potential problems and risk to strategic performance management of supply chains. Once classified, each class will have its own type of impact on strategic performance management of supply chains and consequently the resolution for it,
c) Workflow automation will enable communication and coordination by means of asynchronous message delivery and action triggers. This in turn reduces conflicts and miscommunications e.g. between sales and operations. Thus improving the working environment and
d) Workflow automation will enable inventory i.e. right quantity at the right time and right place, to be substitutes by information i.e. the right information at the right time and the right place, resulting in cost reduction of inventory holding.

1.4. General Research Approach

In order to address the research question, I need a process-oriented focus in our research approach, which would take into account the full richness of organizational interactions, and yet exert no artificial control on the environment being studied. With this in mind, I visited a number of organizations in Singapore with the help of Singapore Manufacturing Federation (SMaF), in search for prospective organizations at which to conduct my research. I found no organization using workflow automation to manage strategic performance of their supply chains. This virtually eliminated the possibility of using non-interventionist research approaches, such as case study or survey research. I therefore adopted Action Research (AR) as my research method of choice.

Organizational AR studies are characterized by the researcher applying positive intervention to the study organization, while collecting field data about the organization and recording the effects of the intervention (Bradbury & Reason, 2001). Susman and Evered (1978) view AR as a cyclical process carried out through the AR cycle, comprising of five stages: diagnosing, action planning, action taking, evaluating, and specifying learning.

One of the reasons why AR is seen as preferably carried out in cycles is the opportunity that this allows for strengthening research findings by building on evidence gathered in previous iterations of the AR cycle (Carroll & Swatman, 2000).

During the iterations, matching improves between the researcher's conceptions of the socio-technical system, expressed in the model (or set of models) comprising the research findings, and that found as a result of the specifying learning stage in each cycle. The frequency of the iterations of the AR cycle is likely to decrease as saturation of findings is reached (Aken, 2004; Mawhinney et al., 2001). This characteristic of AR is a key factor in my decision to use AR for this study.

I started the research design based on the key attributes of strategic performance management of supply chains i.e. synchronization effectiveness, efficiency and competency. These attributes seemed to be closely related to the main attributes targeted for improvement by organizations engaged in strategic planning and competitive analysis, and therefore useful from both a research and practitioner perspectives, in the categorization of workflow automation effects on strategic performance

management of supply chains. These attributes are in turn related by association to the supply chain levels i.e. network, entity and individual to form the respective unit of analysis.

These attributes can therefore be seen as the three main "anchor" variables in our research, as they have been used to classify effects into three major categories i.e. they provided a high-level framework for the selective coding of workflow automation effects in this study (Strauss & Corbin, 1990; Glaser, 1992).

However, these attributes also appeared to be overly broad and difficult to operationalize. So, I could not use these attributes as raw elements in the design of structured research data collection and analysis instruments. This research framework built on specific research questions whose main characteristics will be to address issues identified in the research literature and the first AR cycle at SAM (pseudonym of research site), as well as preserve consistency with the main research question. From this set of research questions, I in turn derived a set of *research variables respective to the three units of analysis,* which are the main components of the research framework. This method of deriving the research variables is adopted from Case-Study Research (Yin, 2003) and Grounded Theory Research (Strauss & Corbin, 1990; Glaser, 1992)

This research study focus is exploratory and interpretive. Therefore, it is important to note that even though specific research questions are devised, the main building blocks of the research framework are actually the units of analysis and the respective variables. These, in turn, are generated based on the research questions. This, approach is defended by Yin (2003). Yin points out that while defining a set of research questions can be an appropriate preliminary step in a research project, it is unlikely to provide an effective background for the decision on what to search for and collect evidence about. The definition of units of analysis and related variables is pointed by Yin as an appropriate way for data collection on evidence and report of findings.

1.4.1. Action Research Guided by Gowin's Vee

Due to the lengthy time required coupled with low control over the environment and the inherently exploratory nature of this study. I need an instrument to guide the research along the iterations and stay focus.

Novak and Gowin (1984) propose a theory-driven research based firmly in a theoretical and methodological framework of a discipline of

education. They offer a heuristic model for the construction or analysis of knowledge in any discipline. This model is referred to as Gowin's Vee. I select Gowin's Vee as a "Roadmap" for guiding this research activities and improving rigor in theory development.

The `V' shape of Gowin's Vee clearly separates the conceptual side, on the left, from the methodological side, on the right, while focusing the research questions downward through the vertex to the specific events or objects being studied. These heuristic provides the guidance in clarifying the theoretical and conceptual sources from which appropriate research questions could be framed and also determine which specific events or objects to be relevant for study. In addition, these heuristic also provide guidance in elaborating the necessary methodological devices required to prepare our observations as evidence to support the various claims and conclusions suggested by our findings. As such, the theoretical and conceptual basis, along with acceptable procedures for data collection, reduction, and presentation, provides the warrants (Rodd, 2000) required by the community of researchers for whom the resulting claims will have meaning. For more details on Gowin's Vee, please refer to Appendix G.

This management research is neither in strict rationalist i.e. quantitative nor strict naturalist i.e. qualitative discipline. But rather a more flexible approach, which reflect elements of both paradigms. Nevertheless, claims must be warranted by links between the theories, concepts, methodology and the results of empirical field investigation. The research communities have discussed warrants at length, in particular, that warrants vary according to the ideological orientations of different scientific communities (Creswell, 2003). The Gowin's Vee heuristic helps in clarifying and delineating the theoretical and conceptual sources from which appropriate research questions arise and from which specific events or objects of this study will be determined.

1.4.2. Main Stages of Research

The research is conducted along four main stages:

a) **Literature review** and first iteration of the AR cycle,
b) **Research design** for remaining AR cycles,
c) Second, third and fourth **iterations** of the AR cycle, and
d) **Thesis writing**

Phase (1) comprises a literature review of empirical research on workflow automation, collaboration, coordination, virtual teams, supply chain management and enterprise integration. This review is performed along with the first iteration of the AR cycle at SAM. This first iteration is exploratory, carried out without a structured research framework (in the form of units of analysis and variables), and strongly focused on action i.e. intervention.

The first iteration of the AR cycle provides a background of participant observation perceptions, which, combines with insights obtained from the literature review, will enable progression to phase (2) where I will prepare and submit a final research design. I will then move on to phase (3), which comprises the 2nd to 4th iterations of the action research.

The first iteration of the AR cycle also provided the basis to construct the Strategic Performance Inhibitors model (SPI) that together comprises the 'intervention framework' for this AR study. Participants from SAM in this first iteration of the AR cycle will also be encouraged to make contributions to research questions that are incorporated into the research framework, for use by participants of future iterations. Finally, the first iteration of the AR cycle will also provide a body of knowledge that, added to the insights obtained from the literature review, provides the foundation for the definition of a structured research framework for data collection and analysis. This framework consists of 3 units of analysis and a set of research variables relative to the units of analysis.

In the second, third and fourth iterations of the AR cycle, data collection and analysis are conducted in a more structured way than in the first iteration, as these are based on the structured research framework generated after the first iteration of the AR cycle. In subsequent iterations, Gowin's Vee heuristics direct and guide the research process evolving in a set of findings based on evidence that is collected along these research iterations.

Once consistency between the findings along iterations particularly, that of the second and third iterations are reached. This will lead to, during the fourth iteration; some saturation to be experienced in the model and knowledge building process. I will then conclude the fourth iteration and move into the final stage i.e. thesis writing.

1.5. Thesis Overview

This thesis comprises 8 chapters.

Chapter 1 contains the relevance of the research focus, objectives and expectation of the research and the general research approach.

Chapter 2 describes the first AR cycle, including the development of the Strategic Performance Inhibitors model (SPI). The SPI model is proposed, as our point of departure from current literature on strategic performance management of supply chains.

Chapter 3 describes the research framework for the subsequent AR cycles, including the units of analysis, research variables, site selection, data collection, analysis, exposition and the basis for guidance by Gowin's Vee heuristics.

Chapters 4, 5, 6 and 7 provide a detailed description of each of the research iterations. These chapters are structured around the AR cycle, and thus their main sections reflect the 5 stages of the AR cycle - *diagnosis, planning, intervention, evaluation, and specifying learning.*

The concluding chapter 8 provides a summary of the research findings, classifying these findings according to degree of reliability and degree of external validity. This is followed by a discussion on implications of the research findings for practitioners and for academic debate on management theories. This chapter concludes with a discussion of research limitations and opportunities for future research.

Chapter 2: Conceptual Models

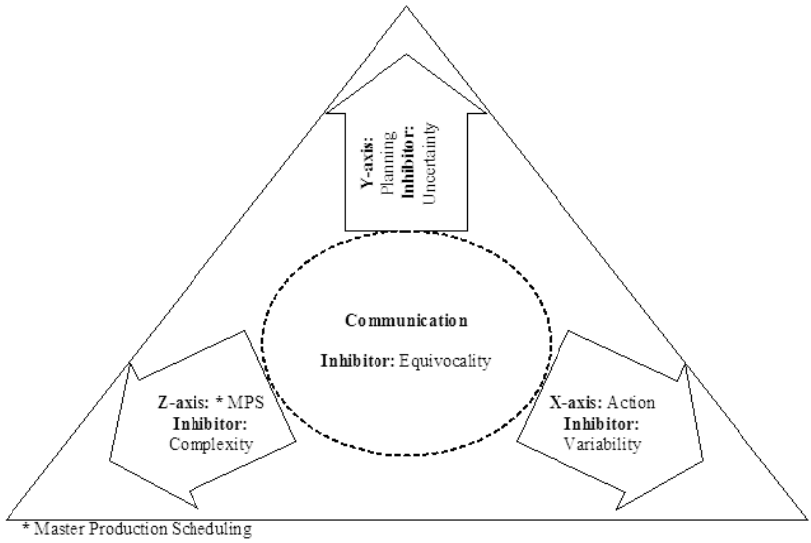
In this chapter is outlined the reasons for building models, the method of development and the context of application for this study.

None of the models studied in the literature review stage provided a general framework for representing concurrency in supply chains (distributed systems), the problem of actually operationalizing complex supply chains has remained challenging: such supply chains not only have a large number of concurrent components (Plans, processes, people, etc;), but these components can interact asynchronously to create an exponential number of possible outcomes. The need to coordinate the behavior of the autonomous entities to maintain coherence in the supply chain adds considerable complexity (Jung & Jeong, 2004) in managing performance in compliance to the metrics outlined in the supply chain service level agreement (SLA). Such coordination involves *dynamic temporal relations* between *events* occurring at *different entities* (Chinn & Madey, 2000), resulting in a large number of messages and the response to them.

2.1. Workflow Equilateral Triangle Model

I started by constructing the Workflow Equilateral Triangle Model (WET) based on flight dynamics of airplanes (There are many similarities between an airplane and a business). An airplane has 3 axes for flight coordination and control i.e. Ailerons (x-axis for roll), Rudder (y-axis for yaw), and Elevator (z-axis for pitch). Similarly, in order for a business to fly well there is a need to control the 3 axes of a business. See below Fig. 2.1

Fig 2.1: Workflow Equilateral Triangle (WET) model



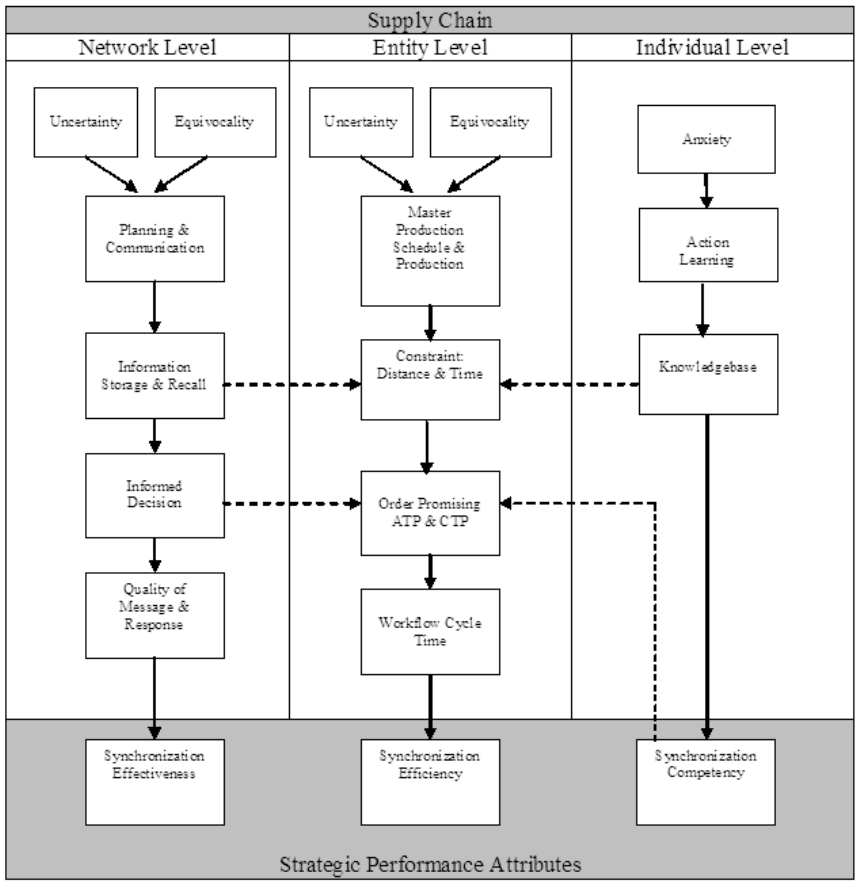
The WET model is an equilateral triangle representing the three primary aspects of a business i.e. Planning, Scheduling (i.e. MPS) and Production (i.e. Delivery). Communication is pervasive throughout the business and therefore is depicted as the core of the model. Communication also enables integration of the three otherwise independent functions of an organization.

The vertical or Y-axis, represents the planning aspects of a manufacturing organization. The outcome of planning due to changes in market forces (i.e. forecast versus the actual) may necessitate the revision of plans. The inhibitor for the planning process is uncertainty of future events. The oblique or Z-axis, represents the Scheduling i.e. MPS aspects of a manufacturing organization. The materials that need to be purchased; when and in what quantities to ensure that finished goods delivery can take place as planned. The production capacity and finished goods inventory required to ensure that the required service level is maintained. The inhibitor for the MPS process is complexity of production scheduling. The production i.e. delivery aspects of a manufacturing organization is represented by the horizontal or X-axis. To ensure delivery performance reliability, the right products, the right quantity has to be delivered to the right place and person. The inhibitor for the delivery process is variability of production and delivery (i.e. action).

If you pull on one of the axis e.g. Y-axis and displace the triangle. By shifting X-axis or Z-axis or both the equilateral triangle can be restored. As one aspect of supply chain e.g. planning occurs or is acted upon, there need to be a corresponding reaction by one or both of the other two aspects of the WET. Any update or change in planning will require a corresponding need to reschedule and/or reconsider the delivery activities. Whilst the functions of Planning, MPS and Delivery are executed independently however to maintain equilibrium of the functions (i.e. in an integrated manner) a means of communication, coordination and collaboration is mandatory. In the context of supply chain, workflow automation fulfills this need. Messages and responses can be exchange with the objective of reducing performance inhibitors, function disruptions and time delays.

Given that WET model is rooted in kinetics. I needed to redefine WET to focus on strategic performance management, in order to "operationalize" the model for this study. The first AR iteration conducted at SAM (i.e. the first study site, please see chapter 4) concurrently with the literature review phase of this study enabled the re-conceptualization of WET model. The process diagram in Fig 2.2 below, documented during the first AR iteration provided the link to frame the WET model to strategic performance of supply chains. The 3 levels of supply chain in the process diagram formed the 3 units of analysis i.e. network, entity and individual and the 3 performance attributes formed the 3 main or anchor variable (i.e. synchronization effectiveness, synchronization efficiency and synchronization competency) of this study. The detail explanation of the other elements in the process diagram is postponed until chapter 4.

Figure 2.2: Process diagram – Strategic Performance Attributes



This re-conceptualization of WET model towards strategic performance of supply chains resulted in the development of the Strategic Performance Inhibitors (SPI) model outlined in Fig 2.3, below. SPI model is a value proposition of policies, procedures and programs for the alignment of related plans, processes and interactions with the objective to improve *throughput* in the supply chains formed by autonomous business entities. Alignment between the entities to maintain "correct order" often involves temporal constraints (Stahl, 2002).

2.2. Strategic Performance Inhibitors (SPI) Model

In this section is the explanation that will sharpen the reader's intuition concerning those aspects of the SPI model that describe the structure, scope and application as relating to strategic performance management of supply chains. Starting at the top of the model, the supply chain is conceptually made up of three levels namely: network, entity and individual. The performance attributes of synchronization effectiveness, efficiency and competency is associated to the respective supply chain level.

Fig 2.3: Strategic Performance Inhibitors (SPI) Model

Supply Chain Level	Network		Entity		Individual
Performance Attributes	Synchronization Effectiveness		Synchronization Efficiency		Synchronization Competency
Performance Inhibitors	Uncertainty	Equivocality	Complexity	Variability	Anxiety
Performance Management Objective	⇩ Reduce Uncertainty	⇩ Reduce Equivocality	⇩ Reduce Complexity	⇩ Reduce Variability	⇩ Reduce Anxiety
Observed Event (Gowin's Vee)	Planning	Communication	* MPS	Operating Standards	Action Learning
Model Elements					
Observable Records of Event	Sales forecast & Customer Orders	Workflow Messages	Purchase & Work Orders	Receipts & Deliveries	Coordination & Expediting
Domain of Event	Sales & Operations Planning	Workflow	Production Control	Shop Floor Control	Workplace
Intent of Event	Strategic	Policy	Tactical	Quality	Knowledge & Skills
Impact of Event	Reduce Risk	Reduce Time Delays	** Improve ATP & CTP	Improve Productivity	Improve Morale

* MPS – Master production Scheduling; ** ATP – Available to Promise, CTP – Capable to Promise

There are 2 main performance inhibitors at the network level in the supply chain i.e. uncertainty of events and equivocality of communication (Pich et al., 2002). The objective is to reduce uncertainty and equivocality in the supply chain. This is implemented through policy e.g. Service Level Agreements (SLA) and by harnessing of Information Technology (e.g. workflow automation). Improvements at the network level result in feed forward to entity level in terms of reduced uncertainty (i.e. risk) and reduction in time delays.

The other 2 performance inhibitors apply to the entity level in the supply chain i.e. complexity of MPS (Blackstone, 2001) and variability of production (Chopra, 2004). The objective is to reduce complexity and variability. This improvement (outcome) is influenced and subordinate to the network level objectives. At the entity level, the objectives are pursued independently through the adoption of ERP. Improvements at the entity level feeds back into the network level through better entity rationalization (i.e. inventory and capacity) and productivity. Thus the interplay between the 2 levels feeding each other over time comes to form iterations or continuous improvement cycles (Dalcher, 2003).

The remaining performance inhibitor applies to the individual level in the supply chain i.e. anxiety of learning. The objective is to reduce anxiety of learning in the workplace (Coutu, 2002). At the individual level, these objective is achieved by means of "action learning" in supply chain and the development of a knowledge-base of past problems (Coghlan et al., 2004). Improvement at this level is pervasive through the entire supply chain as the basic building block of supply chain and business entities is still the individual. To keep the momentum of the continuous improvement cycles (form by the supply chain and entity levels) running, the individual needs to maintain competency through action learning in a changing environment. Motivation to keep going and earning the satisfaction of a job well done is crucial to overcome the anxiety of learning.

Observed events (Gowin's Vee): The meaning of all knowledge eventually is derived from the events or objects being observed. In the context of supply chain, the business events to be observed in this study are:

a) Planning and communication associated with the network level,
b) MPS and processing or assembly operations associated with entity level and,
c) Action learning at the individual level.

2.2.1. SPI Model Elements

The SPI model elements clarify the scope and provide the parameters for possible outcomes of the model application in the context of strategic performance managements of supply chains.

Observable records of event: is the variable that will be used to observe and evaluate the abstraction i.e. performance inhibitors of the observed event corresponding to the three levels of a supply chain:

a) Sales forecast and customer orders for the planning event,
b) Workflow messages & responses for the communication event,
c) Purchase orders and works orders for the MPS event,
d) Receipts & Deliveries for the operating standards events and
e) Coordination and expediting for the action learning event.

Domain of event: is the scope of the observed event i.e. planning in relation to sales and operations planning (S & OP), communication in relation to workflow, MPS in relation to production control, quality in relation to shop floor control and action learning at the workplace.
Intent of event: is the nature of the events objective in relation to strategic performance management of supply chains.

a) The objective of planning in the S & OP domain is strategic. S & OP main objective is to maintain a balance between demand and supply i.e. to maintain a competitive edge and increase market share.
b) The objective of communication in the workflow domain is policy driven. Policies are set of operating rules of engagement to ensure behavior compliance to a desired standard of the organization.
c) The objective of MPS in the production control domain is tactical. Production control in a manufacturing company has the responsibility for MPS. The output of S & OP i.e. demand and supply plan, is used by MPS to generate a detail schedule i.e. what to make, when to make and how many, for execution on the shop floor.
d) The objective of operating standards on the shop floor domain is quality. Shop floor is where the actual manufacturing/assembly of a product takes place. Quality has to be built into the product during manufacturing/assembly in compliance to the product bill of material, manufacturing/assembly drawings and work standards.
e) The objective of action learning in the workplace domain is to develop knowledge and skills. Supply chain is dynamic by nature and the problems faced by the supply chain manager can be new challenges that have not been encountered in the past. The supply chain manager needs to develop a habit of continuous learning on the job.

Impact of the event: is the desired outcome of the event objective in relation to strategic performance management of supply chains.

a) The outcome of the planning from a strategic intent is to reduce risk of potential problems to efficient operations throughout the supply chain. By speeding up the flow of information in the supply chain, inventory can be replaced by information therefore reducing the risk caused by shifts in customers demand.

b) The outcome of communication from a policy intent is to reduce time delays caused by non-response, delay in getting access to complete information, unclear procedures, unclear messages & responses, long lead times and functional conflicts.
c) The outcome of MPS from a tactical intent is to improve ATP and CTP. One of the key goals of a supply chain is to ensure "availability" of the product and the quantity on demand by customers. In the event that the product (or quantity) is not available from inventory (i.e. ATP), then MPS is able to forecast based on the current production capacity to deliver the product and the quantity desired by the customer (i.e. CTP).
d) The outcome of operating standards from quality intent is to improve productivity. Rework, rejects, scrap are all examples of waste i.e. working time and resources. By ensuring the right version of the drawings, work procedure, measurement tolerances, tools to be used are communicated to the right workstations. Costly quality problems can be avoided.
e) The outcome of action learning from knowledge and skills intent is to improve morale. As the supply chain manager resolves potential problems and handle challenges in coordination of the supply chain operations, the supply chain manager gains confidence. This resolution of potential risk to efficient supply chain operation also improves cross functional integration in the organization.

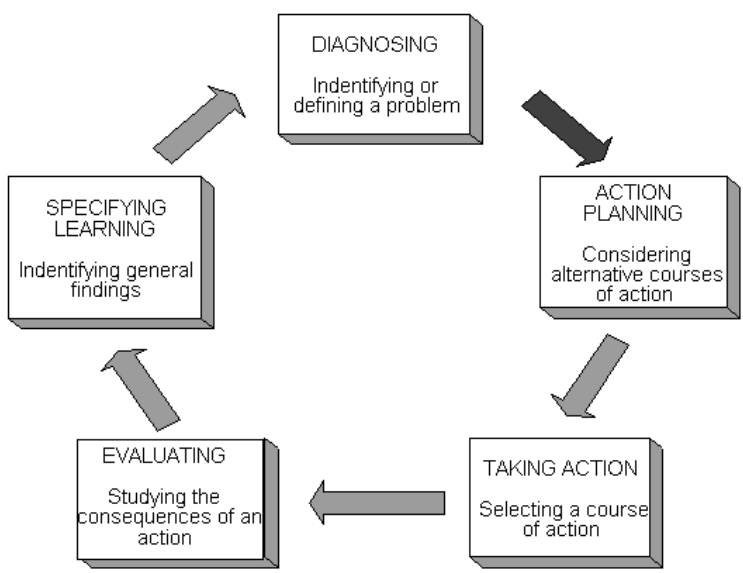
Chapter 3: Research Design

In order to address the research question, I need a process-oriented focus in our research approach, which would take into account the full richness of organizational interactions and yet exert no artificial control on the environment being studied. With this in mind, I visited a number of organizations in Singapore with the help of Singapore Manufacturing Federation (SMaF), in search for prospective organizations at which to conduct my research. I found no organization using workflow automation to manage strategic performance of their supply chains. This virtually eliminated the possibility of using non-interventionist research approaches, such as case study or survey research. I therefore adopted Action Research (AR) as my research method of choice.

3.1. Action Research

Susman and Evered (1978) view a general AR project as a cyclical process carried out through the AR cycle, comprising of five stages: diagnosing, action-planning, action- taking, evaluating, and specifying learning. These stages are illustrated in Figure 3.1.

Fig. 3.1: AR Cycle (adapted from Susman 1978)



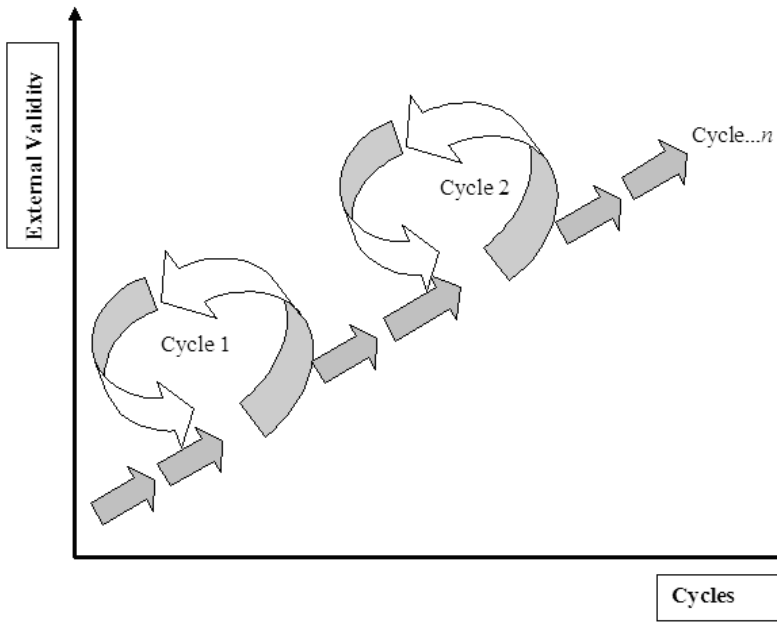
The classical non-participatory approach to AR usually prescribes that all stages but one, specifying learning stage is carried out in cooperation with the client organization. More contemporary approaches to AR, such as participatory AR (or PAR) strive for the full involvement of the client organization in the specifying learning stage as well (Dash, 1999). This research has been conducted along the lines of the classical non-participatory AR approach.

3.1.1. AR Iterations

One of the reasons why AR is seen as preferably carried out in cycles is the opportunity that this allows for strengthening research findings by building on evidence gathered in previous iterations of the AR cycle (Carroll & Swatman, 2000). As the match improves between the researcher's conceptions, of the socio-technical system expressed in the model (or set of models) comprising the research findings and that found as a result of the specifying learning stage in each cycle. The frequency of the iterations of the AR cycle is likely to decrease as saturation of findings is reached (Aken, 2004; Mawhinney et al., 2001).

Expanding the research scope e.g. the areas of the study organization involved in the research and building up the generality of the results through the identification of invariable patterns. This point is illustrated in Figure 3.2 below, which depicts the relationship between number of iterations (cycles) and the external validity of the model describing research findings. The cycles represent each of the AR iterations, where *n* is the total number of iterations in the AR project.

Fig. 3.2: AR cycles and External Validity of Model



3.2. Research Framework

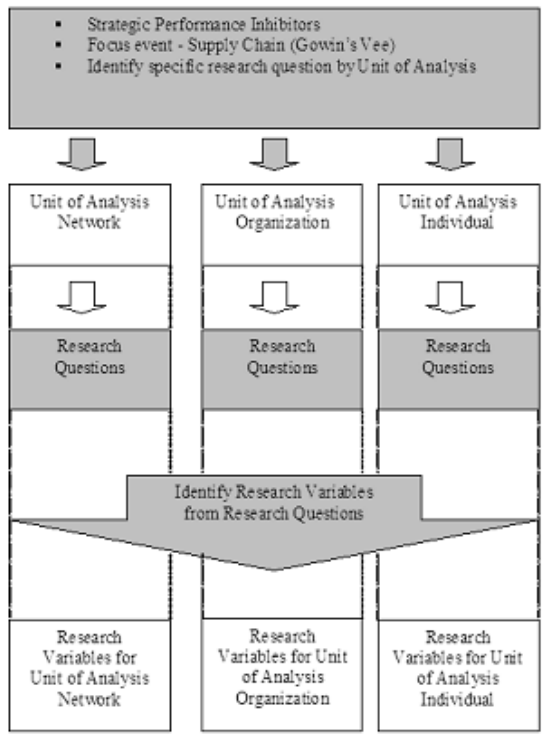
As introduced in Chapter 1, our initial high-level research design is directed at the study of workflow automation effects on the strategic performance management of the supply chains. The building blocks are the SPI model, the focus events and the research site. See Figure 3.3 below.

The SPI model provides the basis for the "units of analysis" associated with the conceptual supply chain levels. Performance inhibitors of the supply chain levels also form the basis for the research questions from which are derived the research variables. These research variables are associated to the respective supply chain levels. In addition the model attributes form the three main anchor research variables i.e. synchronization effectiveness, efficiency and competency

The focus events being observed in this study are detailed in Appendix A. These are Sales Forecasting and Customer order processing for the network level. At the entity level are Production planning, Purchase order

processing and shipping. Learning is pervasive throughout the supply chain and is studied at both the network and entity levels.

Fig. 3.3: Deriving Research Variables



The research site and the AR iteration focus at these sites form an important construct of this research framework. In the first AR iteration at SAM the focus is at the network level and is exploratory by design. The second AR iteration at MAK is focus on entity level from a manufacturer perspective of strategic performance management of supply chain. The third AR iteration at STS is again focus on entity level but this time from a supplier perspective of strategic performance management of supply chain. The fourth and final AR iteration is again at MAK and the focus this time is at the network level.

3.2.1. Units of Analysis

There are methodological implications for the choice of analysis level. If one misses key variables in model development, aggregating to a larger social unit will over inflate the relationships between variables. Also extending conclusions made at the ecological level to individual behavior can also lead to errors. The unit of analysis should correspond to the level of the theoretical mechanisms that are presumed to be affecting the dependent variables. (Stinchcombe, 2005; Patrick & Corbetta, 2003)

With reference to the SPI model detailed in Chapter 2, the three units of analysis are the associated to the three levels in the SPI model as follows;

a) Network (transient unit): Investigate effects at the network level i.e. throughout the supply chain formed by autonomous business entities,
b) Entity (abstract unit): Investigate the effects at the organizational level in the supply chain,
c) Individual (real unit): Investigate the effects at the level of manager responsible for supply chain coordination in the organization.

3.2.2. Research Questions

In this section specific research questions associated with the supply chain level are devised (also refer to Appendix B for additional questions used in 2nd, 3rd and 4th AR iterations). At the network level, the main interest is on how the deployment of workflow automation affects the supply chain ability as a whole to improve its communication, coordination performance level in term of effectiveness. The focus event at the network level is the sales forecast and customer order processing. The network level questions devised are as follows:

a) Does the deployment of workflow automation reduce the workflow set up time (i.e. virtual team formation) throughout the supply chain?
b) Does the deployment of workflow automation improve the quality of messages and response exchange throughout the supply chain during the interactions on customer order processing?
c) Does the deployment of workflow automation improve customer synchronization effectiveness throughout the supply chain?

At the entity level, the main focus is on how the deployment of workflow automation affects the organization in the supply chain to reduce complexity in scheduling and variability of production. The focus events at the entity level are production planning, purchase order processing and shipping. The entity level questions devised are as follows*:*

a) Does the deployment of workflow automation reduce demand for leadership skills during coordination and expediting meetings in the organization?
b) Does workflow automation deployment enable cross functional integration in the organization?
c) Does the deployment of workflow automation improve customer synchronization efficiency in the functional departments of the organization?
d) Does the deployment of workflow automation reduces the workflow cycle time throughout the organization?

At the individual level, the main focus is on how the deployment of workflow automation affects the individual in the supply chain in reducing the anxiety of learning and handling problems. Learning is pervasive throughout the supply chain however the focus event for the individual level has been all communication and interaction associated with coordination of the supply chain. The individual level questions devised are as follows:

a) Does the deployment of workflow automation reduce anxiety of learning for the individual supply chain manager and enable the development of a knowledge base of problems encountered and the resolutions?
b) Does the deployment of workflow automation improve the commitment of the individual supply chain manager?
c) Does the of workflow automation improve the satisfaction of the individual supply chain manager?
d) Does the deployment of workflow automation improve the individual supply chain manager's response time?
e) Does the deployment of workflow automation improve the individual supply chain manager's competency in supply chain problem solving?

3.2.3. Research Variables

The research variables are drawn from the research question associated with the supply chain level.

Table 3.1: Research Variables

Unit of Analysis	Network	Entity	Individual
Variables	Workflow set up time	Demand for leadership skills	Action Learning
	Quality of message & Response	Workflow cycle time	Commitment
	Synchronization Effectiveness	Cross functional integration	Satisfaction
		Synchronization Efficiency	Response time
			Synchronization Competency

3.3. Site Selection

I sought authorization from the organizations to acknowledge their participation by name in research publications through a letter and form similar to the ones shown in Appendix C and D. Although authorization was obtained from SAM, MAK and STS to acknowledge their participation by name in this research.

I decided to withdraw their names from this thesis due to the amount of detail provided about the action research (AR) iterations conducted and the exposure to financial and competitive information that I had access to. Given the confidential nature of this information, I decided to refer to these organizations by pseudonyms i.e.

a) SAM an American manufacturer of home appliance based in Singapore,
b) MAK a Japanese industrial equipment manufacturer based in Singapore,
c) STS a Swedish tool steels supplier based in Singapore.

3.4. Data Collection

The approaches for the collection of research data varied along research iterations. In the first iteration research data is collected in the form of archival data (e.g. internal memos and forms), organizational documents (e.g. technical manuals and internal publications) and unstructured interview and participant observations. In addition to these data sources in the second, third and fourth iteration are added transcripts of structured interviews, workflow messages and responses. The need to collect data through different means and from different sources, often referred as data collection triangulation (Creswell, 2003; Gratton & Jones 2005), has been

defended by AR practitioners as a means to avoid participant observation biases likely to accrue from the researcher's close involvement with the situation being studied (Kumar, 2005; Khosrow, 2004).

Although often being redundant, data collection in the form of unstructured interviews, participant observation notes, structured interview transcripts, and workflow messages and response transcripts, allowed for comparisons that not only seems to have prevented some types of research bias (as discussed later in this chapter), but also likely to have strengthened the internal and external validity of the findings (Druckman, 2005).

3.5. Analysis

In this section is outlined the explanation building process for this study. The main findings of this study are presented in the form of a set of causal models. This is seen as appropriate since the main research question i.e. effects of collaborative solution on strategic performance management of supply chains, has received very little attention and I also could not find existing models relating to the main research question for testing. Moreover, the decision to build knowledge in the form of causal models is highly consistent with previous characterizations of the research approach I have decided to adopt i.e. AR (Remenyi, 2004; Bradbury & Reason, 2001).

The general mode of analysis used in this research is the one referred to as *explanation building* by Yin (1989, p. 113), who points out that "To explain a phenomenon is to stipulate a set of causal links about it", and as *grounded theory building* by Strauss and Corbin (1990; 1994) and Glaser (1992). In the context of approaches such as these, sets of causal links are typically seen as being among the basic elements of a theoretical framework (Partington, 2002). The process involved in the identification of causal links is based on the data collected (in all 4 AR iterations in this study) and is centered on one of the sources of data, against which evidence from other sources is matched. The central data sources is selected based on the volume and perceive degree of observed event coverage. In the first iterations the central data sources is the field notes based on participant observation and unstructured interviews. The central data source in the second, third and fourth iterations are the structured interview and workflow (messages and response) transcripts.

Classifying, condensing, categorizing, regrouping, organizing, structuring, summarizing, synthesizing and simplifying are just some of

the procedures that can be done with a set of data using classification and structuring methods (Thietart et al, 2001). The analysis of data in each of the AR iterations of this study is carried out through an iterative set of steps very similar to the one outlined above. The main steps are: Coding, Memoing, Sorting, Tabulating and Modeling.

Coding: One of the key elements in qualitative data analysis is the systematic coding of text (Hardy & Bryman, 2004; Strauss and Corbin 1990). Codes are the building blocks for theory and the foundation on which the analyst's arguments rest. Implicitly or explicitly, they embody the assumptions underlying the analysis. In this step I actively sought for variables in the research data associated with the focus event being observed (Poole et al., 2000; Glaser, 1992). In the first iteration, there is no concern about associating variables to units of analysis. The categorizing process in this research iteration corresponds to what is referred to as *open coding* (Yates, 2003; Strauss & Corbin, 1990) i.e. the identification of variables, and *axial coding*, i.e. the stipulation of relationships between variables. During the second, third and fourth iterations I have concerns with clearly associating variables to the three units of analysis defined as the main elements of our research framework, and building on the previous selection of variables. The coding process carried out in these research iterations can be seen as corresponding to what is referred to as *selective coding* (Punch, 2005; Strauss & Corbin, 1990).

Memoing: In this step I try to explain the effects previously identified in the coding step, using evidence from both the coding step and previous iterations (Schreiber & Stern, 2001). This explanation process will be carried out for each relevant effect involving two or more variables, and comprises the building of explanations based on evidence at hand pertaining to the effect. An illustration of this process is provided in Appendix H. The names and context in this illustration have been disguised to protect confidentiality.

Sorting: The "memoing" stage will initially result in the identification of new variables, almost as if this analytic process had no end. However, as the study progresses through several iterations of the steps described in this section, the "memoing" stage will gradually move into a "synthesis phase" as several variables begin merging together, a clear indication that the analysis is moving towards data "reconstruction" (Goulding, 2002; Glaser, 1978). The data sorting process is the systematic finding of causes that are the same for different effects, which is aided by the building of causal models in the modeling step (PiekKari & Welch, 2004). This is

one of the reasons why the number of variables used in causal models is smaller than the number of variables at the start of the research iterations.

3.6. Exposition

The outcome of data analysis in each of the AR iterations of this study is expressed in event tables, frequency tables and explanatory causal models. Establishing causal relationships whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships, enhances internal validity (De Vaus, 2001; Seale, 1999). Causal links in our research are expected to describe the relationship between intervening variables that formed the link between the workflow automation and the three main (or anchor) variables - *synchronization effectiveness at the network level, synchronization efficiency at the entity level and synchronization competency at the individual level.*

Tabulating: Data tables are a straightforward and powerful tool for assembling in one place all data on related aspects of a topic or issue (Coghlan & Brannick, 2004; Gray, 2004). Tables provide a useful means of categorizing and summarizing a great deal of information in a non-linear way so that inter-relationships can easily be seen. In the tabulating step, I created data tables. See Fig. 3.4 below, example of a workflow event table; shows the variation in the contents of workflows in each AR cycle. I also created frequency tables to determine how many respondents answered a question in a particular way.

Figure 3.4: Data Table Design

Event ID	No. of Different Workflows	No. of Participants	Mean Cycle Time (Hrs)	Heterogeneity		Medium	
				Site	Dept.	Workflow	Manual

Modeling: In the modeling step, I build explanatory causal models, in the form of causal diagrams, based on the explanations generated in the data analysis stage. These causal models followed to a large extent the typical conventions (Thietart, et al; 2001) used in previous research aimed at building and structuring knowledge as sets of causal relationships between research variables. They will comprise of four types of variables: ***independent, intervening, moderating and dependent variables*** (Sansone et al., 2003). A variable in a causal model is said to be:

a) Independent if it is directly unaffected by other variable in the model,
b) Intervening if this variable directly affects, and is directly affected by, other variables in the model,
c) Moderating if this variable "moderates" the effect that a variable has on another variable in the model and
d) Dependent if this variable is directly affected by other variables in the model but directly affects no other variable in the model.

When building causal models I try to explain the evidence obtained during the iterations only, rather than the lack of evidence. That is, if there are no link connecting two variables in a model, it is because there is no evidence for the existence of this link. This means that I did not try to explain why some of the links are not part of some models, as I believed that the absence of evidence relating these links is an indication that they are not relevant in explaining the main effect (and set of intermediary effects) depicted by those models. However, I do not imply by this that these links are nonexistent, or that the lack of evidence supporting their existence is likely to be replicated in different contexts.

This static type of representation is used in a descriptive, rather than predictive, way (Stebbins, 2001). That is, the causal model showing increases and decreases in certain variables tries to describe what happened in a given research iteration in a summarized way. It does not, however, mean that the researcher is making any claim over the generalisability of the causal model.

3.7. The Need for Guidance by Gowin's Vee

In this section is outlined the reasons for the adoption of "Gowin's Vee" heuristics as the "roadmap" for guiding this research activities and improving rigor in theory development. The alleged weakness of AR (Whitman & Woszczynski, 2003; Rapoport, 1970) coupled with some key possible weaknesses that emerge from the discussion by Orlikowski and Baroudi (1991) about the clash between positivist and non-positivist schools (Sarmento, 2004) created a particular urgency for guidance to improve this AR study theory development rigor from a positivist perspective. They key weaknesses of AR that is addressed with Gowin's Vee in this study are as follows:

Scientific Discipline: AR's typical unplanned and informal structure coupled with the ad-hoc approach of AR, where most of the study is done in cycles with temporary reports, methodologies and frameworks, may be considered as lacking scientific discipline and consequently regarded as

being of low academic interest. During the first iteration, it became clear that I need an instrument to guide the research along the iteration and stay focus. I also wanted to avoid the perception that this research study employed an unscientific method.

Intervention: AR's intervention (seen here as interference) with the research environment that, while potentially beneficial to the study organization, may bias research findings in ways that are difficult to be identified, and make the findings difficult to be replicated by other researchers in different settings. Since by definition I cannot completely avoid interfering with the research environment and still conduct an AR study. I will limit the intervention strictly to the observation. I will not try to enforce any particular type of "artificial" behavior in the organizations and Gowin's Vee focus on events provided the parameters to limit the scope of intervention.

External Validity: Validity refers to the approximate truth of propositions, inferences, or conclusions. Therefore, external validity refers to the approximate truth of conclusions that involve generalizations. A threat to external validity is an explanation of how one might be wrong in making a generalization.

Research rigor is aimed at increasing validity, particularly external validity i.e. which is a measure of the generality of the findings regarding situations other than the one studied. Research rigor is often determined by the reliability of the instruments for data collection and analysis used in the research. This is then linked to the internal and external validity of the research findings (Hunter & Schmidt, 2004). Research instrument reliability tests are often seen as a means to increasing the validity of the final research findings (Gray, 2004)

The threats to external validity in AR are often seen as caused by the focus of AR on in-depth study of a small number of socio-technical systems i.e. three organizations in our research. However, the main reason for our confidence as to the high external validity of some of this research findings is based on the theory of proximal similarity (Alkin, 2004; Overman & Campbell 1988). That is by effectively doing a better job of describing the ways our contexts and others differ i.e. by tabulating workflow event data about the degree of similarity between various groups of people (i.e. who), places (i.e. where) and even times (i.e. when). Further, Gowin's Vee methodology requirements prepare the study observations to hold across different iterations and different

instances of the units of analysis, as evidence to support the various claims and findings of this study.

Lack of control: Action research is inquiry or research in the context of focused efforts to improve the quality of an organization and its performance. It would be impossible to control the SLEPT factors (i.e. social, legal, economic, political, and technological) affecting an enterprise in the real world, whilst conducting the study and testing the hypothesis. The influence of a particular variable might not be feasible for isolation, testing or refinement of a causal model. Therefore, the extent to which a dependent variable is influenced by a set of independent variables cannot be confirmed through empirical observation. This lack of control is one of the main reasons for AR to be seen as inappropriate to test or produce strong theories, or build up research models based on solid evidence.

It is undeniable that a low degree of control over variables of the socio-technical system being studied can hamper the test of causal links between these variables. Testing links between variables, however, requires both variables and links to be clearly stated before the research starts. This is in turn likely to limit research findings by focusing the research on a limited set of variables and leaving out others that might be relevant for the understanding of the event under consideration (Black, 2002; Glaser, 1978; 1992; Glaser and Strauss, 1967). A high control over the environment being studied is also likely to lead those involved in the research to behave in an artificial way and thus irreversibly bias research results. This is one of the reasons why a number of methods commonly used in the natural sciences are rendered useless in social research and thus in Information Systems (IS) research, which, as well as management research, is a form of social research.

Gowin's Vee heuristic guidance on data collection and direction towards meeting the demands of research rigor for this study is comparable to that of controlled laboratory or field experiments. Not only did my research design allowed for the collection of data from different sources about the same events and variables, a desirable form of triangulation in research data collection (Creswell, 2003) the study of the same units of analysis across iterations also allows for comparison of workflow automation effects in a longitudinal manner (Jablin & Putnam, 2004) and thus the avoidance of cross-sectional biases.

Several of the research findings reported in this research are based on a frequency analysis of multiple-choice type of responses to open-ended

questions in which interviewees are asked for their perceptions regarding the effect of workflow automation on specific aspects of strategic performance management of supply chains. Given that this type of assessment is likely to be riddled with the same type of biases as in questionnaires with a pre-defined set of alternatives e.g. unsupported responses based on distorted perceptions. I always strive to frame questions in a neutral way and asked respondents to explain their responses. Responses backed up with no rational supporting explanation were disregarded in the frequency analysis (i.e. they were considered *do not know* responses). So were those responses whose explanation given is unrelated to the question, an indication that the respondent did not understand the question or did not have valid evidence to support the answer. In doing so I hope, not only to have minimized the effect of perception bias, but also given the opportunity for those involved in the research to reflect on their own practice.

Personal Involvement: Action Research is the process by which practitioners attempt to study their problems scientifically in order to guide, correct, and evaluate their decisions and actions**.** The usual personal involvement of researchers with organizations in AR studies may hinder good research by introducing personal influence in the behavior of those being studied and the findings. Whilst personal involvement from the part of the researcher is likely to bias research results, it is inherent in AR because it is impossible for a researcher to both be in a detached position and exert positive intervention on the socio-technical system being studied. The likelihood of bias is particularly high when the number of situations experienced by the researcher is small and the affective intensity of his or her involvement is high, owing to affective biases (Partington, 2002).

One of the key elements to reduce bias due to personal involvement in this study is triangulation of research data (Creswell, 2003; Hardy et al., 1996). Whenever my perception suggested a particular effect I try to enrich the analysis by taking into consideration structured interviews, participant observations field notes and workflow message transcripts.

Chapter 4: An Exploratory Study at SAM

4.1. Introduction

This chapter describes the first iteration of the AR cycle conducted at SAM, an American manufacturer of Air-conditioning appliances in Singapore. The company has approximately 165 employees when this iteration is initiated and revenues of 386 million US dollars (S$ 618 million) per annum. About 75 employees work in the main office building where the research iteration is conducted. The remaining 90 employees are based in a plant at a different location and are not directly involved in the study.

The main goal of this first iteration of the AR cycle, from a research perspective, is to conduct an exploratory study of SAM supply chain i.e. SAM as a manufacturer and its tier 1 and tier 2 suppliers (15 local suppliers and sub contractors are selected on the basis of ease of accessibility). Telephone calls, faxes, emails, face-to-face meetings and workflow messages will be studied.

4.2. Diagnosing

SAM produces a complete line of residential and commercial air conditioning equipment at its modern and highly automated factories in Singapore. The finished products are sold through a worldwide network of independent distributors and installers who are dedicated to uphold the company's high standards of quality.

The philosophy is simple: *Be the highest quality, lowest cost producer of air conditioning equipment in the world*. Is it successful? SAM share of the market has grown faster than any other major manufacturer. Quality and Value speak for themselves.

SAM completed the purchase of a European company that included two manufacturing operations that assembly refrigeration and air conditioning products. SAM has been very successful at increasing its presence in the mature HVAC industry, due primarily to the following philosophies:

a) High quality at a low cost equals value,
b) The highest paid, most productive workforce in the industry,
c) Low overhead, flat organization,

d) Money normally spent on advertising and promotions is now invested in research and development which translates to high quality at a low cost to the consumer,
e) Products that are engineered for reliable long life, utilizing the best components with some of the lowest failure rates in the industry,
f) One of the best warranties in the industry.

The company has been a user of ERP (Enterprise Resources Planning) from SAP. SAM wanted to focus on the supply side of the business now that the internal operations of the company are at the management desired performance level. This objective came about due to the consequential pressures on SAM by the EDB (Economic Development Board) to increase the local content level to more than 30% in the finished product.

SAM management set the goal that all suppliers in tier 1 and tier 2 be strategically connected to SAM in the order fulfillment process. Tier 1 suppliers are to be identified as suppliers or sub-contractors that are the first line of support for SAM, in meeting the manufacturing cost and delivery schedules. These groups of suppliers are already certified to have achieved the quality standards of SAM and therefore incoming quality inspection from this group of suppliers is not required. Tier 2 suppliers are identified to be suppliers or contractors that have been successful in the bid to supplier but are yet to be certified. This classification of suppliers only applied to all direct materials and only key indirect materials identified by engineering.

Currently, all communication to suppliers and contractors is either through fax, email or telephone. Order specification, quality and pricing issues usually required a face-to-face meeting that more often than not ended in a “hot discussion”. Although SAM is highly IT enable and most of the managers’ IT literate, suppliers and sub-contractors of SAM are widely dispersed in technographics (Modahl, 2000). Some were running, their planning and scheduling on Microsoft Excel. There were a large number of suppliers and contractors that are in this category with annual revenues of S$ 10 - 15 million range.

There is no way of implementing ERP systems at this suppliers and sub-contractors of SAM. This would require an investment of both time and money. Also, these small and medium enterprises (SME) are not ready to implement ERP systems due to a lack of resources and management/owner appreciation of IT and its ROI. There is a need to identify an alternative means of improving communication and interaction without going through the laborious ERP route.

SAM also needed to implement a set of metrics that would create visibility of the suppliers and sub-contractors performance. Further, once established, this set of metrics shall be a key component in the promotion or "black-listing" of a supplier or sub-contractor. Therefore, the set of metrics adopted must confer to standards in the Industry best practices and must be fair on all parties. This metrics must have a direct relation to the bottom line financial reporting of SAM.

4.3. Action Planning

Rather than just "plugging in" some technology or software, it is decided that a better way to move forward, would be to set up a steering committee reporting directly to the chief operation officer. This committee will meet every fortnight to review the progress and resolve issues. A subset of the steering committee (including members from both SAM and SAP) came to be called the workflow team. IT Manager from SAM is appointed Project Manager. The team will decide and seek approval on the 3 main issues:

a) What technologies are to be harness in the deployment of workflow,
b) What metrics are to be established and
c) What are the improvements to be achieved in terms of strategic performance?

The steering committee will review the SL 6 ERP software components feasibility in achieving the set objectives. Once approved, a Project plan will be rolled out. No further approval will be needed as long as the budget limitations are not violated. It is the decision of the steering committee that no cost is to be incurred by the supplier or contractors in the supply chain. Also, the deployment must be dynamic with intuitive learning for the SAM users.

The Phase I of the study, duration of about 3 months, is to study the "as is" practices of SAM and the suppliers, in their efforts to synchronize their actions and interactions. Data collected during this phase will be mainly of face-to-face meeting and verbal telephone conversation on planning, coordinating and expediting activities.

Phase II is deployment of the workflow automation to support operations at SAM. During this iteration a) customer order processing b) production planning and c) purchase order processing events will be implemented. During this phase, which will last about 4 months, effects of workflow automation on performance of supply chain will be studied with the goal of identifying the effects i.e. research variables.

Phase III is the reporting on outcome and findings of the iteration. This phase will last 3 months after Phase II completion.

4.4. Action Taking

The committee approved the use of workflow automation based on Microsoft Outlook/Exchange Server and Excel spreadsheets.

The next decision is on the metrics to be used. This metrics should be industry standards that would appeal to the practitioners and also to the researcher. One option is to explore using the Supply-Chain Operations Reference (SCOR) model metrics. From this will be derive the workflow metrics that are required to evaluate strategic performance management of supply chains. These will further need to be linked to the financial accounting terms to provide a quantitative measure of outcomes of deploying workflow automation at SAM. After further search and deliberation the committee approved the proposed outlined in Table 4.1.

4.4.1. Workflow Metrics

In this section is the explanation on the links between the performance attribute to the SCOR metrics (i.e. industry standards). These in turn are linked to the workflow metrics for the express purpose of evaluating the effects of workflow automation (i.e. collaborative solutions) on strategic performance of supply chain. In this way the performance attributes of the SPI model are operationalized for this AR study.

Table 4.1: Performance Metrics

Supply Chain				
Level	**Performance Attribute**	**SCOR metrics**	**Explanation**	**Workflow Metric**
Network Level	Synchronization effectiveness	Reliability	The performance of the supply chain in delivering the *right* product at the *right* place in the *right* time and in the *right* quantity.	• Delivery Performance • Fill Rate/Cycle • Order fulfillment
		Cost	*Costs* associated with operations	• Cost of Goods Sold • Transaction Cost • *RMA Cost
Entity Level	Synchronization efficiency	Response Time	The *velocity* at which a supply chain fulfills customer orders	• Cycle Time • Reaction Time
		Flexibility	The *agility* of the supply chain in responding to marketplace changes to gain or maintain competitive advantage	• Lead Time • Production Flexibility • Change Adoption
Individual Level	Synchronization Competency	Value-added	The *knowledge and skill* with which the individual supply chain manager performs the coordination	• Knowledgebase • Collaboration • Productivity

* RMA: Return Merchandise Authorization

Supply chain reliability and cost are grouped together as the anchor research variable synchronization effectiveness. Delivery responsiveness and flexibility are grouped together as anchor research variable synchronization efficiency. These main research variables together with action learning are then operationalized for this study by redefining the SCOR metrics as workflow metrics to be observed in this AR iteration.

Network level: The workflow metrics are all related to the observed event i.e. customer order processing (please refer to Appendix A):

a) Delivery performance
b) Fill rate/cycle,
c) Order fulfillment
d) Cost of goods sold,
e) Transaction cost and
f) RMA cost

The performance attributed synchronization effectiveness is understood, in the context of workflow, as being able to respond with the "correct and complete" information for decision making. In the context of strategic performance management of supply chains, information (i.e. knowledge)

of the event has to be stored over long intervals i.e. days and weeks before being applied. At this level, the first performance inhibitor i.e. uncertainty can be reduced by speeding up the flow of information (i.e. correct and complete) throughout the supply chain for the customer order processing event. The second performance inhibitor i.e. equivocality can be reduce by means of written communication that can be stored and recalled over long period throughout the supply chain for the customer order processing event.

Entity level: The workflow metrics are related to the observed event i.e. Production Planning and Purchase order processing (please refer to Appendix A):

a) Cycle time,
b) Reaction time,
c) Lead time,
d) Production flexibility,
e) Change adoption

The performance attribute synchronization efficiency is understood, in the context of workflow, as getting the message across without the constraints of distance and time. In the context of strategic performance management of supply chains, schedule change (i.e. time) of the event has to be transmitted in the form of a message at the right time, right place and to the right person. At this level, the first performance inhibitor i.e. complexity can be reduced by managing the detail level of the MPS at the volume and mix levels in the entity for the production planning event. The second performance inhibitor i.e. variability can be reduce by means of having in place operating standards and work procedures that are available on demand to the shop floor and purchasing personnel in the entity for the event production planning and purchase order processing.

Individual: The workflow metrics are related to the observed event i.e. Action learning:

a) Knowledgebase,
b) Collaboration and
c) Productivity

The performance attribute *synchronization competency* is understood, in the context of workflow, as the ability to construct the message or response as a resolution to the coordination problem at hand. In the context of strategic performance management of supply chains, synchronization competency of the supply chain manager is to maintain “alignment with the customer”. At this level, the performance inhibitor

i.e. anxiety of learning can be reduced by giving access to knowledgebase of past problems and resolution. Collaboration at the workplace, cross-functional and throughout the supply chain can be implemented by means of workflow automation.

4.5. Evaluating

A number of apparent patterns have been observed from data analysis in the evaluating stage. These related both face-to-face discussions and workflow automation. The patterns observed in face-to-face discussions related to strategic performance management of supply chain and are contrasted with the patterns observed in workflow automation.

4.5.1. Observations in Meetings and Verbal Communications

a) The first observed pattern is the difficulty of bringing people together at the same time (place), and the consequent efficiency losses caused by this difficulty
b) The second observed pattern is a dominance of most meetings by one or two individuals, mainly based on seniority in the management hierarchy
c) The third pattern observed in the meetings is the short duration of the verbal contributions by each participant. Participant would speak for a while (i.e. a few minutes or less) and either be interrupted, or stop and wait (or openly ask) for feedback from the other participants. Often non-verbal feedback in the form of gestures with hands and head (e.g. nodding, body language) would lead to the interruption of a verbal contribution. There have been numerous meetings, where no official minutes were recorded.
d) The fourth pattern observed is that participation could be solicited, by directly addressing the individual responsible for the function e.g. delays in delivery can be directed at the shipping manager by calling out his/her name.
e) The fifth pattern observed is that there often is a lot of "finger-pointing" between staff from different departments, sites, suppliers and contractors. Usually, each party has its own set of documents and understanding about what has been discussed during the past communications and interactions on the subject
f) The sixth pattern observed is that some participants in the meeting always "buy time" to let the matter rest for the time being. This is mainly done by a quick response, knowing well enough that the task could not be done. Whilst, protecting oneself by saying "*I will have to check with our …..…..*" This is an interesting phenomenon with

especially suppliers and contractors; they are quick to response (in the positive) as compared to internal staff from different departments. However, the response is rarely complete and reliable.

g) The seventh and final pattern observed is that some members did not have time enough to be prepared for the meetings. Given the urgency involved in coordinating and expediting meetings which are usually called when something has already or is about to go wrong. Not having the time to get the *right data* is more likely the root cause for being unprepared. This often times lead participants to give "quick and dirty" solutions to problems without really having understood the issues.

4.5.2. Observations in Collaborative Workflow Automation

During the first 3 months of Phase II i.e. Workflow Modeling Stage, my observation of the workflow activities, leads to the identification of three main behavioral patterns, summarized as follows:

a) The first pattern observed is that a workflow set-up time i.e. getting all parties to focus on an issue, is much easier (more efficient) with workflow automation. Whilst, not disrupting routine production activities.

b) The second pattern observed is that, members are committed to define clearly the roles and responsibilities. Individuals experience learning about other functions during this stage and for the first time begins to comprehend the consequence of certain actions and delays induced by their actions downstream.

c) The third pattern observed is that participants would have a preference for "prevention" rather than look for "cures". Production is a dynamic working environment i.e. constantly changing. Participants prefer to be alerted (proactively) to possible conditions, before such conditions occur and have a negative effect on their work.

During the 1 month after Workflow deployment (Phase III), my observation of the workflow activities, leads to the identification of three main behavioral patterns. Summarized as follows:

a) The first pattern observed is that a response took longer than in verbal communication but that the response is more *complete and correct*. This also required more individual effort. The written message took a longer time to construct and check for fear of being misinterpreted and having to face consequences for the lack of clarity.

b) The second pattern that emerged is a segregation of SAM employees that are competent with the computer and those who are not. The older (demographics) managers seemed to resent the computer based workflow deployment. These managers from SAM and most suppliers preferred to "talk". They further stress during unstructured interviews with the researcher that their relationship is an important factor, when it comes to coordinating and expediting i.e. making things happen.
c) The third pattern observed is that coordination and expediting cost much less, for workflow automation. There is no need for senior managers to chair meetings with suppliers and contractors. There is no need to get all parties together in a room as was done in the past. Decentralization of coordination and follow-up can be deployed without compromising on organizational integration and service levels.

4.6. Research iteration impact on SAM

In the past, SAM have tried various approaches such as Management by Objectives (MBO) i.e. setting objectives and KPI (Key Performance Indicators) such as to reduce inventory days by 30%, to improve customer service by 50%. These approaches to improvement created conflicts amongst the functional departments and was abandoned for other initiatives such as Just in time (JIT), Lean and Quality Circles. Although this later initiatives did create some improvements, there is still a need for an integrated approach. Workflow automation provides an integrated approach for improvement in communication and coordination throughout the supply chain.

Communication of the customer order information by workflow automation is in asynchronous mode to all parties throughout the supply chain. This mode of communication create significant efficiency gains in "order promise date" i.e. ATP (available to promise), CTP (capable to promise) and delivery performance to plan. These findings are supported by data collected at SAM. Also, an understanding of the performance inhibitors formed the foundation for setting up of realizable objectives as opposed to setting conflicting functional goals in the past. Early in the iteration cycle, it is evident that a small improvement in order confirmation or engineering change resulted in exponential improvement in speed of action (i.e. change adoption) and elimination of "waste" downstream. These consequential improvements in communication lead to improved relationship amongst cross functional units. Delays were no

longer arbitrarily the fault of someone. All activities could be tracked, thus resulting in a more transparent work environment.

4.6.1. Order Promise Date

Customers are given a realistic timeline for order delivery. The ERP software uses memory resident processing technology that provides the capability for SAM to implement real-time Capable-to-Promise (CTP) functionality. CTP not only verifies whether a customer's order can be satisfied through available inventory (Available-to-Promise/ATP) but also verifies that both the necessary materials and capacity will be available at the time needed to satisfy the customer request. Make proposal on the quantities available by dates for confirmation with the customer in a matter of minutes.

4.6.2. Impact of Rush or Change Orders

ERP software provides a detailed view of the overall plan prior to execution. It helps determine how to use existing capacity and how to coordinate purchasing to satisfy customers order. It also highlights any problems and can help evaluate "what if" scenario. SL 6 provides a detailed display of all orders in the system and identifies all orders impacted by *changed orders*. These enable SAM to know exactly (impact analysis) which customers and which orders, *the loading of a rush order*, will impact.

4.6.3. Launch Control

ERP software launch control creates demand for material as close to the requirement date as possible (postponement strategy), minimizing on-hand inventory. When inventories are at a minimum level, launch control starts orders at the right time, which enables them to flow through the plant with minimum delays, reducing manufacturing lead times. In addition, when materials do not arrive as promised, SL 6 ensures that resources can shift to other work orders so no time is wasted. The result is a significant decrease in work-in- process (WIP) inventory, expediting costs and "safety" stock inventory.

4.6.4. Material and Capacity

ERP software plans each operation of customer order recursively through its BOM (Bill of Material). Balance available capacity with the actual

projected workload without assuming that capacity is unlimited or "infinite." All materials required for each order are synchronized with the capacity schedules to ensure that the right material is available at the right time, in the right place. MPS is continually updated (i.e. net change) in relation to the dynamic changes of SAM customers' orders.

4.7. Financial Indicators

SAM current financial performance is the product, among other things, tens and perhaps hundreds of decisions and priorities made every day. SAM peers have made their own decisions and priorities, some similar to SAM, and some different, that produce results that may differ from that of SAM. Please refer to SAM - Benchmark Report in Appendix I. Based on this report the *value to improvement* calculations will show where SAM may be headed by maintaining the current strategies and priorities. It will also show what SAM may achieve, opportunities for improvement, by making different choices.

At annual growth rate of 20%. Table 4.2, below, projects a straight-line growth of some of SAM key financial metrics. In other words, the table assumes that all the current performance characteristics do not improve or worsen as your net sales grow at a five-year, twenty-percent rate. *(Note how the total cash tied up in inventory, trade receivables, and trade payables grows).*

Table 4.2: Current Five-Year Forecast, Without Any Changes

	Current Year	Year 2	Year 3	Year 4	Year 5
Growth		20%	20%	20%	20%
Sales	386,700,000	464,040,000	556,848,000	668,217,600	801,861,120
COGS	305,400,000	366,480,000	439,776,000	527,731,200	633,277,440
Receivables	72,000,000				
Payables	86,000,000				
Inventory	59,900,000				
Inventory					
Days	72	72	72	72	72
Value Per/Day	836,712	1,004,055	1,204,866	1,445,839	1,735,007
Total Value	60,243,288	72,291,945	86,750,334	104,100,401	124,920,481
Receivables					
Days	68	68	68	68	68
Value Per/Day	1,059,452	1,271,342	1,525,611	1,830,733	2,196,880
Total Value	72,042,740	86,451,288	103,741,545	124,489,854	149,387,825
Payables					
Days	103	103	103	103	103
Value Per/Day	836,712	1,004,055	1,204,866	1,445,839	1,735,007
Total Value	86,181,370	103,417,644	124,101,173	148,921,407	178,705,689

4.7.1. Value of Reducing Days of Inventory

The amount of inventory SAM carries impacts two financial metrics: cash and profits. Inventory requires and ties up cash. Cash needlessly tied up in inventory reduces cash reserves and/or requires additional debt. There are carrying costs tied directly to inventory. A common estimate (the default used by this report) of inventory carrying costs is 35% of inventory net value i.e. storage, handling, obsolescence, insurance, taxes, shrinkage, damage, interest, etc; If SAM were able to reduce its **72** days of inventory to **37** days (matching the performance of SAM peers performing in the upper quartile), with each day of inventory valued at **$836,712** the impact would be:

a) $ 29,284,932 of cash freed as a one-time benefit,
b) $ 10,249,726 reduction in annual carrying costs ($ 29,284,932 x 35%).Therefore, operating costs would be reduced and profit before tax would be improved by $10,249,726 a recurring benefit.

4.7.2. Value of Reducing Days of Receivables

Decreasing days of accounts receivable has a major impact on your company's overall financial performance. It generates free cash. Something as basic as collecting your bills sooner after you sent them out can have a dramatic impact on your company's cash flow. It also means that a company has to borrow less, and liquidity ratios are strengthened. If your company is able to reduce its 68 days of receivables to 54 days (matching the performance of SAM peers in the upper quartile), with each day of receivables valued at
$1,059,452 the impact would be: $14,832,329 additional cash generated for the company.

4.7.3. Value in Negotiating Better Days of Payable Terms

Stretching accounts payable (by negotiating better terms) has a major impact on your company's overall financial performance. It conserves cash. This usually means that a company has to borrow less, and that all of the company's liquidity ratios are strengthened. As with inventory and accounts receivable, the cash that can be generated from extending your payables terms are straightforward and dramatic. SAM records indicate that the company is performing at or above the level of its peers in the upper quartile.

4.7.4. Five-Year Forecast, With Improvement Opportunities

The tables below illustrate the dramatic opportunity to improve SAM financial performance by improving SAM days of inventory, receivables, and payables metrics. Table 4.3 is a restatement of SAM current performance. Table 4.4 calculates the cash savings of improved performance, matching the performance of SAM peers in the upper quartile. Table 4.4 provides an annual and cumulative view of the financial improvement opportunities that becomes available to SAM. The forecasts assume a straight-line, 20-percent growth rate over five years for all your key financial data points. Margins are held at the "Current Year" rate.

Table 4.3: Improved Five-Year Forecast, With Improvement Opportunities

	Current Year	Year 2	Year 3	Year 4	Year 5
Growth		20%	20%	20%	20%
Sales	386,700,000	464,040,000	556,848,000	668,217,600	801,861,120
COGS	305,400,000	366,480,000	439,776,000	527,731,200	633,277,440
Receivables	72,000,000				
Payables	86,000,000				
Inventory	59,900,000				
Inventory					
Days	37	37	37	37	37
Value Per/Day	836,712	1,004,055	1,204,866	1,445,839	1,735,007
Total Value	30,958,356	37,150,027	44,580,033	53,496,039	64,195,247
Receivables					
Days	54	54	54	54	54
Value Per/Day	1,059,452	1,271,342	1,525,611	1,830,733	2,196,880
Total Value	57,210,411	68,652,493	82,382,992	98,859,590	118,631,508
Payables					
Days	103	103	103	103	103
Value Per/Day	836,712	1,004,055	1,204,866	1,445,839	1,735,007
Total Value	86,181,370	103,417,644	124,101,173	148,921,407	178,705,689

Table 4.4: Total Annual and Cumulative Improvement Opportunity

	Current Year	Year 2	Year 3	Year 4	Year 5
Inventory	29,284,932	35,141,918	42,170,301	50,604,362	60,725,234
Receivables	14,832,329	17,798,795	21,358,553	25,630,264	30,756,317
Payables	0	0	0	0	0
Annual Cash	44,117,260	52,940,712	63,528,855	76,234,626	91,481,551

4.8. Specifying Learning

In the specifying learning stage of AR iteration, explanations are built to account for the effects observed in the evaluating stage, as discussed in Chapter 3. As suggested by Yin (2003, p. 120), the explanations are

stipulated as a set of causal links between the variables identified in the evaluating stage and illustrated through causal diagrams. This explanations lead to the identification of new variables, which are essential to the establishment of those causal links. I did not attempt to build causal diagrams as this AR iteration is exploratory by design and the field data collected is predominantly unstructured. However, this did not prevent me from preparing the groundwork to strengthen the research framework for use in the next AR iteration.

It is evident early in the iteration that the latent variable, synchronization efficiency and effectiveness are related to the observable variables "workflow cycle time" and "quality of message/response" respectively.

Customer order processing i.e. an event (please refer to Appendix A) at the network level triggers a workflow. Uncertainty has a negative effect on the event outcome (i.e. on order promising and delivery on time). A transaction (i.e. order acceptance and delivery confirmation) would evidently require an interaction. This would necessitate an "Interface" that facilitates a means of communication that is no longer constraint by distance and time. Equivocality has a negative effect on interaction, making further clarification and reconfirmation necessary, between the parties, before the message is understood. In order to make informed decision, access to correct and complete information is a crucial. Making informed decisions has a positive effect on the quality of message/response resulting in supply chain performance effectiveness.

The same event i.e. customer order processing at the entity level triggers MPS. Complexity has a negative effect on the event outcome i.e. available to promise (ATP), of the finished products inventory. In case of insufficient inventory, provided there is sufficient material and capacity "on-hand", SAM is still capable of order fulfillment i.e. capable to promise (CTP). If there is a shortage of material or capacity, material requirement planning (MRP) and/or capacity requirement planning (CRP) will be triggered. Delivery is a key representation of action in a supply chain. Variability has a negative effect on action and makes rescheduling necessary if conditions for order fulfillment are no longer feasible. Workflow enables communication and coordination that is not constraint by distance and time. This improves order promising and delivery reliability with little or no expediting. Workflow cycle time is reduced resulting in supply chain performance efficiency.

Once again the same event i.e. customer order processing at the individual level triggers a supply chain manager to action learning.

Learning anxiety has a negative effect on synchronization competency i.e. to construct the message or response as a resolution to the coordination problem at hand. Access to knowledgebase of past problems and resolution reduces the anxiety of learning.

4.8.1 Financial Measures of Strategic Performance

The first of the four strategic goal perspectives is financial (Kaplan & Norton, 1996). Therefore it is necessary to establish early in the study the association between the performance variables and quantitative financial indicators. This is done in the first AR iteration of this study. This link from performance variables to financial terms i.e. the language of business, is seen as desirable for both academic and practice. See Table 4.5, below.

Table 4.5: Financial Measures of Strategic Performance Variables

Performance Variable	Explanation	Financial Indicator
Delivery Reliability	Receivables (Warren et al., 2004) are simply no-interest cash loans extended to customers. Their only valid purpose is to encourage sales. Days in excess of terms raise your costs and increase your risk of cash loss. Faster collections is vital to a company's cash flow ***Each day of receivables is worth $ 1,059,452 to SAM***	• Days of Receivables
Replace Inventory with Information	Inventory is not an asset. It is a liability (Fields, 2002; Goldratt, 1990). Its purpose is to protect throughput. Excess inventory hurts quality and increases product cost. Days of inventory are based on inventory "turns." One turn equals 365 days, and five turns equal 73 days. It pays to attack inventory with religious zeal. ***Each day of inventory is worth $ 836,712 to SAM***	• Days of Inventory
Efficiency	Profitability ratios (Boone & Kurtz, 2005) answer the question, "Is this company making any money?" Profitability in any company is the, bottom-line indicator of financial performance. It indicates, whether management has been successful or not with its policies, practices and decisions. In this respect, profitability ratios are a direct reflection on all areas of management performance.	• Assets Turnover Ratio • Return on Assets Ratio
Supplier Relationship	Payables (Warren et al., 2004) are simply cash lent to you at no interest. It is best to conform to internal policy on payables. Negotiate terms to keep your payables as long as you can. Pay when promised, but no earlier.	▪ Days of Payables
Action Learning	Value added (Grant, 2003) can be defined as the difference between revenue received by a company and the amount it paid for goods and services.	▪ Value added per employee

It is evident during the iteration at SAM that synchronization efficiency has a direct impact on the variable customer service level. Improvements in synchronization efficiency provided an opportunity for SAM to replace inventory with information i.e. the service level can be maintain whilst reducing the "Days of Inventory". Customer service level improvement has a positive impact on the "Days Payables" and "Days Receivable". These contribute to an increase in "Gross Profit".

4.9. Chapter summary and concluding remarks

In this section is the summary on the findings of the first iteration of the AR cycle, carried out over a period of approximately 10 months at SAM, an American manufacturer of home appliances based in Singapore. A total of 75 people are involved directly or indirectly in this AR cycle. Also involved in this study are 15 suppliers and contractors, of SAM.

The research data collected in this research iteration is predominantly unstructured and exploratory in nature. Data analysis indicates support for the hypothesis that workflow automation improves *synchronization efficiency;* understood as the efficiency of getting the *messages* across in asynchronous mode reducing the constraints of distance and time. The primary factor in the increase of synchronization efficiency appears to be efficiency gains in communication, coordination and information (i.e. customer order processing and production scheduling) access by participants of the workflow. The findings of this study also support that action learning of participants in supply chain at SAM has been improved by workflow automation. This resulted mainly through the development of a knowledge base on problems (and resolutions), challenges, risk and threats to efficient supply chain operations that were encountered in the past.

I could not find clear and unequivocal evidence that workflow automation improves, *synchronization effectiveness;* understood as being able to respond with the *correct and complete* information (for decision making). The effectiveness gains in communication and coordination appears to depend on the workflow scope and context. As in the case of SAM, some individuals refuse to interact through the workflow system for expediting customer orders, due to perceive threats such as; delays to message reading, message not read at all, confidentiality, written commitments and related risks.

Research findings in this first iteration of the AR cycle might have been biased by the scope of the study i.e. only two events *(i) customer order*

processing and (ii) master production scheduling and by the nature of the *researcher intervention*. The focus of the research on only two events could have been detrimental to the external validity of the findings, since some of these could be tightly related to factors that are peculiar to the events studied or the particular organization and industry to which it belongs. Nevertheless, this focus has probably allowed for a deeper understanding of the context being studied, a characteristic often reported as inherent in AR studies (Bradbury & Reason, 2001), and therefore reduce the likelihood of misinterpretations.

The research findings might have been biased by the nature of the researcher intervention i.e. leading SAM workflow participants to behave in an artificial way. For example, open access that I have to the chief operating officer of SAM, might have led staff to work harder and use the workflow system more intensely than they would otherwise have done. However, such positive behavior would not be detrimental to the research. I believe that the context created by the researcher's intervention has been documented in enough detail to allow for its replication in similar organizations.

Chapter 5: A Pilot Study at MAK

5.1. Introduction

This chapter describes the second iteration of the AR cycle at MAK. A total of 28 management staff are involve, either as workflow participants of the Customer Synchronized Resources Planning (CSRP) team or respondents of structured interviews. Another 13 staff are indirectly involved in the work carried out by the CSRP team, mostly for data collection relevant to the team decision-making needs.

The main goal of this second iteration of the AR cycle, from a research perspective, is to conduct a pilot study at the entity level i.e. manufacturer. MAK is considered an industry leader for machine tools and is the largest machine tool builder in Singapore. MAK is entirely managed by Singaporean, although its Japanese parent wholly owns it. MAK is the first to manufacture CNC machining centers in Singapore. MAK has since designed and developed several CNC machine tools models. From 2004, MAK have successfully manufactured and launched several top selling vertical machining centers. Other models of MAK have also been well received by metalworking industries.

MAK is fully committed to developing innovation capabilities and continues to meet the increasingly sophisticated needs of industries in Singapore. The creative mix of its employees and a continuous inflow of foreign talents allows for the “cross-pollination” of ideas necessary for innovation.

5.2. Diagnosing

MAK is a global provider of advanced machining technology and application support for the metal cutting and die/mold industries. MAK is responsible for distribution in Southeast Asia and India. MAK Singapore manufactures vertical milling machines and machining centers. MAK develop and deliver turnkeys and systems and has a foundry for machine tool sub-components.

5.2.1. Company Profile

Manufacturer of: CNC Milling Machines, CNC EDM Machines, CNC Vertical Machining Centers, CNC Wire-Cut Machines

Marketing of MAK Products: CNC Horizontal Machining Centers, Modular Machining Cells (MMC), CNC 5-Axis Horizontal Machining Centers, CNC Milling Machines, CNC Graphite Milling Machines, CNC Vertical Machining Centers, CNC Copy Milling Machines, CNC Wire-Cut Machines, High Precision Manual Milling Machines, CNC EDM Machines and Tool & Cutter Grinding Machines

Singapore Plant is for: Manufacturing Assembly, Sales, Service, and Training Facilities

5.2.2. Customer Synchronized Resources Planning (CSRP)

The company is a user of Frontstep CSRP Systems. MAK wanted to focus "outside the company walls" now that the internal operation of the company is at the management desired level of integration. This request came about due to the consolidation taking place in the industry due to mergers and acquisitions amongst the production systems integrators and stand-alone industrial equipment/machinery industry.

The chief operation officer of MAK emphasize that production of the completed/finished machine is customer order driven. Highly configurable options are available. Forecasting of sales based on finished machines cannot be achieved with any degree of reliability due to the many options coupled with long lead times. However, it is possible to build sub-assemblies of common standard parts (i.e. modules) of the machines based on forecasting to reduce manufacturing lead times (i.e. postponement strategies). The manufacturing cycle for a complete machine is long i.e. 6 - 9 months. The "Bill of Materials" (B.O.M) can be 8 levels deep and composed of approximately 4,000 components. These components can be electrical, electronic or mechanical.

The chief operating officer and his team of managers strongly believe that all materials, activities and processes that are internal could be planned and controlled. However, it is usually an external influence that causes drastic variation in the processes and performance of MAK that needs attention i.e. external factor change introduced at the "last minute" or after the production is in progress. The change normally is already known, however ironically the information never gets to the right party

until it is already too late. This often times results in finger pointing and confrontation amongst staff, suppliers and contractors.

The chief operating officers vision is to implement a "virtual organization" structure based on the following principles (Edwards et al., 2004):

a) Transformation by means of Information Technology i.e. of paper into digital records,
b) Workflow automation supporting human communication as a means of conducting the primary activities of the organization and maintaining organizational coherence,
c) The implosion of bureaucracy with the eradication of specialized tasks being replaced by cross-functionality,
d) The networking of individuals from technically separate firms (such as suppliers, customers, service providers, etc ;)
e) To the extent that clear external boundaries of the organization become difficult to identify in practice

Further, the team is given the following tangible goals to be realized after the workflow automation software has been deployed:

a) Replace costly calls to the sales and service staff with low cost electronic orders /messages,
b) Eliminate the need for re-keying of orders,
c) Minimize partial deliveries through better management of out of stock situations
d) Reduce returns - eliminating partial or out of spec deliveries significantly reduces fulfillment costs
e) Improve delivery timeliness - integrating directly to your warehousing and distribution systems
f) Reduce inventory costs - reduce stock and increase turn through tighter business process and better information – where possible eliminate inventory entirely - place customer orders directly onto your suppliers and distribute direct or cross dock,
g) Provide Customers with their own view of Products/Pricing visibility of their orders

The team is to determine the "gap" of MAK readiness to lead a supply chain initiative. Identify what factors: business, legal, human, social and cost that has to be considered and evaluated before embarking on this initiative. The goal is that all suppliers be digitally connected to MAK in the order fulfillment process. Currently, all communication between individuals, departments, customers, suppliers and contractors is either

through fax, telephone or emails. Order specification, quality and pricing issues usually required a face-to-face meeting that more often than not ends in a confrontation.

5.3. Action Planning

The formation of the CSRP team is approved by the chief operating officer. The team shall comprise of key users and department managers. The first meeting shall provide a forum for discussion and identification of the events to be reviewed by the team for workflow adoption. Further, a Team leader representing and taking ownership of the event and interaction will be identified.

The deployment methodology to be adopted will be the "FOCUS Methodology". This methodology makes provision for business process modeling specific to CSRP Software data model from FRONTSTEP. Integrated in the methodology is specification for role and responsibility of each workflow participant; data ownership, rules for escalation, triggers for alerts and other related functions.

Training on the new means of communication and coordination is to be planned for the pilot group. Communication shall be by means of electronic messages and responses. This will also reduce the need to conduct face-to-face meetings, especially in an organization like MAK, where getting all the team members together at one place can be a challenge in itself. Equivocality in the interactions will be reduced through the business rules enforced by the workflow automation software. Every message will be cross-referenced to a goal, process and objective. Further, the "construct" of the message will be implemented with a clear header, body and footer format (standard templates). Actions requested will be highlighted with temporal constraints and escalation rules. The same rules will be applied to the "responses".

The project is to be executed in 2 phases. The documentation of "as is" in phase 1 and implementing the change with workflow automation in Phase 2. The CSRP team shall report progress directly to the chief operating officer on a fortnightly basis.

5.4. Action Taking

The CSRP team is formed at the project kick-off meeting. Ms. Emily, VP of Planning is appointed Project Manager. Based on the broad guidelines outlined by the chief operating officer, the CSRP team selects customer

order processing and production planning as the events (please refer to Appendix: A) for workflow deployment. This process can be broken down into the following interactions:

a) Quotation Stage,
b) Planning Stage (what-if simulation by planners),
c) Order confirmation stage,
d) Job order creation (cross reference to customer orders) and
e) Purchase order creating (cross reference to customer order)

The Project Manager forms a workflow team comprising of sales, planning, IT and production staff. The Materials Manager (Ms. Yap) is selected as Team Leader. With this appointment, Ms. Yap takes over the ownership of the workflow deployment in MAK. Although she is not the most senior individual in the team, it is decided that since she is central to the selected event, she should take the lead role. Ms. Yap has been with MAK for 12 year and is please to assume the role.

During the assessment stage, the two events selected are mapped as detailed workflow models using the standard MS Office software (i.e. MS-Word, MS-Excel and MS-Visio). These models are then returned to the team participants as attachment to email messages.

During the Implementation stage, with a few exceptions, all activities are performed with workflow automation. All orders and change request and responses from/to the customer are recorded in the workflow database. There are also messages and response referencing issues related to the order delivery process. The study is completed on time for "gap" analysis and assessment for decision-making on the implementation of the workflow automation initiative for suppliers of MAK.

5.5. Evaluating

The CSRP team phase 1 lasts one month. The team consist of ten active members; four from the sales department, one from IT department, two from planning and three from production department. Of the 10 staff selected to participate, only the department managers contributed postings to the study phase. Interviews indicated that part of the discussion has taken place orally, mainly by means of brief face-to- face and phone conversations between staff of the sales and planning departments. The departments are located in 2 different buildings. Those buildings are, in turn, located approximately 20 meters apart of each other.

The CSRP team phase I outcome is presented to the chief operating officer. Phase II begins immediately after phase I is completed. Phase II is completed in the next 2 months. The interaction in the team comprised workflow postings, and a number of one-to-one phone and face-to-face conversations. According to estimates provided by group members 70 per cent of the total time spent by team members and other key users in the supply chain is through workflow interactions, whereas the remaining 30 per cent is in oral one-to-one interactions.

Emerging patterns of workflow automation effects on strategic performance of supply chain becomes evident in the evaluating stage. These patterns related to variables of the three units of analysis: Network, entity and individual. These variables are *workflow set up time (i.e. Team formation for collaborative workflows) and enabling cost*, for the network unit of analysis, *degree of interaction and demand for Leadership skills* for the entity unit of analysis and *individual influence* for the individual unit of analysis. A description of these variables and related effects is provided next.

Team formation for Collaborative Workflows: The sales department persistently complained about order promising problems to the staff of the IT department, prior to the start of this study. This contributed to the widening communication gap between Sales and IT departments. Complaints are mainly about the data accuracy, reliability of information on reservations and actual inventory position. These complaints are typically met with a defensive reaction from the IT department, whose attitude towards sales appeared to be one of "*...chemistry problem...*" according to the sales manager (this quote was extracted from my participant observation field notes).

Upon completion of the CSRP project the sales manager feels that his relationship with, other members of the IT department has improved considerably. The quote below, from my participant observation field notes, illustrates this feeling: *"...he (one of the participants from the IT department) has been avoiding greeting or talking to me...probably because of my complaints about IT support...after this workflow modeling collaboration, our relationship improved considerably..."*

The improvement mentioned above concerned the sales manager's relationship with the staff of the IT department. But the IT Manager, on the other hand, seems to feel uncomfortable with the CSRP team. Regarding this feeling, my perceptions (extracted from my field notes) were that: *"...she (the IT manager) seems to feel uncomfortable with the*

fact - of involving other department personnel to lead workgroups that are basically in her view, IT domain..." This is also observed by the Team Leader (she is from materials management) during her conversations with the IT Manager and supported by defensive e-mail messages sent by the IT Manager to all participants of MAK involved in this study. The messages refer to problems that have been raised during the study phase of workflow deployment. The IT Manager denied, though, in an interview with me about any feeling of discomfort caused by the CSRP initiative. However, she adds that "*...if the subject is particularly sensitive, I prefer to have it spoken rather than written*".

When asked whether the CSRP initiative have raised particularly sensitive issues, the IT manager added that: *"...I could have felt that the problem was one incompetent IT staff, telling users that there are bugs in the program…if he had sent a message about this and the message was distributed to the workflow participants, I would have felt annoyed….."*

The main reason for the feeling mentioned above, according to the IT Manager, is the fact that messages could be saved, printed out, and later used for "*...other purposes...*", as she put it. It was my interpretation; based on the IT Manager's remarks in the interview, that one example of this could be the misuse of a candid admission by management as a basis for disciplinary action and during review of annual departmental performance.

Degree of interaction: A compilation of the CSRP team activities suggests a drastic reduction in the interaction between departments, in comparison with verbal communication i.e. face-to-face meetings. A measure of the degree of interaction is defined as the ratio between the number of messages and responses and number of individuals per workflow cycle.

28 members exchanged 1,360 workflow messages during the 2 months of phase II; this gives an average of approximately 48 messages per participant, apparently very low when compared with our perception of team interaction in some of the face-to-face coordination meetings conducted in the first AR iteration.

Interviews with team members indicated that, in their opinion, the degree of interaction would be considerably higher, had the coordination been conducted verbally, which supports our perception. Moreover, two of the group members declare that they have been more selective in their participation of the workflow automation. In some cases giving workflow

message response lower priority over other routine activities, than they would have in a face-to-face co-ordination/expediting meeting.

Also, two of the group members did not contributed any response to the order processing related messages. These members reveal during interviews that they have both read the messages, and have been interacting verbally with other participants. These discussions, took place between members of the sales (same) department only. Some workflow participants also declared having discussed coordination related issues with staff outside the CSRP team, which indicates that the responses to messages involved more participants than the ones included in the workflow model.

Demand for Leadership: Most of the coordination workflows originated from the sales coordinator and are related to customer orders. Also, most of the workflows, from others participants, are response to messages from the sales coordinator. The workflow from the sales coordinator clearly set the context and pace of the workflow, despite the fact that the sales coordinator is not a senior manager.

After the workflow automation project is completed, the sales coordinator also admitted having severely limited interpersonal skills, particularly because her native language is not English. Moreover, her cultural background is markedly different from that of the typical Singaporean. One of my perceptions, extracted from my participant observation notes with the sales coordinator, states that "*...leading a face-to-face meeting would be considerably more demanding and stressful for me...*" This factor and her position in the organization is perceive by the sales coordinator as likely to considerably hinder her from leading face-to-face coordination and expediting meetings.

Enabling Cost: Though a distinction is often made between coordination activity and production activity in organizations (Olson et al., 2001*)*, coordination itself is an extremely broad term. It is usually defined at a very abstract level, as the alignment of distinct but interdependent activities. However, from an economic perspective, only production activities add value to the products. Coordination activities only add to the cost.

The project kick-off and formation of the workflow team meetings are conducted face-to-face. Collaboration effort for the processes selected has been through workflow automation. This means of communication and coordination causes less disruption and allow for effective personal time

management. I see this as a less costly workflow set-up process than the one typically employed in face-to-face meetings. The latter often involved briefing each of the participants about the topic prior to the discussion in order to convince them to commit time to the discussion, negotiating an agreed time for the meeting with each participant, and finding an appropriate venue.

The CSRP team completed its coordination and expediting activities with very little individual cost for the participant, placing a greater burden on the Team Leader. However, the Team leader and I are of the opinion that face-to-face meetings to discuss the same issues would have required more time from participants. She spent only 20 man-hours (approximately) in a month. In the past, her estimate is that 70 percent of the time she has been engaged in coordination and follow-up activities and only 30 percent of her time in productive work. An examination of the number and length of messages and responses in unstructured interviews indicated that the average time spent by the other workflow participants is approximately 10 man-hours, during the entire phase II i.e. 2 months.

Individual Influence: One of the key users in the logistics department and the MIS manager raised concerns about whether the CSRP team should continue its activities. Each of them raised concerns at different times in the study.

The key user from logistics department raised the issue verbally to the Team leader. Further in an electronic message sent only to the participants of the logistics department, he commented that "*I don't think we should involve them (the IT department) in the discussion of these issues…"* Most of the issues referred to by the key user from logistics, however, are clearly related to communication problems between the two departments.

This happened early in the study phase, and has no perceive effect towards preventing the team from proceeding with the CSRP initiative. This has no harmful effect on the key user future participation in the team. After a few responses to the Team leader's first workflow are posted in the first phase, the IT manager declared in an e-mail posting that "*...I find (the IT support) to be pretty good and getting better...*" and later verbally hinted to the Team leader that the IT team is better equipped to “take ownership” of the workflows. Nevertheless, the Team leader continues her activities without further disruptions from the MIS Manager.

5.6. Research iteration impact on MAK

At MAK the key coordination problems arise when the *value* of a shared information system depends on how different individuals and groups use the system jointly (Morgan, 2002). For example, the planning manager who maintains the capacity planning system that helps his subordinates automatically schedule job orders and also displayed each work center loads, faces significant challenges. Each work center needs to maintain an accurate, up-to-date capacity plan that publicly defines its loads and "free time." Maintenance of capacity plans on a computer system created significant amount of workload i.e. work done largely for the benefit of others in the organization. In this case, the sales personnel responsible for making promises on order delivery. These systems “in practice” have a political economy of effort that can make it hard for those who did most of the data entry and maintenance, to realize that they have gained proportional value (Olson et al., 2001).

The next level of coordination difficulty at MAK comes from the use of massive, *technically complex* computer systems that span an entire organization. While a complex system may improve aspects of a manufacturer’s coordination, making these systems run smoothly on a daily basis can be a huge coordination challenge of its own. At MAK, the Frontstep ERP system has faced significant implementation difficulties. As different functions are more tightly linked together, the new dependencies between functional groups have to be coordinated (Bach et al., 2001). The technical capabilities of the system, and any modifications, have to be negotiated by all of the groups relying upon the system. The organizational complexity of using ERP at MAK made it clear that internal politics are a better predictor on the extent of ERP usage in MAK than technical factors alone (Knöll et al., 2001).

All workflows are deployed with significant operational success before the project is declared completed. The workflows involve a total of 4 types of interaction involving 28 staff of MAK and all activities relating to the event of Customer order promising. Team leader's perception (from my participant observation field notes) and interviews with some of the participants suggest that the results achieved by the workflows are perceived as of slightly better quality than the ones likely to be achieved without workflow automation.

5.7. Specifying learning

In the specifying learning stage of this research iteration, explanations are built to account for the effects observed in the evaluating stage, as discussed in Chapter 3. These explanations are summarized in the subsections below. As suggested by Yin (2003, p. 120), the explanations are stipulated as a set of causal links between the variables identified in the evaluating stage and illustrated through causal diagrams. This explanations lead to the identification of new variables, which are essential to the establishment of those causal links. At the end of this section, all the findings in this research iteration are summarized in a discussion regarding workflow automation effects on strategic performance of supply chain i.e. *synchronization effectiveness, synchronization efficiency and synchronization competency*. This discussion includes a comparative analysis of the findings of this research iteration against those of the first AR cycle.

I decided to remove the causal diagram illustrations of this AR iteration due to a lack of confidence about the set of causal links between the variables resulting from a lack of data to support the explanations. These causal diagram illustrations are postponed until Chapter 7 when I revisit MAK.

5.7.1. Team formation for Collaborative Workflows

The improvement in the relationship between the departments may have been influenced by the impersonal characteristic of workflow automation (Daly & Knapp, 2002), which can make it easier to start and conduct collaborative workflows involving staff from conflicting departments. Workflow automation can help establish new communication channels between departments and, in turn, increase the amount of interdepartmental communication. This can foster the occurrence of new collaborative groupings in a dynamic mode. It is important to stress however; that previous studies suggest that the impersonal characteristic of workflow automation can also lead to more conflict. People seem to express themselves more frankly and be less polite, when interacting by electronic means (Doukidis et al., 2003).

The CSRP team review of processes caused some discomfort amongst department Managers i.e. IT, Logistics and Sales. This can be explained by the fact that the introduction of new communication channels between departments leads the managers to feel that their control over

departmental staff has been eroded or reduced. Previous studies show that workflow automation can contribute to reducing managers' control over their subordinates in hierarchical organizations (Burke & Cooper, 2005). This explanation, though, was not supported by the interview transcripts with the managers. A competing and more acceptable explanation is that electronic messaging and response pose more threats to participants than telephone conversations. Electronic messages can be stored and forwarded by parties, as records that can be used against them in the future. In some organizations this threat may increase when different departments are represented in the same order processing and fulfillment workflow. At MAK, the departments involved are expected to be defensive, due to the past mutual criticisms.

The effect of higher perceive *threats* to virtual team participants particularly managers, who typically are the ones "to get blame" for performance problems is in conflicts with the positive effect (also a result of workflow automation in virtual teams), of lower barriers to interdepartmental communication and collaboration. Fig. 5.1 illustrates the relationship between these two conflicting effects on the occurrence of new workflows.

The reaction from managers could be weak in organizations where functional boundaries are not so well defined, such as "adhocracies" and “matrix” organizations (Cummings & Worley, 2005). On the other hand, this negative reaction could be sufficiently strong to considerably limit the occurrence of virtual teams in organizations with a high number of separate departments with well-defined boundaries, such as "bureaucracies".

5.7.2. Degree of Interaction

The drastic reduction in the interaction between workflow team participants can be explained in four main ways:

a) It may have been caused simply by a lack of interest from workflow team participants
b) It may have been induced by individual ideas being better thought out before they are written down and sent to the workflow team as messages. This may decrease the need for requests “for clarification” and consequent replies.
c) It may have been related to the workflow modeling and rule of engagement suggested in SLA (Service Level Agreement). The combination of workflow model and SLA policies provides clarity

and transparency. Thereby reducing redundancy in interaction and clarifying the scope of interaction

d) As the interaction based on workflow automation is in asynchronous mode, the leader's control over workflow team contribution is very low. Whether participants provide their inputs or not is at their own discretion, which may tend to make their participation in the workflows more selective than it would be in a face-to-face meeting

The first explanation was ruled out, because the problems with the order processing had apparently become serious enough to warrant higher management attention. As discussed before, those problems are affecting MAK image. To resolve these problems, is seen as a strong motivation by the staff, to be actively involved in the workflows. As they believe that the situation can be improved locally i.e. within the scope of the two departments involved. This is seen by them as a more desirable alternative than a top-down intervention from senior management.

The second explanation finds confirmation in the behavior displayed by the sales coordinator. Knowing that others could misinterpret her messages, she tries to be as precise and clear as possible. This leads her to provide better “thought-out” messages and responses than in an oral telephone conversation or a face-to-face meeting. The third explanation is supported, to some extent, by the fact that all replies from workflow participants are closely related to the main workflow messages pertaining to the event.

Finally, the fourth explanation is partially corroborated by the fact that some of the workflow participants declare being more selective in providing inputs to the workflow than they would have been in an oral telephone conversation or a face-to-face meeting**.**

5.7.3. Demand for Leadership Skills

There is a low demand for leadership skills from the Team leader to effectively lead the coordination and expediting efforts through workflow automation. This can be explained by the fact that the workflow automation conceals individual characteristics, such as rank in the organization hierarchy (Samuel, 2005). Had not those characteristics been filtered by the system, the Team leader could have felt uncomfortable in a leadership role. She would have been constantly reminded, by the other managers’ very presence, that she is probably not the most qualified individual to lead the supply chain coordination and expediting meetings.

A complementary explanation is the low stress put on individuals, including the leader, to provide their inputs in a workflow message. This more relaxed characteristic of workflow automation has been identified in previous studies as an important factor influencing the quality and depth of individual's contributions (Hara et al., 2003). This explanation is consistent with the leader's view about the increased stress of leading a face-to-face meeting, compared to a workflow based supply chain coordination process.

5.7.4. Individual Influence

There is some evidence, from what happened when the IT manager and the users raise their concerns about the workflow participation, that the individual influence of certain managers is reduced in workflow automation. This phenomenon can be explained by the impersonal characteristic of workflow automation. Individual characteristics that foster control over groups, such as organizational status and verbal skills, are filtered by the system. This makes it much more difficult for managers to control the supply chain coordination proceedings, or impose their views on the participants

The explanation above, however, seems in contradiction with the perception by the team leader that she has been able to lead the coordination more easily than in a face-to-face situation. This calls for a complementary explanation, as the team leader also has low control on the team. The fact that the workflow followed a smooth path can be explained by the fact that the team leader presented the goal of workflow to the participants first. The fact that the participants proceed with the workflow deployment suggests that they had agreed and accepted the goal. Had the group not implicitly reached an agreement the workflow would probably have stalled, according to the low individual influence effect of workflow automation.

I did not attempt to construct a path diagram on individual influence due to the level of confidence about its links to the variable; functional disruption. Contingency on type of organization is one plausible explanation for the lack of clear and direct evidence.

5.7.5. Enabling Cost

There seems to be a considerable reduction in the cost of conducting coordination and expediting as a result of workflow automation. While there seems to be a significant reduction in the demand of time from the

team leader in comparison with an exclusively oral teleconferencing or face-to-face meeting, the largest gains accrued to the participants.

The reduction in cost can be explained by looking at the 4 main types of direct costs in face-to-face meetings:

a) There are the set-up costs, which are related to bringing people physically together for the meetings. One can reasonably assume that these costs increase with the physical distance between individuals.
b) There are the disruptions costs, as in face-to-face meetings members are required to interrupt their routine activities to be in the meetings.
c) There are the participations costs, as typically each of the individual members cannot engage in parallel activities during face-to-face meetings.
d) There are opportunity costs relating mainly to delays

These four types of costs are reduced by collaborative workflow automation in a combined way. In the workflows studied there is a slight reduction in the setting up costs (the two departments were located in the same facility), a reduction in the disruption costs (especially in the planning and production department), a drastic reduction in the participation costs and a reduction in delay cost, resulting from consequential disruptions affecting production activities.

The summary of the findings in the sections above suggest several causal links between variables related to the entity unit of analysis. Three main dependent variables emerged as a result of the above analysis: *demand for leadership skills, degree of interaction and enabling cost* - along with some new intervening variables.

A low demand for leadership skills is likely to allow for a decentralization of workflow deployment, which may foster the occurrence of local workflow participation. These workflow teams, however, are in my view unlikely to result in any workflows that target competitive issues or strategic processes. The breadth of knowledge and the authority to initiate a workflow over such issues is rarely found in lower managerial levels. Therefore, a low demand for leadership skills may only foster the occurrence of new workflows dealing with issues at the operational, rather than strategic levels.

The drastic reduction of cost can affect all types of workflows, from operational to strategic. However, the groups involving the most expensive staff (i.e. the better paid staff), which is typical in strategic

processes, are likely to attain the most significant savings in participation costs.

Finally the lower degree of interaction in workflow automation can have a negative impact, on the interaction, in particular where there must be a high exchange of knowledge and information between individuals. This may happen as workflows move towards business processes that cut across several different departments, and whose remodeling involves risks. These characteristics tend to be found more likely, in strategic than operational processes (Locke, 2002). This suggests that, while strategic focus workflows may benefit from workflow automation, this is likely to be achieved as a result of a combination of workflow automation and other types of interaction including face-to-face and other oral (e.g. telephone conversation) or written communications.

5.7.6. Synchronization Efficiency

The findings in this research iteration suggest an increase in synchronization efficiency due to workflow automation. One of the main explanations for this increase is, by definition, a decrease in the set up time for team formation associated with deployment of workflows. A second reason is a decrease in the demand for leadership skills from prospective leaders of workflows (i.e. virtual teams), which, as discussed before, may lead to an increase in the possible number of collaborative workflows in the same time period (e.g. a week) as compared to face to face meetings.

5.7.7. Synchronization Effectiveness and Competency

Data analysis of this AR iteration points to a close association between the supply chain manager's competency and the variable synchronization effectiveness. It seems that synchronization effectiveness is contingent on the supply chain manager's competency. In order to face new challenges, the supply chain manager has to be able to harness action learning as a means, to structure past problems as knowledge for use by the organization (Poirier, 2003). Such a practice is not evident at MAK.

Taking a narrower view of synchronization effectiveness, the establishment of a link between the workflow outcome and the improvement in the quality of customer order processing would provide a basis for the assessment of workflow automation impact on the variable synchronization effectiveness. However, this link is difficult to establish based on the evidence at hand, even in the light of the drastic

improvement in the quality of order promising and delivery indicated by the feedback from workflow participants. Some other factors, such as the Team leader's experience acquired during the past 12 years with MAK, might have had a direct impact on the quality perceptions.

The drastic reduction in the degree of interaction between individuals in the workflows has very little, if any, impact on the effectiveness of the workflows. Small group communication theory (Littlejohn & Foss, 2005**)** offers an explanation for this based on the type of tasks the group performs. Workflow participants perform primarily *additive tasks*, whereby they provide individual inputs on information that has been structured before. *Conjunctive tasks*, such as generating basic lists for analyzing and modeling workflows, are performed by the Team leader, facilitators and consultants from Frontstep, in face-to-face contact with the end users on site. Previous studies suggested that group outcome quality increased with a higher interaction in conjunctive tasks, and decreases in additive tasks (Stangor, 2004).

Therefore, a low degree of interaction is unlikely to have a negative impact on the quality and reliability of workflow messages. Conversely, poor facilitation and negligent leadership may have a strong negative impact on this variable. A complementary explanation for the apparent lack of impact "…*of a much lower degree of interaction*" on workflow effectiveness, and in consequence on synchronization effectiveness, is that individual contributions are better distributed in the workflow, due to a decrease in individual influence on the proceedings of the workflow. Also, these contributions tend to be more carefully prepared in workflow automation than in face-to-face meetings. There are indications that merely forcing members to participate in meeting may decrease team effectiveness (Jablin & Putnam, 2004).

However, these explanations did not provide enough background for the building of an explanatory causal model with a certain confidence about its links, particularly due to the lack of direct evidence. Even though some participants declare having perceive an increase in workflow messaging and response quality, the number of times this effect is mentioned is too small even for simple analyses (e.g. frequency analysis) which would have provided a better insight into how widespread this perception has been among workflow participants.

5.8. Comparison with the previous iteration

The findings relating to: *"How are efforts to manage strategic performance of supply chains affected by workflow automation"* summarized above covers aspects that are considerably different from the ones discussed in the first iteration of the AR cycle.

One of the possible reasons for this is the difference in the scope of the interventions in these two AR iterations. While the scope of the first AR iteration is the entire supply chain, the second AR iteration directly involved only a selected group of staff engaged in customer order promising and production planning, of a manufacturer and a selected population of suppliers. Data collection in the first AR iteration is based on evidence obtained form a relatively larger population in the supply chain, whereas the data collected in this AR iteration drew on evidence from only one organization perspective i.e. manufacturer.

Another possible reason for the contrast in the findings is the difference in the iteration focus. While the first iteration is mainly exploratory, this iteration is guided by Gowin's Vee heuristics. This leads to the iteration being conducted with more rigor and focus, in that the findings are more specific and has greater depth. Also, in the first iteration, much effort was expanded on linking the performance variables to quantitative financial indicators.

Nevertheless, findings in this AR iteration are generally consistent with those in the first AR iteration. The decrease in *enabling cost*, for example, is consistent with the perception by workflow participants in the first AR iteration of a decrease in the time spent in making informed decisions. Moreover, the findings in this AR iteration provided a better insight into how supply chain communication efficiency gains can be obtained, pointing to a combination of decreases in conversational ambiguity, participation cost and disruptions as the main causes.

The suggestion that there is an increase in the number of workflows is also consistent with the findings in the first research iteration, but the main cause is different. While in the first AR iteration communication efficiency gains are seen as the main cause, here it is the decrease in the demand for leadership skills, which appears to play a major role. I believe these two findings to be complementary regarding primary causes, and confirmatory as regards the higher-level effect that workflow automation is likely to increase the number of workflows per unit of time in the context of strategic performance management of supply chains.

An exception to this general consistency in the findings across iterations seems to be the identification, in this iteration, of an increase in the threats to management brought about by “employee empowerment” as a result of workflow automation.

In the first research iteration, however, I see a remarkable increase in the reliance on workflow automation. Are these findings contradictory? Apparently, they are. On the other hand, it appeared that the remarkable increase in the actual number of interactions observed in the first iteration may have been strongly influenced by the fact that SAM chief operating officer championed and provided unconditional support to the workflow drive. Although there is insufficient evidence to support this assumption, the influence of the chief operating officer may account for these seemingly contradictory findings.

5.9. Chapter summary and concluding remarks

This chapter reports on the second iteration of the AR cycle whereby a pilot study is completed. The study is conducted at MAK, a wholly owned Japanese MNC (Multi National Corporation). The study scope covers the customer order processing and production planning events. This iteration is completed in 4 months. A feedback from the staff indicates that drastic improvements in the perceive efficiency and reliability of the order planning and promising has been achieved at MAK.

This AR iteration leads to the identification of 5 main dependent variables affected by workflow automation. These variables are *workflow set up time (i.e. Team formation for collaborative workflows) and enabling cost* for the network unit of analysis, *degree of interaction and demand for Leadership skills* for the entity unit of analysis and *individual influence* for the individual unit of analysis

The study suggests that the workflow automation caused a decrease in the demand for leadership skills, in enabling cost, and in degree of interaction. The study also indicated that workflow automation lowers barriers to Interdepartmental communication. This favors the occurrence of new virtual teams (i.e. workflows) involving different departments. On the other hand, the study indicates that these virtual teams tend to be perceived as bringing about more security threats to management, which can induce negative reactions from managers. Finally the study suggests that while strategic performance management of supply chain benefit from workflow automation, this is likely to be achieved as a result of a

combination of workflow automation and other types of interaction including face-to-face and other verbal or written communications.

The findings presented in this research iteration may have been weakened by the fact that the study focus only on one unit of analysis i.e. entity. The results may have been distorted by idiosyncratic characteristics of both MAK (as entity) and the two events (i.e. customer order processing and production planning) being studied and by my own involvement. Therefore, the models presented should be understood as interpretive aids to be used as a basis for further research, as opposed to tentative generalizations of what is likely to happen in organizations.

Chapter 6: A Supplier Study at STS

6.1. Introduction

This chapter describes the third iteration of the AR cycle at STS. With over 300 years of experience in producing the world's finest tool steels, the group is committed to research and development so that STS materials meet the needs imposed by changing technology and the competitive market. STS Singapore, with more than 30 years of local presence, also adapts to a dynamic environment through continuing this focus on investment and development of facilities as well as services.

The main goal of this third iteration of the AR cycle, from a research perspective, is to conduct a study at the entity level, i.e. supplier. STS is one of the key suppliers of tool steel products to MAK. STS, being a downstream supplier of products to finished goods manufacturer like MAK, is compelled by business economics and competitive pressures to be synchronized with MAK.

The entire STS organization is involved in this AR iteration with some participation from sales department of MAK i.e. customer of STS.

6.2. Diagnosing

STS Singapore houses the latest technologies and expertise at their 6,400-sq.m facilities. STS strive to be the best in the supply of quality products with high value added services. STS close relationship with customers (i.e. manufacturers) is a cornerstone to the success in established markets. STS philosophy is to add value to these partnerships by growing with the customers changing needs.

STS professionalism is also founded on a commitment to provide only the finest quality services to customers and optimizing yields from existing resources. STS customers depend upon consistent expertise and premier products throughout the manufacturing process, heat treatment and machining services to ensure that they attain the highest overall profitability i.e. STS strive to operate at a maximal economy of return.

Tool users enjoy pre-production technical expertise and prompt service. They also appreciate that tools manufactured from STS products are

known for their durability; resistance to chipping; cracking and tool failure. These superior features reduce production stoppages and maintenance costs during production runs at customer plants.

The company has been a user of ERP from SAP. Functional areas of the enterprise are integrated to reduce redundancies and inaccuracy in data recording and reporting. STS has a focus on the operational and performance aspects of their supply chain. Business processes to be reviewed and re-engineered to reduce delay in customer services response. The goal is to synchronize the internal operations of STS to the customer's (i.e. MAK).

At the start of this AR iteration, the managing director of STS shared his frustration that despite having invested S$ 12 million in an AS/AR (Automated Storage & Retrieval) system, STS *is not able* to determine upon receipt of a customer order, with confidence that the order could be fulfilled. Also, if the order could not be fulfilled, is STS *capable* to fulfill the order within the constraints of time and cost, based on MPS and MRP? There are many people involved from different departments and there seems to be a lot of redundancy, in the customer order confirmation and MPS processes. Customer services team is not able to make a qualified promise to customers at order taking on item availability i.e. ATP and CTP.

6.3. Action planning

It became evident in the early stages of my study at STS that there is a need for workflow automation now that the ERP system is already in place. Workflow automation will help to address issues of redundant data capturing, single-source (repository) of planning data and production capacity. Workflow automation should provide an operating environment that enables STS to synchronize with MAK processes whilst providing tools that allow for customization of workflows and processes.

The following key features are deemed necessary:

a) Graphical user interfaces,
b) Multi-media capabilities,
c) Complete cross referencing drill down to activity,
d) Online documentation,
e) Project and decision support,
f) Workflow management and messaging
g) Security control.

The following goals are to be achieved:
a) Automate STS business processes,
b) Collaborate with customers,
c) Deliver accurate quotes fast,
d) Reduce operating costs,
e) Optimize labor efficiency,
f) Better plan and utilize capacity,
g) Minimize returns and rework,
h) Become more profitable

6.4. Action taking

The Customer Relationship Improvement (CRI) team is formed at the start of this AR iteration. Andrew Lim the Production Manager is appointed Project Leader. Based on the broad guidelines by the MD, the CRI team selected all four events and interactions of STS, related to performance management of supply chain to be studied (please refer to Appendix: A). The 4 main events are:
a) Customer Order Processing,
b) Production Planning,
c) Purchasing and
d) Shipping.

Andrew as Project Manager (reporting directly to MD), formed workflow teams for each event.

See Table 6.1 below, during the assessment stage, the events that are selected for mapping as detailed workflow models. These models are then returned to the workflow teams as attachment to messages. During the Implementation stage, with a few exceptions, all activities are performed with workflow automation. All orders and change request and response from/to the customer i.e. 3,050 in total are recorded in the workflow database.

Table 6.1: Events Summary Table

Event ID	No. of Different Workflows	No. Of Users	Mean Cycle Time (hrs)	No. of Sites	No. of Departments	No. of Workflow Messages	No. of Oral Contacts
STSE1 (Sales)	8	18	21	2	3	850	150
STSE2 (Planning)	12	26	48	1	2	750	250
STSE3 (Purchasing)	15	22	24	5	4	800	200
STSE4 (Shipping)	6	10	42	1	2	650	350

6.5. Evaluating

Eight dependent variables are identified in this study. Three dependent variables are related to the entity unit of analysis, namely: *workflow cycle time, demand for leadership skills and cross functional integration*. Another four variables are related to the individual unit of analysis, namely: *individual satisfaction, individual commitment, individual response time and individual learning (i.e. action learning)*. The one remaining dependent variable is related to the network unit of analysis, namely: *message & response quality*.

Data related to each of the 8 dependent variables is discussed next, along with the impact of workflow automation on the enabling cost of workflows for supply chain coordination. This 9th dependent variable *enabling cost* of workflows is not identified as a dependent variable in any of the causal models built during this research iteration. Nevertheless, the impact on this variable is analyzed separately in this section. This is done for two reasons:

a) This impact is seen as "drastic" by most of the respondents, which I believe is particularly due to the high functional and site heterogeneity,
b) Data on savings (or cost reduction) from the use of workflow automation are readily available at STS, and are seen as relevant for the discussion of workflow automation effects on one of the main independent variables of this study i.e. the anchor variable *synchronization effectiveness*.

6.5.1. Workflow Cycle Time

The analysis of structured interviews indicates that nearly 76 per cent of the respondents thought that workflows are completed in less time (measured in number of days) than conventional paper workflows (see Table 6.2). The main reason given by the respondents is a reduction in *message delivery and reaction time*, particularly in workflow involving staff from different functions (departments) and sites.

Message delivery and reaction time generally described by respondents as the time needed to get a message (request) to the right parties, including the recipients acting upon the message i.e. a chain of reactions (alternative actions to be evaluated by participants of the workflow). Several respondents noted that workflow cycle time tends to increase with *cultural and language* heterogeneity.

Table 6.2: Effects on Workflow Cycle Time

Answer	Frequency	Percentage (%)
Decrease	58	76.3
Increase	8	10.5
Had No Effect	9	11.8
Do Not Know	1	1.3
Total No. of Respondents	76	

Interestingly, cultural and language (site) heterogeneity in the CRI team formed at STS seems to be strongly correlated with functional (departmental) heterogeneity, a phenomenon that is in our view strongly influenced by the choice of events selected for workflow modeling and deployment. *This is confirmed by a correlation test between the numbers of departments and sites involved in the workflows shown in Table 6.1. The Pearson correlation coefficient obtained from this test was r = 0.97 (Refer to Appendix F for details), which suggest a strong correlation between number of departments and number of sites in the workflows studied.*

When asked about the influence of workflow automation on participants from the same site, but not necessarily working in the same room, most respondents indicated that workflows would still be completed in less time. The main reason given is that there is less functional disruption and not having to adapt their individual timetables to accommodate a face-to-face meeting.

About 10 per cent of the respondents (only 8 respondents) thought that workflow automation will take longer than conventional paper workflows. These respondents are unanimous in their explanation. As one of them put it in a structured interview: *"Individually, (it is) probably faster to route a workflow than ring around [i.e. telephone]. However, I have no idea how long it will take people to read their inbox messages and respond. Sometimes this is where the delays are caused and it can work out quicker to just call them"*.

That is, according to these respondents' perception, the individual response time can be higher in workflow automation. Members may take longer to respond to electronic messages than to verbal request for opinions and information made over the telephone or in a face-to-face meeting (see Table 6.3, below). The mean individual response time to a workflow messages (STS.E1) in this AR iteration, was approximately 5 hours. The mean response time in a face-to-face meeting is almost immediate (feedback). This comparison does have a considerable impact on the respondents' perceptions of workflow automation on individual response time.

Table 6.3: Effects on Response Time

Answer	Frequency	Percentage (%)
Decrease	9	11.8
Increase	49	64.5
Had No Effect	18	23.6
Do Not Know	0	0
Total No. of Respondents	76	

As our research focus is on strategic performance management of supply chains; *workflow cycle time* (see Table 6.4, below) is seen as taking precedence over individual response time and therefore more significant in the discussion of the workflow automation effects on one of the main anchor variables i.e. ***synchronization efficiency.***

Table 6.4: Mean Workflow Cycle Time

Event ID	Mean Cycle Time w/o Workflow (hrs)	Mean Cycle Time with Workflow (hrs)	Difference Percentage (%)
STS.E1 (Sales)	48	21	56
STS.E2 (Planning)	54	48	11
STS.E3 (Purchasing)	60	24	60
STS.E4 (Shipping)	48	42	13

6.5.2. Demand for Leadership Skills

Data analysis seems to suggest that workflow automation reduces the demand for leadership skills in coordinating and expediting in supply chain. These leadership skills can take different forms, such as the ability to solve conflicts and to coordinate the work of autonomous entities in the supply chain. It is not our goal to precisely define and measure the main components of leadership skills, but rather to assess respondent's general perceptions about workflow automation effects on leadership skill requirements. Statements of two key, workflow team leaders, who admitted having had severe difficulties in the past when they had to lead face-to-face meeting (on problem solving coordination and expediting) supported the perception that there is a decrease in the demand for leadership skills. Those difficulties are, in their view, *completely eliminated* by workflow automation.

Unstructured interviews indicated that the above effect may have been linked with two other workflow automation effects. One of these effects is called *hierarchy (boundary/barrier) suppression* i.e. the suppression of barriers to free communication due to hierarchy differences (Josserand, 2004). The other effect is a reduction of *individual influence* by workflow automation. Over 71 per cent of structured interview and questionnaire respondents are of the opinion that workflow automation suppresses hierarchy barriers in workflows (see Table 6.5, below). Some of them stated that, as subordinates, they feel less constrained by their managers.

Table 6.5: Effects on Barriers Suppression

Answer	Frequency	Percentage (%)
Decrease	54	71
Increase	049	0
Had No Effect	12	15.7
Do Not Know	10	13.1
Total No. of Respondents	76	

Approximately 45 per cent of the respondents feel that individual member influence on proceedings in coordination and expediting is reduced in workflow automation (see Table 6.6, below). Individual influence may be unrelated to managerial level, resulting from other factors such as oral communication skills and physical appearance. The main explanation given by respondents for both hierarchy suppression and lower individual influence in workflows is the relative perceive "anonymity" present in workflow automation. Some respondents' noted that this "anonymity effect" is still present when team members know each other well (e.g. participants from different departments who meet periodically).

Table 6.6: Effects on individual influence

Answer	Frequency	Percentage (%)
Decrease	34	44.7
Increase	8	10.5
Had No Effect	22	28.9
Do Not Know	12	15.7
Total No. of Respondents	76	

However, about 11 per cent of the respondents suggest that individual influence could be increased in workflows, particularly when members know each other well, because authoritarian and confrontational individuals would feel less constrained to try and impose their will on others than they would in face-to-face meetings.

6.5.3. Message and Response Quality

Approximately 80 per cent of the respondents are of the opinion that the quality of Message and response has been increased by workflow automation; whereas only 5 per cent of the respondents feel that workflow automation has no effect on this attribute. Conversely, approximately 8 per cent of the respondents thought that the, "quality of

response" has been decreased by workflow automation (see Table 6.7, below).

The main reasons given by the respondents for the increase in message and response quality are lower stress and disruptions, higher individual contribution quality, higher issue focus, lesser "going back and forth" to seek clarification and easier referencing of related information than in telephone and fax communication.

Table 6.7: Effects on message and response quality

Answer	Frequency	Percentage (%)
Decrease	5	6.5
Increase	61	80.2
Had No Effect	6	7.8
Do Not Know	4	5.2
Total No. of Respondents	76	

The main reason provided for the decrease in response quality is the lower team participation. According to the respondents the lower control over individual participation in workflow automation, when compared with face-to-face meetings, is also the main cause for the decrease in team participation stress perceive by individuals. This effect is seen as positively affecting the quality of individual contributions in combination with another factor - *the inherently better quality of written over verbal responses*.

The influence of this factor is also observed during the facilitation of expediting late orders. In some cases, for example, participants and managers noted that the process of writing about late orders and constraint processes improves the understanding and communication of production department problems i.e. allowing for all variables to be considered, in comparison with only speaking about the problems.

Approximately 63 per cent of the respondents thought that change adoption (e.g. engineering change notice) is higher in workflow automation than in conventional phone, fax or email based communication. About 26 per cent did not know whether change adoption is increased or decreased by workflow automation. This uncertainty is in our view cause by difficulties on the part of the respondents in understanding what the concept of change adoption meant. None of the respondents thought that change adoption is lower, that is, the remainder of the respondents thought that workflow automation has

no effect on change adoption or did not know how to respond (see Table 6.8, below).

Table 6.8: Effects on Change Adoption

Answer	Frequency	Percentage (%)
Decrease	0	0
Increase	48	63.1
Had No Effect	8	10.5
Do Not Know	20	26.3
Total No. of Respondents	76	

Participant observation notes and transcripts of workflow interactions seem to confirm the positive influence of workflow automation on change adoption, and point to a similar influence on goal focus. It is evident in this iteration that workflow automation drastically reduced workflow cycle time (as illustrated in Table 6.4, above).

Also, workflow automation enables workflow progress tracking, pro-actively non-intervention triggering of action request based on pre-set parameters and escalation rules. Some workflow participants noted that such practices could hardly be achieved without workflow automation. Without such tracking enablement, participants of workflows could get their priorities wrong or "forget" verbal commitments. Resulting in disruptions and causing "ad-hoc" execution of activities, consequently leading to a higher level of complexity in scheduling and chaos on the production floor.

As with change adoption, approximately 83 per cent of the respondents' thought that coordination related *information access* is increased in their workflow automation, in comparison with conventional phone, fax and email based communication (see Table 6.9, below). This indicates that members perceive an increase, due to workflow automation and in their ability to fetch information that (they felt) is necessary for them to effectively execute the coordination and expediting activities.

Again the small proportion of respondents (13%) who "did not know" how to answer this question, in our view, is due to the abstract nature of the concept of workflow/process related information access (which was pointed out by most of the 10 undecided respondents).

Table 6.9: Effects on Information Access

Answer	Frequency	Percentage (%)
Decrease	0	0
Increase	63	82.8
Had No Effect	3	3.9
Do Not Know	10	13.1
Total No. of Respondents	76	

Although some members perceive this increase in information access as likely to increase response quality, participant observation and unstructured interviews suggested that the written message and response quality can decrease due to cultural and language heterogeneity, or when action oriented task are being communicated.

In some workflow messages, the sales or engineering staff seems to omit necessary information, assuming that the purchasing and production staff would fetch it on their own if required during the workflow life cycle. As a result, some staff simply refrained from participating, as opposed to seeking further clarification of unknown terms or concepts, for example. According to one such group member: *"... (in workflow automation), if someone starts writing about things you don't know, you are turned off ... in a face-to-face meeting you can ask that person for the meaning (of a term or concept) during a coffee-break, for example...."*

Interestingly, the respondent who provided the comment quoted above noted that he would not feel inclined to ask for a clarification in a face-to-face meeting, because he feels that the other members could see this as a lack of functional competence on his part. He believes that the open admission of lack of process-related knowledge or information in his workplace could be damaging to the perception (of himself) that his bosses and peers hold. He would rather try and ask for a clarification during a coffee break by approaching the person who brought up the issue individually and as privately as possible.

The higher quality of written inputs from members, mentioned as a positive factor in the "Increase in the quality of individual contributions", seems to be associated with an increase in the effort that an individual has to put into contributing to their workflows, in comparison with face-to-face meetings. Some respondents, for example, pointed out the need to better structure and clarify ideas when writing electronic messages to the group to avoid misinterpretations. This may require word processing skills (e.g. to cut and paste text parts, generate and attach graphs to a

message, or save messages for later use), which in turn seems to be one of the reasons why individual participation is reduced, especially amongst older employees.

A few responses quoted from structured interview transcripts seems to suggest that some individuals are more likely than others to refrain from contributing postings, by noting that "*...slow and unsure mouse users can be put off by workflow automation...*", and that "*...computer illiterate folk are unlikely to participate in the workflow activities...*"

The response frequency analysis indicates a slight trend towards an "increase in member access to pertinent process-related information". However, there is no indication from the analysis of responses to structured or unstructured interviews that workflow automation increased the total amount of information (or knowledge) exchanged by individuals. Qualitative evaluation from a communication perspective of face-to-face meeting, suggests that verbal contribution requires less individual effort, equivocality can be reduced by almost immediate feedback on the comprehension of the message, broader scope of discussion and lesser threat of repercussions of the spoken word. Workflow automation tends to be focus on the subject matter of discussion; the written word requires more individual effort and has greater implication than spoken words. All pointing, to a decrease in information and therefore knowledge, exchange between individuals.

On the other hand, a cognitive evaluation of face-to-face meeting, suggests that all verbal information gathered during the meeting cannot be committed to memory (i.e. Short term memory). Some kind of note taking e.g. summary has to be devised to ensure that information gathered is not lost. Especially, that recall and application may take place after long time intervals. Workflow automation characteristics are suited for information storage and retrieval without any loss of quality. This can be seen as suggesting that individuals can store and recall (retention) larger amounts of information and therefore knowledge in workflow automation than face-to-face meetings.

6.5.4. Individual Satisfaction

Although about 38 per cent of the respondents perceive no workflow automation effect on their personal satisfaction from participating in their workflows, approximately 29 per cent of the respondents pointed out that their satisfaction decreased because of the workflow automation (see Table 6.10, below). The most frequent explanations for this effect are

lower personal contact, lower member participation (or team interaction), and greater effort that an individual has to put into compiling messages and response, in comparison with face-to-face meetings.

My participant observation notes suggests individuals experience frustration whenever they get an incorrect response to their workflow messages (possibly due to misinterpretations) or a request for more information, when individuals have already spent hours on compilation of the workflow message i.e. attachments with relevant information, summarization and proof reading.

As shown before in this chapter, apparently these negative characteristics are observed with certain frequency in individual responses in all workflow teams. A further analysis of discussion transcripts suggests that these characteristics are present particularly in the early stages of workflow deployment at STS.

Table 6.10: Effects on Individual Satisfaction

Answer	Frequency	Percentage (%)
Decrease	22	28.9
Increase	25	32.8
Had No Effect	29	38.1
Do Not Know	0	0
Total No. of Respondents	76	

Conversely, about 33 per cent of the respondents thought that their satisfaction is increased due to workflow automation. The three main explanations given by these respondents are workflows are less disruptive, allow for a better distribution of contributions (inputs from all participants), and are less stressful on individuals than equivalent face-to-face meetings.

Some respondents also pointed out that the workflow automation allows for more interaction between staff from different departments and sites, because several communication barriers are removed, such as distance and different time schedules. This, in the opinion of these respondents, leads to a higher social interaction than if they had to rely only on face-to-face interaction, even though this extra interaction lacked "social" contact to some extent. This extra interaction in turn leads to an increase in member satisfaction according to these respondents.

6.5.5. Individual Commitment

Approximately 72 percent of the respondents are of the opinion that workflow automation contributes to a higher individual commitment to response quality in their daily execution of work, in comparison with no workflow automation (see Table 6.11, below). The most frequent explanation presented for this is a better distribution of information within the organization, enabled by workflow automation.

Table 6.11: Effects on Individual Commitment

Answer	Frequency	Percentage (%)
Decrease	10	13.1
Increase	55	72.3
Had No Effect	11	14.4
Do Not Know	0	0
Total No. of Respondents	76	

A few respondents mentioned change adoption as one of the success factors in individual commitment. Although not an intuitive effect, my research data about the workflow message and response quality suggests that an effective change adoption may have an influence on coordination success. This research data is obtained within a month of each workflow deployment, through unstructured interviews with the leaders, regarding the success of their workflows.

But does team interaction not play an important role in the individual commitment to team goals? According to Social Development Theory (Vygotsky, 1978), it does. The major theme of Vygotsky's theoretical framework is that social interaction plays a fundamental role in the development of cognition. Vygotsky states: "*Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (inter-psychological) and then inside the child (intra-psychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals"* (pp. 57). If there is any correlation between change adoption and degree of interaction, it may have been offset by other factors (Lerner, 2001). It appears from interviews and participant observation notes that, in the successful workflow teams, commitment is high from those who have to implement the change, typically some or all of the participants.

However, as approximately 13 per cent of the respondents pointed out, individual commitment may be decreased by workflow automation. These respondents are unanimously of the opinion that commitment is decreased among those who do not actively participate or have little active participation in the workflow deployment. Some respondents pointed out, more specifically, that the lower the individual's active participation in the workflow, the lower would be his or her commitment to work at “staying synchronized” with others in the supply chain.

6.5.6. Individual Learning (Action Learning)

Half of the respondents thought that action learning is higher in workflows, in comparison with similar interactions where workflow automation is not available (see Table 6.12, below). Respondents split learning into social learning and process or technical learning (Haines, 2000). Social learning is the learning about other member's perspectives and ideas. Process learning is the learning about the workflows targeted by the team for automation. The main reason suggested by respondents as causing the increase in individual learning is the higher sincerity and quality of individual contributions (inputs from all participants) in workflow team.

Approximately 7 per cent of the respondents, on the other hand, thought that member learning is reduced when using workflow automation. The main reason presented is the lower team interaction in workflow automation than in similar face-to-face meetings. One of the respondents also explained the reduction in member learning by noting that, unlike workflow automation, face-to-face meetings allow for additional informal conversations where social and process learning occurs.

Table 6.12: Effects on Individuals Learning

Answer	Frequency	Percentage (%)
Decrease	5	6.5
Increase	39	51.3
Had No Effect	20	26.3
Do Not Know	12	15.7
Total No. of Respondents	76	

A few respondents pointed out that member learning is also increase by the broader functional and process representation in workflows fostered by workflow automation. The explanation behind this perception,

according to these respondents, is that if one can involve more functional and process representation in a workflow. Then one can increase the scope of learning of participants in the virtual team (Kintu, 2003). Workflow automation, according to these respondents, made it easier for prospective participants from different functions to be included in the workflow data model. This is strongly supported by the frequency distribution of responses to the question of whether workflow automation fosters functional heterogeneity in workflows, as summarized in Table 6.13, below.

Table 6.13: Effects on functional heterogeneity

Answer	Frequency	Percentage (%)
Decrease	0	0
Increase	71	93.4
Had No Effect	3	3.9
Do Not Know	2	2.6
Total No. of Respondents	76	

The main reason for the increase in functional heterogeneity, according to the respondents' perception is the decrease in the functional disruption fostered by workflow automation. One can speculate based on this perception that the difficulty of matching face-to-face meetings and individual timetables increases with the number of different departments represented in the coordination and expediting process.

6.5.7. Organizational Enabling Cost

Approximately 87 per cent of the respondents are of the opinion that the operational cost of running coordination and expediting is reduced when workflow automation is available, in comparison with similar phone, fax and email based coordination and expediting (see Table 6.14, below). Most of the respondents perceive the cost reduction as "drastic". Reasons given are no travel and accommodation costs in groups involving members from different sites, lower participant function disruption, and lower individual participation cost, in comparison with similar conventional coordination and expediting means.

Table 6.14: Cost of Workflows

Answer	Frequency	Percentage (%)
Decrease	66	86.8
Increase	1	1.3
Had No Effect	2	2.6
Do Not Know	5	6.5
Total No. of Respondents	76	

The argument presented by respondents in favor of the perception is that the goal of workflow automation is not simply coordination or expediting. Workflows are typically formed around a set of existing processes and procedures concerning product, service, quality and productivity (term here as a "problem" to be solved). The urgency in the solution of these problems for the organization is described as a success factor in supply chain improvement (Gang Yu & Xiangtong Qi, 2004). The commitment of staff time to "coordination" activities, however, can worsen these problems, and thus reduce efficiency and productivity even further.

As an example, consider an ERP II system; that is a massive, technically complex computer system that spans an entire organization. The main goal of the system is to reduce unproductive work. However, work would likely increase, at least initially, if some staff in the department stopped performing their functional activities and participate in ERP implementation meetings (Firestone, 2003). Some aspects of enterprise coordination may be improved by implementing complex systems. However, making these systems run smoothly on a daily basis is a huge coordination challenge of its own (Khosrow, 2003). As different functions are more tightly linked together, the new dependencies between functions have to be coordinated.

Some respondents' perceive workflow automation as likely to mitigate this problem (i.e. commitment of staff time to "coordination" activities) by reducing the time staff has to commit to face-to-face discussion, as well as allowing staff to participate in the discussion at a convenient time (addressing the exception conditions only).

Unlike the reduction in individual function disruption, the argument presented by respondents for a reduction in individual participation costs due to workflow automation is a more direct one, and is easy to verify based on some estimated figures. The average time that would have to be spent by each individual in coordination and/or expediting group

discussion is estimated, (as a result of approximately 17 unstructured interviews) to be slightly over 20 hours if the discussions are carried out exclusively through face-to-face meetings. This time is reduced by workflow automation to approximately 5 hours. This amounts to a reduction of approximately 75 per cent in the participation time.

By the same token, I could conclude that the average time spent by workflow team leader is reduced from 20 hours to about 3 hours, according to my own estimates matched against that of the Team leader's records. This amounts to an 85 per cent reduction in the coordination and expediting team participation time.

See Table 6.15 below, considering that the staff costs the organization on average 180 dollars an hour (STS per man-day rate), and that the number of individuals involved in a workflow is 18 (STS.E1), than workflow automation reduced the organization's expenditure per event.

Table 6.15: Cost Comparison

Cost Type	W/O Workflow Automation	With Workflow Automation
Participants = 18 (STS.E1)	180*20*18 = 64,800	180*5*18 = 16,200
Team Leaders = 1 (STS.E1)	180*20*1 = 3,600	180*3*1 = 540

It is important to stress that this reduction considers only time-savings and therefore is likely to apply to a broad range of workflows. It disregards, however, other types of costs such as travel expenses, which can make the reduction in cost an even more significant advantage of workflow automation.

6.6. Research iteration impact on the organization

At the end of the research iteration, Andrew as project manager prepared a summarized report that is submitted to the senior executives involved in the workflow deployment and, subsequently to all participants. The resulting feedback from participants suggests that most of them perceive the workflow automation as having benefited the organization in four main distinct ways:

a) By contributing towards increasing the quality (mostly) and productivity (to a lesser extent) of the workflows targeted by the workflow teams,
b) by contributing towards increasing process-related knowledge and information between the different sites and departments involved in the workflow while the orders are in progress (mostly), and after the

workflows are completed to a lesser extent and with this effect waning over time,

c) By contributing towards the formation of a customer relationship workflow integration with MAK (i.e. customer) culture in the organization; and
d) By allowing workgroup leaders to learn through best practices adoption the planning and coordination skill set to eliminate “waste”.

In spite of the perceive benefits listed above, the workflow automation deployment is seen by some middle managers as "*...a waste of time, resources, and money...*” as one of them put it. Interestingly, these managers apparently shared some common personal characteristics. They are mostly "managers who came through the rank and file", in the jargon used at STS, in the sense that they are typically involved in direct production activities. They are also generally negative towards the use of computer technology, except for data management e.g. storing and maintaining data. They are generally both pragmatic and authoritarian according to the views of their subordinates. Participant observation field notes, on the interaction of these managers with their staff, in all cases, support these views.

Two middle managers perceive the research iteration as particularly beneficial to their areas. These managers have been involved as participants in the workflows and reported most of the organizational benefits listed above. One of these managers reported having modeled his own workflow for application of leave approvals and monthly expense claims of staff, doing away with paper forms, in his department.

The contrasting behavior of two senior executives towards the project is particularly puzzling to me. These two senior executives are the heads of the respective functional areas involved in workflow deployment. One of them appears to be very content with the organizational results of the workflow deployment. He believes, that workflow automation should be incorporated as a process into the routine activities of STS as a whole. He stated that "*...there is a place for collaboration (workflows automation) in our organization...*", and stated his interest in setting up a full-blown project to involve all the suppliers of STS.

The other senior executive reacts in a very negative way to the CRI initiative, for what he considers as being an ineffective deployment. He appears to be determined to pose insurmountable obstacles for the deployment of an organization-wide workflow automation initiative (this executive is probably one of the STS more influential personality). His

reaction appears to be predominantly defensive, rather than motivated simply by a lack of confidence on the benefits likely to accrue from workflow automation. This defensive reaction may have been caused by a lack of political attention and “respect” from the workflow team early on in the deployment stage. For example, during the CRI team set up, the project manager pointed out a number of inefficiencies in several of STS processes. Further interactions with this senior executive confirmed that such “open-approach” is poorly aligned with what he considers to be a "politically correct" conduct.

6.7. Specifying learning

In accordance to the data analysis process described in Chapter 3, the results of the evaluation stage leads to the generation of explanatory causal models incorporating relationships between variables. The main independent variable in these models, as in the previous research iterations, is *workflow automation*. The dependent variables in the causal models are the ones described in the evaluation stage, plus the variable *cross functional integration* and the anchor variables *synchronization effectiveness, synchronization efficiency and synchronization competency*. From a strategic performance management of supply chain perspective, *Team formation for collaborative workflow* from the 2nd AR iteration has been re-conceptualized to include *barrier suppression, information access and enabling cost of workflows to* form cross functional integration.

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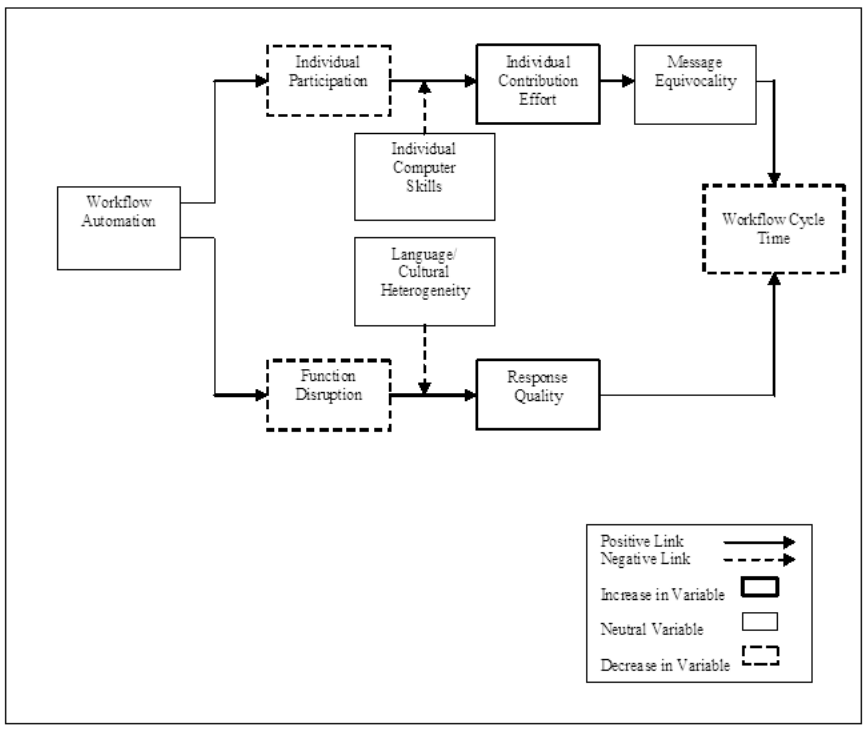
The remaining research variables in the initial research framework are either discarded, or incorporated in the causal models as intervening or moderating variables together with new variables identified during data analysis. These causal models are discussed next.

6.7.1. Workflow Cycle Time

The variable *workflow cycle time* seems to have been decreased by workflow automation according to structured interview respondents’ perception. Two variables seems to have affected *workflow cycle time*. One is *message equivocality*, which seems to be much reduced in workflow automation, than in conventional phone and fax communication in similar circumstances. *Workflow cycle time* seems to be directly affected by *message equivocality, i.e.* by the time that individuals comprehend the message completely and respond correctly to a workflow message (Koufteros et al., 2002).

Workflow cycle time also seems to be directly affected by *response quality*. Interview analysis suggests that the effect of the variable *response quality* could offset that of the variable *message equivocality* on *workflow cycle time*, particularly in workflows involving staff from different sites. This suggests the existence of a variable – *cultural and language heterogeneity* - moderating the influence of *response quality* on *workflow cycle time*. The causal links between these variables are represented in the explanatory causal model in Figure 6.1, below.

Fig 6.1: Path Diagram – Workflow Cycle Time



The effect of workflow automation on the variable *message equivocality* can be explained through the consideration of some intervening variables. Participant observation and interviews seems to suggest that *message equivocality* is influenced by the variables *individual contribution effort*, which reflects how difficult it is for a member to compile a workflow message, and *individual participation*, which reflects the control that other participant, particularly the manager, authorizes the subordinate to have.

An increase in individual contribution effort, combined with a decrease in individual participation control, apparently leads individuals to construct more thought out workflow messages. The effect of workflow automation, on individual effort to contribute seemed to be moderated by the variables individual *computer skills*, which influences the ability of a participant to interact with the workflow comfortably, and *individual computer literacy*, which is a function of the amount of knowledge that participant, holds particularly about how the supply chain and workflow system operates. Slow typists, for example, appear to usually take more time to compile, whereas those who are less skilled in the operating computers seem to refrain from participating.

Some participants indicated frustration of not knowing exactly when their messages would reach the other person. Message replication could take from some minutes to (in very rare occasions) as long as two days, due to faults in the workflow system, the local area network (LAN), or the main outlook exchange server (based in Hong Kong). Even though the status of the messages (e.g. pending, delivered, read) could be easily checked through the system, some participants seems to have difficulty in understanding the concept of "message status". These participants appear to be at the lower end of the computer literacy scale. I decided not to include the variable *individual computer literacy* in the explanatory model in Figure 6.1 because I believe that this variable is strongly correlated to the variable *individual computer skills*, that is, a participant at the low-end scale of computer literacy is unlikely to have high computer skills (although exceptions may exist).

Also important in reducing *workflow cycle time* seems to be the influence of the variable *function disruption*, i.e. disruption of a individual's routine activities due to participation in a coordinating or expediting meeting. In the respondents' view workflow automation decreases disruption of individuals' routine activities (i.e. activities that are related to individuals' organizational functions), an effect that appears to be completely independent of site (i.e. language and cultural) heterogeneity. On the other hand, a high correlation between site and departmental heterogeneity is found in the workflows conducted in this research iteration, and departmental heterogeneity seems to be correlated with the degree of individual function disruption caused by coordination and expediting activities.

However, the influence of the variable individual's *function disruption* on *workflow cycle time* did not seem to be a direct one. It seems to be mediated by the variable *message quality*. This can be better understood

with reference to face-to-face meetings. In this type of interactions, it is obvious that the variable "message quality" is directly affected by the variable *function disruption*, as the more disruption coordination meetings cause on an individual's timetable, the less likely, that the individual will be available to attend meetings at short notice. Moreover, a further analysis of this influence leads to the realization that face-to-face meetings are very unlikely to come up with a proposed solution in only one meeting.

6.7.2. Demand for Leadership Skills

The variable *demand for leadership skills* seems to have been reduced by workflow automation (Woltring et al., 2003). The demand for leadership skills in CRI teams seems to be affected by the variable *individual influence* (see Figure 6.2, below).

Based on pattern matching of explanations given by respondents in structured interviews, that the variable *individual influence* is a good predictor of the variable *hierarchy (barrier) suppression* within the scope of analysis on variations in demand for leadership skills i.e. if individual influence is reduced, *hierarchy suppression* increases within this limited scope.

Therefore, only one of these two variables - *individual influence* - is consider in the explanatory causal model explaining the relationship between workflow automation and demand for leadership skills (Chiok, 2001). For a similar reason I also left the influence of oral communication skills out of this explanatory model, at least explicitly. While *individual influence* in face-to-face meetings may result from individual characteristics unrelated to managerial level, such as oral communication skills as an example, those characteristics are always possessed individually. In this sense, the influence associated to an *individual's* rank in the organizational hierarchy will be reduced by workflow automation in the same way as the *individual's* oral communication skills and body language.

Individual anonymity (i.e. individuals' perceive sense of anonymity) seems to be a key variable in explaining the reduction in individual influence that occurs in workflow automation (Mathena, 2002). Another key variable is *individual participation control*. Perceive anonymity seems to increase with workflow automation, mainly due to the impersonal characteristic of workflow automation (Thurlow et al., 2004). The variable *individual participation control*, on the other hand, seems to

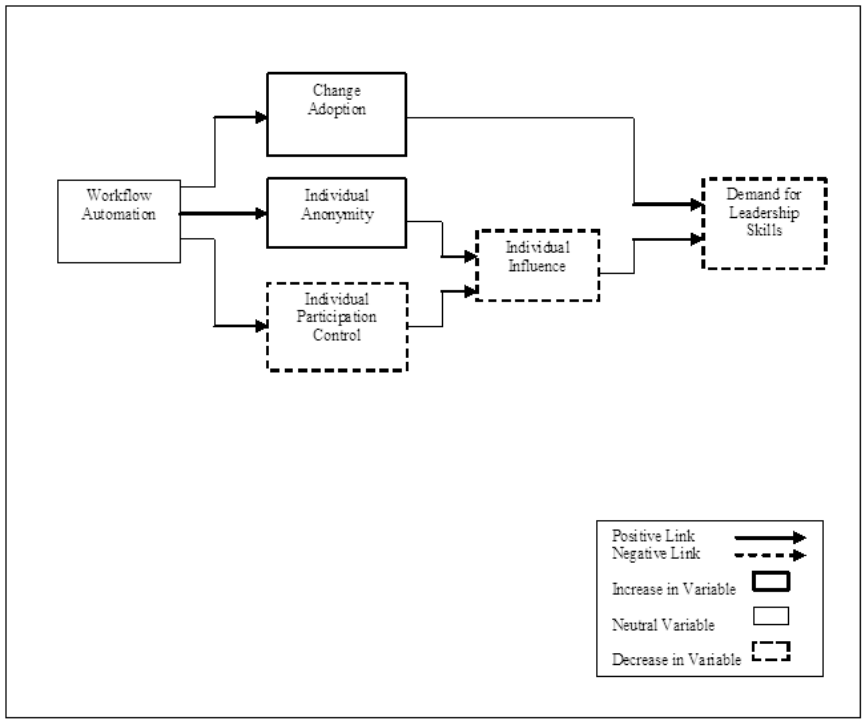
decrease with workflow automation, particularly due to the asynchronous nature of this communication technology (DiMicco et al., 2004).

When CRI team members interact asynchronously via workflow automation, they cannot be "pushed" into giving a response to a direct question or to contribute right away to the problem at hand, as often happens in face-to-face meetings (e.g. by directing a question to a particular individual).

I could not find any explanation to account for some of the respondents' belief that workflow automation can, in some cases, increase individual influence. In follow-up interviews with those respondents, though, they seem to associate that effect with the "bluntness" of some of the participants' response in their workflows. According to their view, such "blunt" comments would not happen in face-to-face meetings, where people are generally more polite and non-confrontational. That influence, however, did not seem to be disruptive from a coordination perspective, since the respondents' also stated that their goals and objectives of the workflow remained unchanged by those "blunt" comments.

During the data analysis of workflows transcripts it became clear that an important factor in the reduction of the demand for leadership skills has been the increase in the variable *change adoption*, fostered by workflow automation (Harris & Ogbonna, 2001). This perception is consistent with some of the workflow leaders' opinions about the positive influence of workflow automation on change adoption, mentioned earlier in the evaluating stage.

Fig 6.2: Path Diagram – Demand for Leadership Skills



6.7.3. Message and Response Quality

The variable *message and response quality* seems to be increased by workflow automation. Seven variables seems to directly affect the quality of response from CRI teams, namely *individual stress*, *departmental heterogeneity*, *site heterogeneity*, *individual interaction*, *individual contribution quality*, *team focus* and *information access*. *Individual stress* and *individual interaction* seemed to be lower in teams when workflow automation is present. Conversely, *departmental and site heterogeneity*, *individual contribution quality*, *team focus*, and *information access* seemed to be higher. The explanatory causal model in Figure 6.3 below depicts the relationship between workflow message and response quality.

Participant responses in interviews suggests that the variable *individual stress* is reduced mainly due to the lower individual participation control in workflow automation, a finding that is consistent with previous findings in the empirical literature on cognitive behavior (Pohl, 2004). A lower individual participation control, however, also appears to lead to a

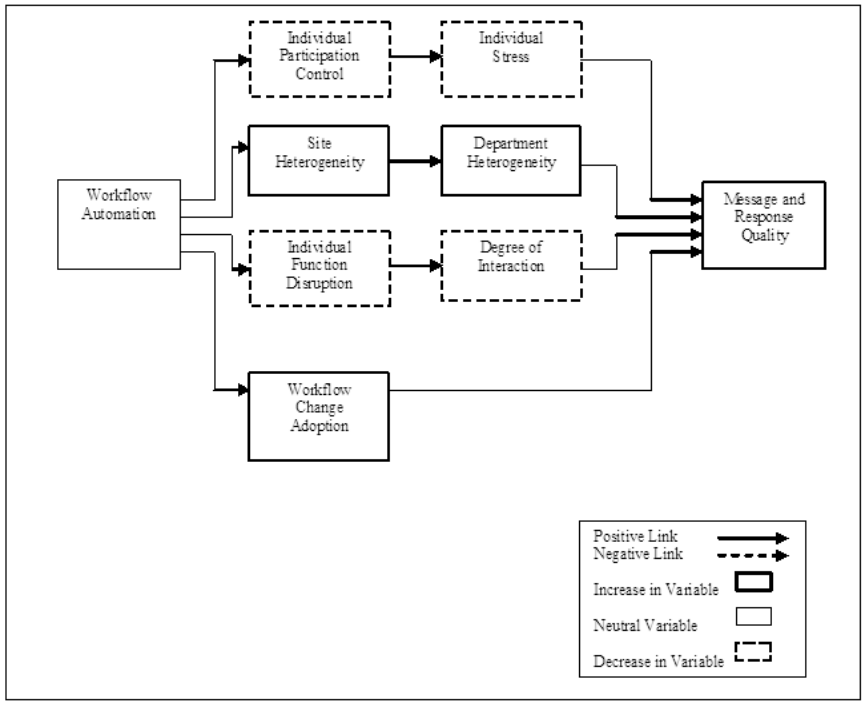
lower individual participation, as some workgroup members tend to give lower priority *(urgency)* to their participation in the workflow messages than to their routine functional activities, particularly if these individuals have low computer skills i.e. the variable *individual computer skills* plays a moderating role in the model. On the other hand, individual participation seems to be fostered by the lower individual function disruption in workflow automation.

Participant responses indicate that the variables *site (i.e. cultural & language) heterogeneity* and *departmental heterogeneity* directly influences *message and response* quality (Mudrack, 2003). Site heterogeneity seems to positively affect *message and response quality* because different offices have different perspectives of the same processes, since they run those processes in different geographical and regional settings. Workflow model standardization across different geographic and regional setting can facilitate workflow effectiveness.

Respondents also indicate that the influence of departmental heterogeneity on *message and response quality* can be moderated by the variable *problem complexity*. It seems that as complexity increased, so did the need for more interaction. In an unstructured interview, for example, a senior manager pointed out that workflow automation would be appropriate in workflows addressing "simple and routine" issues, but would fail in handling "complex" issues. That senior manager did not define complexity, but indicated that it may strongly correlate to the departmental heterogeneity in the workflow. In his view, the reason for this is that processes that cut across several departments *(boundaries)* are likely to be more complex than processes totally contained in one department only. He noted that this is probably compounded by the fact that staffs in different departments often have different knowledge backgrounds and different perspectives of the organization, which may lead to the use of different concepts and approach in framing the problem, thus increasing its complexity (Samii & Karush, 2004).

Departmental heterogeneity apparently has not been directly influenced by workflow automation. It appears that the variable *site heterogeneity* intervenes, particularly in a supply chain with a large number of entities spread over a large number of different sites. Another intervening variable seemed to be *function disruption*, since the functional diversity in workflows involving several different departments is likely to lead to a higher disruption of individual functional activities if those individuals have to meet face-to-face.

Fig 6.3: Path Diagram – Message and Response Quality



Following this line of reasoning a face-to-face interaction involving only IT support staff, for example, is likely to disrupt individual functional activities to a lower extent than if the interactions also involved quality control inspectors (or the customer's incoming QC inspectors). This is because it seems to be generally more difficult to match timetables of staff from different departments than of individuals from the same department. Therefore, a lower individual function disruption fostered by workflow automation is likely to lead to a higher functional heterogeneity in the workflow (in this case, a moderating variable), if the coordination scope so requires.

The influence of workflow automation on the variable *individual contribution quality* seems to be moderated by the variable *individual computer skills*. Some workflow Team leaders and unstructured interview respondents seem to reasonably expect participants with good computer skills to more likely be contributing elaborate messages, whereas those individuals with poor computer skills to likely refrain from contributing or contribute only short messages with brief information.

A further analysis of STS workflow database, matched with participant observation notes, supports this perception to some degree.

The respondents' perception that the variable *team focus*, which is influenced by *change adoption*, positively affects the quality of the message and response and is consistent with the general assumption that when teams stray from their initial goal the quality of the team outcome in general tends to decrease. This assumption is supported by Katzenbach study on short-lifetime teams (Katzenbach, 2000).

The positive impact perceive by some respondents of information access to external workflow-related information (e.g. documents and archival records), reflected in the presence of the intervening variable *information access* in the model, is consistent with study-based assumptions about the benefits of workflow automation to distributed groups/virtual teams (Umar, 2003).

6.7.4. Individual Satisfaction

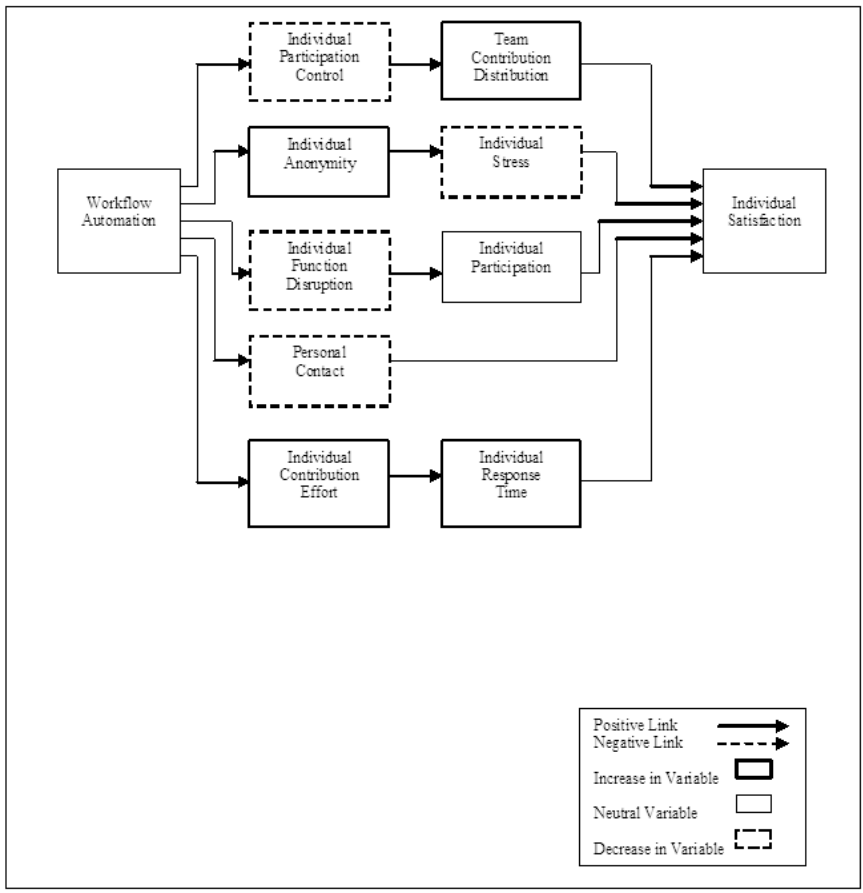
Individual satisfaction seems to be neither increased nor decreased by workflow automation. Six variables seemed to directly affect the variable individual satisfaction. These variables were *individual stress*, *team contribution distribution*, *degree-of-interaction*, *individual response time*, *function disruption* and *personal contact*.

Individual stress, workgroup interaction, function disruption, and personal contact appears to decrease with workflow automation; Team contribution distribution, and individual response time appears to increase. The causal links between these variables are shown in the explanatory causal model in Figure 6.4, below.

The reduction in the variable individual *stress* appears to be caused by two workflow effects i.e. an increase in individual anonymity and a decrease in individual participation control. The reduction in the variable *degree of interaction*, on the other hand, seems to be caused by a decrease in member participation, which in turn appears to be linked to both an increase in individual contribution effort and a decrease in individual participation control in workflow automation, in comparison with similar face-to-face interactions. As discussed previously in this chapter, the impact of workflow automation on individual contribution effort appears to be moderated by the variable *individual computer skills*.

The evidence obtained from interviews and participant observation suggests that both variables *function disruption* and *personal contact* decrease with workflow automation. The impact of workflow automation on *function disruption* has been discussed before in this section, when I made considerations regarding the variable *workflow cycle time*.

Fig 6.4: Path Diagram – Individual Satisfaction



The negative impact of workflow automation on *personal contact* can be explained by the fact that people tend to use the workflow system for most of their work, which is indicated by the proportion of workflow automation and oral communication in the teams in Table 6.1 above, and by the fact that individuals used the workflow system for most interactions and only resort occasionally to face-to-face meetings and the telephone.

The higher proportion of coordination and expedition activities is perhaps motivated by the benefits accruing to team from the use of workflow automation, such as reduction in *function disruption* and *workflow cycle time*. This, in turn, leads to lower *personal contact* between individuals. Personal contact between individuals is characterized in interview responses by co-presence and, as I see it, can be safely assumed to be higher in teams that meet face-to-face.

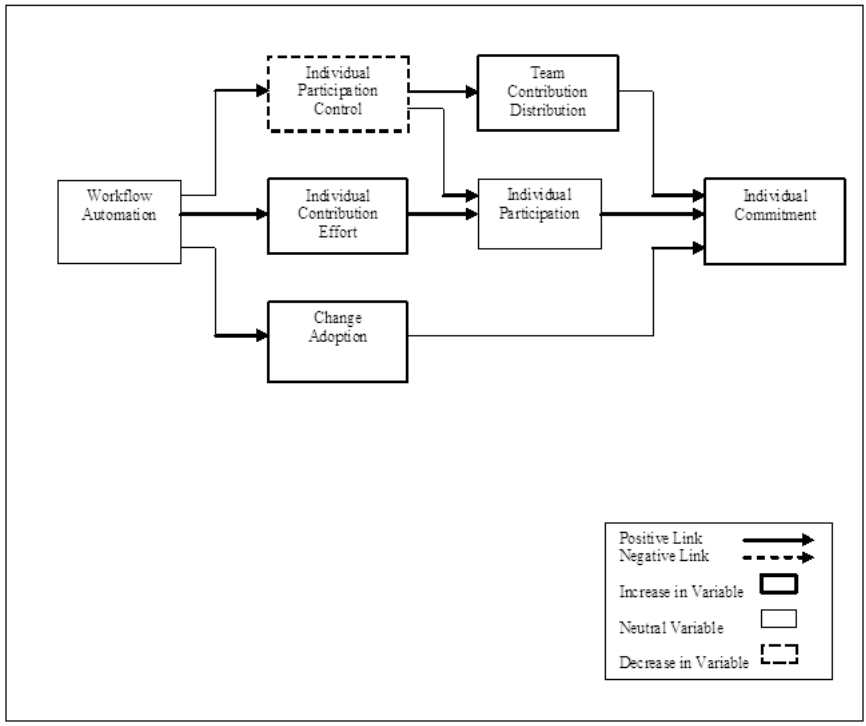
The variable *team contribution distribution*, which measures the degree of distribution of contributions among workgroup members, seems to be increased by workflow automation, apparently due to a reduction in *individual participation control*. For example, in a face-to face meeting one person, such as the group leader or participant with specific knowledge relevant to the problem domain, may dominate most of the meeting, reducing the distribution of contributions among other members (Clampitt, 2004). It seems reasonable to conclude from the evidence gathered in this AR iteration that workflow automation hinders individuals from playing such dominant roles. As discussed before, the variable *individual response time* appears to be affected by the variables *individual contribution effort*, which is increased by interaction through workflow automation, and *individual participation control*, which is reduced by workflow automation.

6.7.5. Individual Commitment

Individual commitment seems to have been generally perceived as increased by workflow automation. Structured interview and questionnaire responses indicate that three main variables directly affected the variable *individual commitment*, which refers to the individual commitment to construct a good quality response. One of these variables was *team contribution distribution*, which appears to be higher in workflow automation than in face-to-face working teams. This in turn appears to have led to an increase in *individual commitment*.

The second variable is *individual participation*, which seems to be decreased by workflow automation. This decrease appears to have led to a decreased in individual commitment. The third variable affecting individual commitment is *change adoption*, which also seems to be higher in workflow automation than in similar face-to-face meetings. The increase in this variable also appears to have increased *individual commitment*. All these variables have been discussed before, and their links with other variables are shown in Figure 6.5, below.

Fig 6.5: Path Diagram – Individual Commitment



6.7.6. Individual Response Time

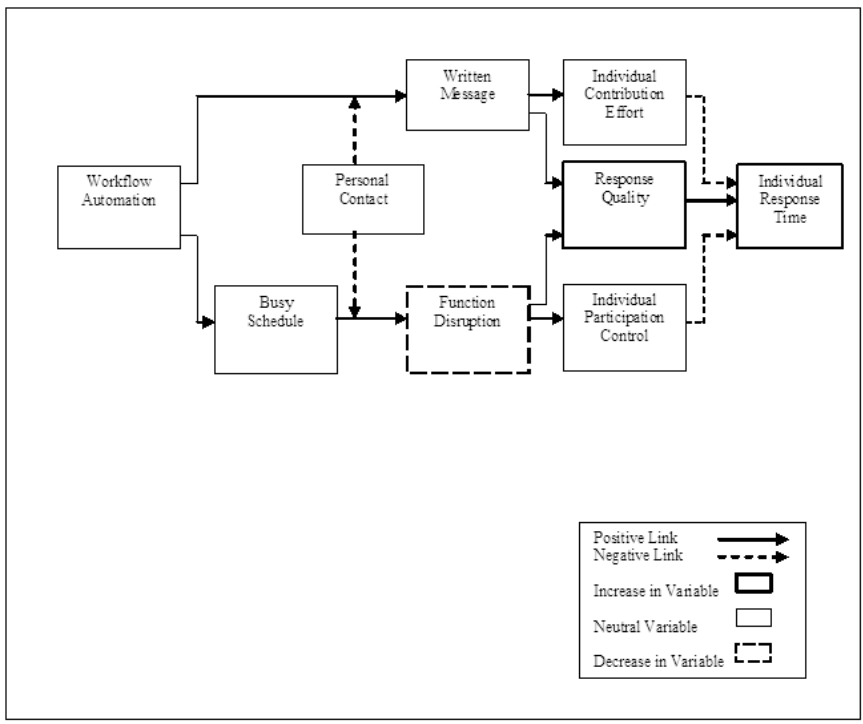
Workflow automation allows people to interact without having to compete for airtime at their own pace. This leads to a reduction in individual function disruption. On the other hand, some individuals perceive this characteristic i.e. asynchronous mode of communication, as contributing to the increase in response time.

Workflow automation leads to lower control of individual participation (i.e. response or not and after how long). This can lead to a lower level of participation. All this, plus the fact that the workflow system filters social cues and does not allows for personal "touch", can lead to the perception that workflow automation increases individual response time.

Workflow automation reduces member work disruptions caused by answering phone calls and unscheduled meetings. This allows members with busy schedules to plan with better certainty and reliability. The perception that a reduction in uncertainty would have not otherwise

occur, leads members to perceive that the quality of response and decision-making is improved. However, this improvement in quality as a result of the written message is more demanding on the individual i.e. contribution effort, leading to an increase in individual response time. All these variables have been discussed before, and their links with other variables are shown in Figure 6.6, below.

Fig 6.6: Path Diagram – Individual Response Time



6.7.7. Individual Learning (Action Learning)

In the interview respondents' opinion, I noted that four main variables directly affect the variable *individual learning*, which measures both social and process-related learning by individuals and groups (Bell et al., 2002). These respondents' opinion generally supports the notion that individual learning is increased by workflow automation. One of the four variables mentioned by interviewed respondents is *individual sincerity*, which is perceived to be higher in workflow automation than face-to-face teams. This is seen as likely to have increased individual learning because process related problems and personal opinions, in consequence, may

have been conveyed more frankly than in face-to-face coordination meetings.

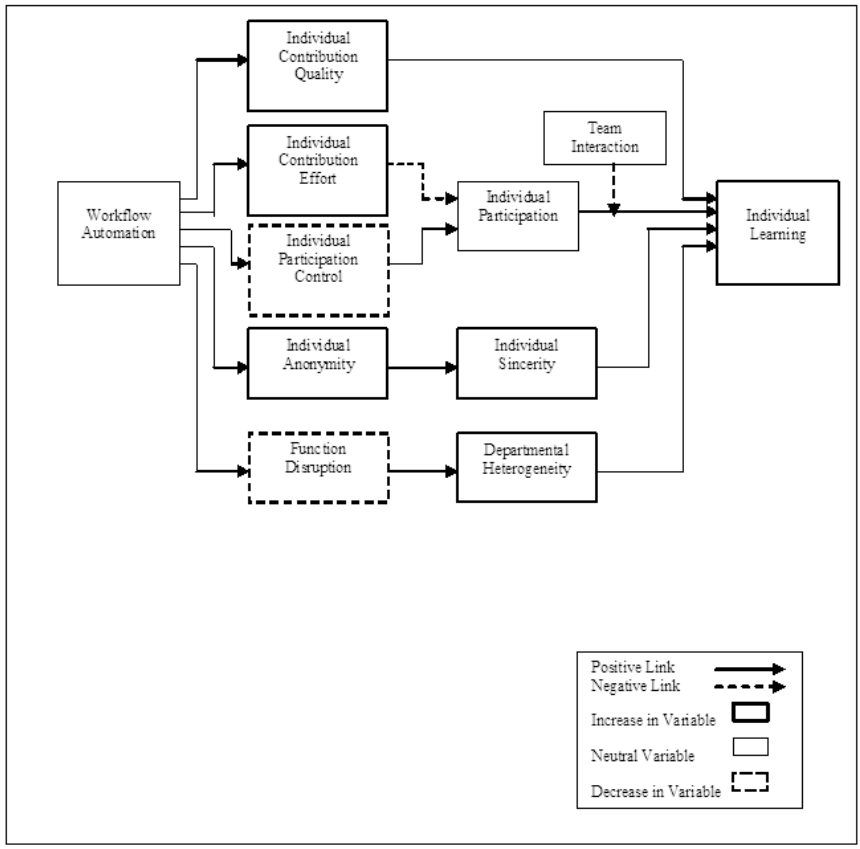
Also perceive to be increased by workflow automation is the second variable "*Individual contribution quality*". This factor may also contribute towards an increase in individual learning, as better quality contributions are likely to contain more useful knowledge and information than poor quality contributions. The third variable is *degree of interaction* which, evidence strongly suggests, is drastically decreased by workflow automation. This factor may decrease individual learning, as it is plausible to assume that an increase in *interaction* is likely to lead to an increase in the amount of knowledge and information exchanged between individuals.

The fourth variable is *departmental heterogeneity* (i.e. how heterogeneous is the workflow as far as *functional* representation is concerned), which seems to be increased by workflow automation. An increase in departmental heterogeneity in the workflow appears to lead to an increase in individual learning due to the broadening in the scope of knowledge and information communication that an increase in departmental heterogeneity appears to contribute to.

All these variables, except *individual sincerity*, have been previously discussed in this chapter. The causal links between these variables are shown in Figure 6.7, below.

The most important factor influencing the increase in the variable *individual sincerity* seems to be the increase in individual anonymity in workflow automation. This is supported by previous research, which suggests not only that workflow automation increases anonymity, but also that this leads to people conveying their ideas more frankly (Wolfe, 2001). It has been often reported, for example, that anger and frustration are much more frequently communicated in electronic group discussions - a phenomenon called *flaming.*

Fig 6.7: Path Diagram – Individual Learning



6.7.8. Cross Functional Integration

Three main factors appear to affect cross functional integration i.e. deployment of a workflow automation practice and culture throughout the organization. The first factor seems to be related to an increase in the variable *Management support*, which reflects management support for strategic performance management of supply chain. Management support is universally recognized as of paramount importance in productivity improvement projects, whether projects involve radical or incremental process change (Camp et al., 2004). Any organizational change project will meet with resistance (Hazeltine & Bull, 2003). Thus, without the support from management, particularly at the top, cross functional

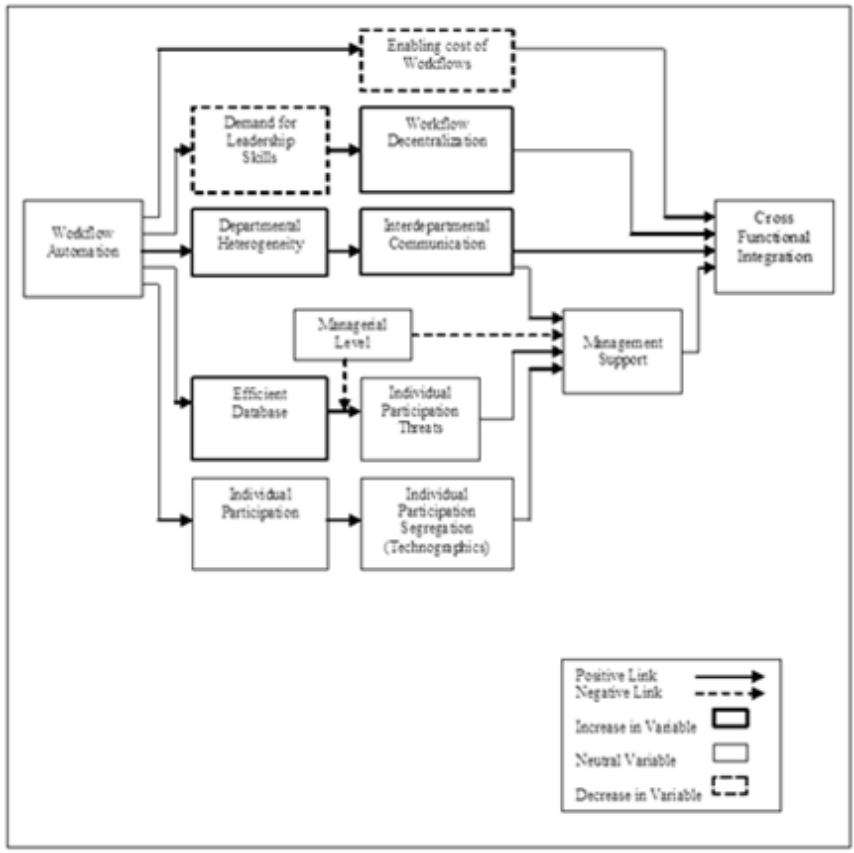
integration through workflow deployment is likely to be considerably limited.

The second factor in cross functional integration seems to be related to an increase in the variable *Workflow decentralization*, which is a measure of how well the work (i.e. customer services, coordination and expediting activities) is distributed in the organization. Sometimes management support is not enough to guarantee commitment from those who will implement the workflow or play roles in the new process as participants. As pointed out by those who defend bottom-up and top-down approaches, lack of commitment can lead to failure in the implementation of change (Shanks et al., 2003). Commitment to workflow deployment can be achieved with the decentralization of activities, as highlighted by total quality management studies (Dahlgaard et al., 2005).

The third cross functional integration factor appears to be related to an increase in the variable *Interdepartmental (Interfunctional) communication*, which is a measure of the amount of knowledge and information exchange between different departments in an organization. The importance of this factor to cross functional integration comes from the fact that workflow's organizational impact is higher when processes that cut across several functional areas or departments are implemented. That is, workflow must have enough breadth to generate organization-wide improvement (LaBonte, 2001).

This study indicates that the three factors described above are affected by workflow automation, in the context of strategic performance management of supply chain. A qualitative description of the relationship between these factors and workflow automation is depicted in Figure 6.8 below, where they are represented by the three variables *Workflow decentralization*, *Interdepartmental communication*, and *Management support.*

Fig 6.8: Path Diagram – Cross Functional Integration



The study suggests that an increase in the variable *workflow decentralization* is likely to accrue from workflow automation. The most important reason seems to be a decrease in the demand for leadership skills. In all workflows deployed, the leader is not the most senior manager in the workflow team. Moreover, two of the leaders confirmed that they had faced severe difficulties in leading face-to-face groups in the past, and that they would likely give up their leadership to more senior manager if their coordination and expediting activities were not based on workflow automation. The reduction in demand for leadership skills, combined with the considerably lower enabling cost of workflows, is likely to contribute to the growth in cross functional integration by means of workflow deployment in the organization.

Another positive factor in cross functional integration is an increase in the variable *Interdepartmental communication*. This factor is apparently caused by the higher interdepartmental heterogeneity in workflow automation. The higher interdepartmental communication, however, may lead to a decrease in the variable *management support*. This influence seems to be stronger at lower and middle management levels. Some of STS Managers at these levels seem to perceive that controlled and selective communication of information (i.e. filtering of information that flow bottom-up and top-down in the organization) as one of their most important managerial functions. The higher interdepartmental communications enabled by workflow automation may pose a threat to the maintenance of this type of function in the organization and therefore lead these managers to react to the cross functional integration workflow initiatives in a negative way. This conclusion is consistent with previous research findings on management reactions to the introduction of asynchronous computer-mediated communication systems (Bromme et al., 2005).

Three other variables, besides *interdepartmental communication*, seem to have negatively affected the variable *management support*. These variables are: *Individual participation threat, efficient database and workflow participation segregation*. Several members identified as a threat to them the fact that workflow automation enabled a more efficient record keeping of actual events and interactions. This perception seems to increase, in association with the level of management. Some senior managers, for example, refrained from using workflow automation even though they declared having monitored the workflow with interest (this was corroborated by their knowledge about the workflow content, shown in unstructured interviews). When asked why they had not been using workflow automation, they answered that they wanted "*...to know how the medium worked...*", as one senior manager put it. In another structured interview, a senior manager stated that in his opinion, neither he nor any other manager would likely send electronic messages to a whole group of people about a controversial issue. Such electronic messages, according to him, could easily be used as written evidence against their senders at a later stage (e.g. as evidence of their admission that some delays and problems have been caused by their departments).

When asked about supply chain wide impacts of large-scale workflow automation, several unstructured interview respondents, pointed out that one of the outcomes of such a project would be the segregation between those with high computer skills and those with low computer skills i.e. workflow automation is seen as likely to increase the variable

technographics. This assumption is somewhat supported by the fact that even within workflow team individuals with lower computer skills are likely to contribute less or refrain from contributing altogether.

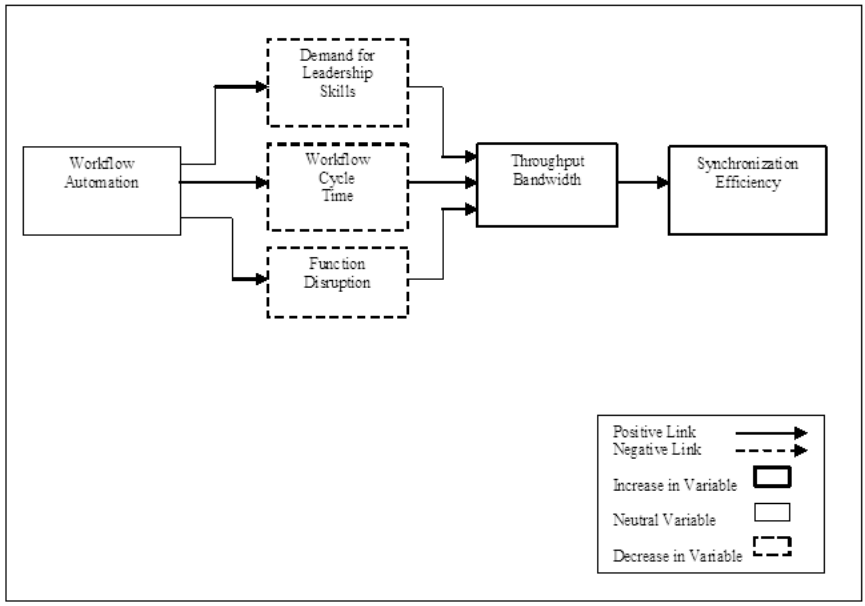
According to my data analysis, the overall impact of competing positive and negative factors on cross functional integration by means of workflow deployment is likely to lead to failure than success at STS. This is supported by factors that lead to a lack of management support. It appears that organizational workflow success would unlikely be achieved at STS without a change in the managers' perception of their role in the organization.

6.7.9. Synchronization Efficiency

The findings of this research iteration indicate an increase in supply chain performance efficiency as a result of workflow automation deployment. Two intervening variables appear to directly account for this increase – *throughput bandwidth*, which seems to be increased by workflow automation. The variable *throughput bandwidth*, in turn, seems to be directly affected by three other variables - *demand on leadership skills*, *workflow cycle time* and *function disruption* - all apparently decreased by workflow automation. These causal links are depicted in Figure 6.9, below.

The identification of the variables *throughput bandwidth* as directly affecting performance efficiency follows naturally from the definition of process productivity (Hunt, 2000) applied to the concept of collaboration. This definition focus on cycle times associated with running workflows and *throughput* capacity. *Throughput*, in turn, is linked with the "amount" of workflow that can be done per unit of time, being "number of events and interactions (i.e. concurrently)" a possible measure of this "amount" (Jia and Rajkumar, 2006).

Fig 6.9: Path Diagram – Synchronization Efficiency



The conclusion about the increase in the variable *throughput bandwidth* due to workflow automation is predominantly analytical, and follows from the primary effects of workflow automation on demand for leadership skills, workflow cycle time and function disruption. Nevertheless, one particular piece of evidence appears to provide direct support to the existence of a causal link between workflow automation and an increase in the possible number of concurrent activities per unit of time i.e. the perception by several participants that workflow automation would "enable" their respective workflows to occur, which otherwise would likely be difficult or impossible. Moreover, there are no dissenting opinions regarding this perception.

The decrease in the variable *demand for leadership skills* induced by workflow automation apparently allowed staff of relatively low status and low leadership skills (e.g. conflict resolution and coordination skills) in the organization to lead teams. This is likely to contribute to an increase in the possible number of teams per unit of time by broadening the organizational base of potential team leaders.

The decrease in the variable *workflow cycle time*, on the other hand, has a direct impact on the possible number of *throughput bandwidth* because it allows for the start and completion of more *workflows within* the same time period.

The decrease in the variable *function disruption* by workflow automation has the potential to allow for the participation of staff in workflow interactions that would normally be prevented to do so due to time constraints imposed by their respective functions in the organization. In addition, as observed in two of the workflow teams in this AR iteration, workflow automation appears to make it easier for staff to participate in more than one workflow team at a time. Not only time and physical barriers are practically eliminated, but the time spent by participants on interaction is drastically reduced.

6.7.10. Synchronization Effectiveness and Competency

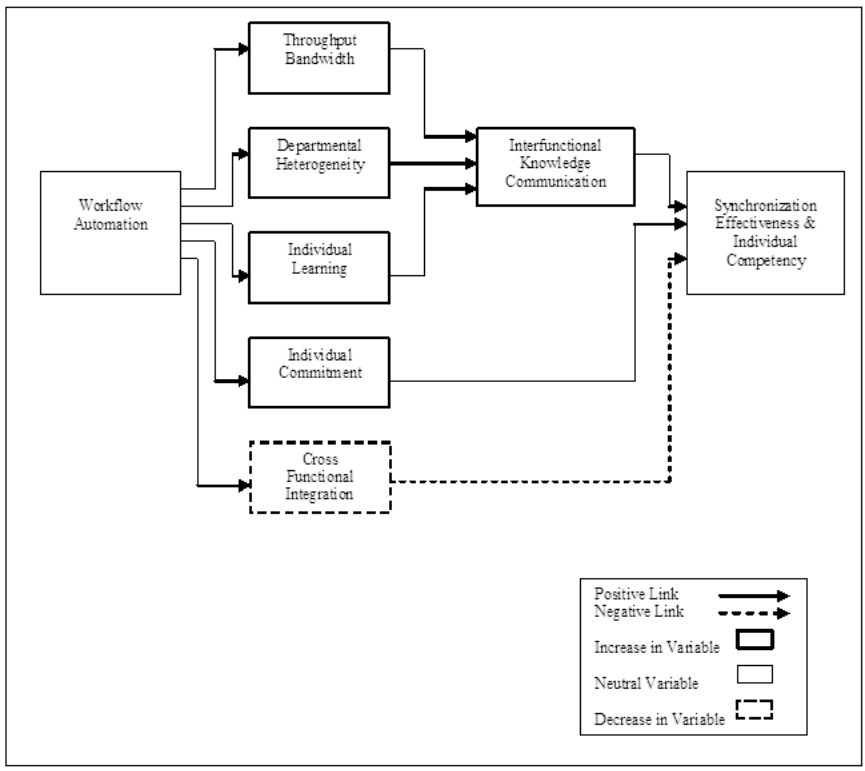
My experience in this and the two previous research iterations suggests that the benefits of workflow to an organization cannot be properly understood only by looking at direct and immediate process improvements brought about by workflow automation. There seems to be at least three types of benefits:

a) There are the direct benefits i.e. the most easily identifiable ones. These are message & response quality, synchronization efficiency, and workflow set up cost reduction. Improvements directly accruing from the deployment of workflow automation,
b) There are knowledge sharing benefits, which follow from the exchange of socio-technical knowledge i.e. knowledge about processes and social structure in the organization (Schwandt & Marquardt, 2000), that occurs during coordination and expediting problem solving workflows. These benefits result from knowledge and information sharing across intra and interdepartmental functions, which has been identified as a key factor influencing organizational competitiveness, particularly in Learning organizations (Shani & Docherty, 2003) and
c) There are organization cultures building benefits accruing from the fostering of a culture of continuous improvement, as workflow deployment is achieved throughout the organization and supply chain (Detert et al., 2000).

At this stage, ideally, these three types of benefits must be considered in the assessment of synchronization effectiveness. In this sense, even though a number of workflows may not be effective individually, the

related workflow modeling and documenting efforts may still be effective for supply chain synchronization. A single workflow model targeting core organizational processes (i.e. customer facing) may lead to drastic productivity gains that considerably improve how the organization stands among its peers and competitors. Without a culture of continuous improvement (Fairfield-Sonn, 2000), the higher competitiveness achieved may not be sustained over the long run, as the competition catches up.

Fig 6.10: Path Diagram – Synchronization effectiveness



A direct corollary of the conceptual augmentation discussed above is that the potential of workflow automation to improve *synchronization competency* of the supply chain manager as a result of the increase in inter-functional knowledge and information dissemination throughout the supply chain (Cunningham et al., 2000). This function of workflow automation in supply chain must be considered in the assessment of its effect on synchronization effectiveness. The explanatory causal model in Figure 6.10 reflects this, by proposing that organizational workflow effectiveness is directly affected by the variables *inter-functional*

knowledge communication, *individual commitment*, and *cross functional integration*.

Although the new extended perspective of the variable *synchronization effectiveness* discussed above provides a broader scope for the assessment of effects on this variable, the evidence from this research iteration does not clearly suggest either an increase or a decrease in this variable due to workflow automation. The evidence gathered during this research iteration points towards an increase in the variable *inter-functional knowledge communication* due to workflow automation. This increase appears to be caused by a simultaneous increase in three other variables as a result of workflow automation. These variables are *throughput bandwidth*, *departmental heterogeneity*, and *individual learning*. To say that there is a simultaneous increase in these three variables implies that workflow automation would potentially occur more often than similar face-to-face meetings, involving more departments (and thus probably more functions), and contribute more towards individual learning than similar face-to-face meetings. This seems to naturally suggest an increase in inter-functional knowledge communication.

In my view, the increase in individual commitment through workflow automation is likely to have a positive impact on *synchronization effectiveness* by increasing the chances that *change adoption* will be implemented. The evidence gathered in this AR iteration, however, neither provides strong support to the assumption that there is an actual increase in this variable (although a large number of respondents perceive such an increase), nor suggests that this possible increase is anywhere near drastic. I nevertheless decided to maintain *individual commitment* as an intervening variable in the causal model for completeness.

As a final remark about the causal model linking workflow automation with synchronization effectiveness, it appears that the decrease in the variable cross functional integration induced by a lack of management support in STS (see explanation in 6.7.8 above) has the potential to negatively affect synchronization effectiveness by hindering the building of a "Participative Problem Solving Culture" in the organization.

6.8. Comparison with previous iterations

As with the second iteration of the AR cycle, the findings relating the workflow automation effect on strategic performance management of supply chain summarized above covered aspects that are considerably different from those discussed in the first iteration of the AR cycle. This

is mainly due to due to the difference in the scope of the interventions. Although the organizational scope of the AR intervention is broader in this research iteration than in the second, it is still considerably narrower than in the first, i.e. only one organization is involved in this research iteration, which prevented the gathering of direct evidence regarding network-wide workflow automation effects. Nevertheless, the findings of this research iteration are generally consistent with those of the first.

One possible exception to this consistency of findings obtained across the first and this research iteration is the warning signs from this iteration indicating that cross functional integration by means of workflow deployment is ultimately hampered by lack of management support. Although consistent with findings from the second research iteration, this is contradictory with the remarkable improvement in the first iteration. A possible explanation for this contradiction, offered in Chapter 5, was the influence of support from the chief operating officer as a factor exerting a strong positive influence on cross functional integration by means of workflow deployment. Although lacking enough support, this explanation is still adopted here by exclusion i.e. I have been unable to produce any other plausible explanation based on the evidence at hand.

The findings in this research iteration are generally consistent with, and considerably refined those drawn from the second iteration. The variable *cross functional integration* warrants a special mention in this respect, as it results from a re-conceptualization of the variable *Team formation for Collaborative Workflows* (in the second iteration). This re-conceptualization leads to the identification of a number of intervening variables that are not present in the explanatory causal model generated in the second iteration.

6.9. Chapter summary and concluding remarks

This chapter reports on the third iteration of the AR cycle whereby all workflows are modeled and deployed over a period of 3 months. The client organization in this research iteration is STS, the Singapore operations of a European tool steels company.

The findings of this research iteration suggest that the workflow cycle time can be reduced by workflow automation. The main reason for the reduction in the workflow cycle time (generally seen by participants) is the reduction of set up time (i.e. the time required to bring people physically together). This factor tends to offset the negative effect that workflow automation have on individual response time, due to a higher

individual contribution effort (especially for participants lacking in computer skills) and to a lower individual participation control (i.e. it is easier for a participant not to contribute when the interaction is not face-to-face).

Demand for leadership skills seems to be lower in workflow automation than in face-to-face meetings. In workflow automation, leaders do not have to be as competent as they would have to be in face-to-face meetings in tasks such as resolving conflicts between different parties, coordinating team work, preventing the team from steering away from its initial goal, or making sure that the team follows a pre-defined protocol. The main cause for this is a decrease in individual influence and an increase in change adoption, both apparently caused by workflow automation.

There is an improvement in the quality of message and response generated by participants induced by workflow automation. This seems to result from a difference between negative and positive factors. The main negative factor associated with workflow automation is lower individual participation. The main positive factors are lower individual stress, higher site and departmental heterogeneity in the workflow, higher quality of individual member, higher team focus, and higher individual access to information relevant to the workflow activity.

Individual satisfaction does not seem to be affected by workflow automation in a decisive way. This results from a balance between positive and negative factors. The main negative factors are lower degree of interaction, higher individual response time, and lower or no personal contact. The main positive factors are lower individual stress, better distribution of individual contributions, and lower disruption of individual's routine work.

Individual commitment to workflow responses seems to increase with workflow automation. This seems to occur due to a better distribution of member contributions, and a higher change adoption, according to respondents' perceptions. These factors seem to offset the negative effect of lower individual participation caused by workflow automation.

Socio-technical learning also appears to be increased by workflow automation. This is apparently due to better quality of individual contributions and higher individual sincerity, which seems to offset the negative effect of lower degree of interaction caused by workflow automation. This study suggests that the cross functional integration by

means of workflow deployment may be hampered by lack of management support. The reasons for this at STS seemed to be:

a) Lack of management support caused mainly, by the higher perceive threats brought about by workflow automation,
b) Reduction of lower and middle management control over information flow, which leads to lack of support of workflows by these managers and
c) Segregation (technographics) of staff with low computer skills from staff with high computer skills in the organization.

These negative effects may outweigh the positive effects of higher interdepartmental communication, higher decentralization of workflow automation initiatives, and lower organizational cost of workflows that follow from workflow automation.

The findings relating the workflow automation effect on *synchronization efficiency* in this research iteration are considerably different from the ones discussed in the first iteration of the AR cycle, particularly due to the difference in the scope of the interventions and in the availability of process-related and workflow history information. Nevertheless, the findings of this research iteration are generally consistent with those of the first in pointing to an increase in organizational workflow efficiency.

There is not enough evidence, however, pointing to an increase nor decrease in *synchronization effectiveness*, which has been re-conceptualized to account not only for immediate process improvements brought about by workflow automation, but also for knowledge sharing and participative problem solving culture building benefits. In the light of this re-conceptualization, *synchronization effectiveness* is then seen as directly affected by the variables *inter-functional knowledge communication*, *individual commitment*, and *cross functional integration.*

Chapter 7: MAK Revisited

7.1. Introduction

This chapter describes the fourth iteration of the AR cycle at MAK, the same Japanese Machine Tool Company where the second iteration was conducted. The entire MAK organization is involved in this iteration, including India and China plants, in comparison with the second iteration. A total of 97 individuals including staff from 15 different suppliers' (2 are from Malaysia) and contractors of MAK participate as workflow team members in this AR iteration.

The main goal of this fourth iteration of the AR cycle, from a research perspective, is to conduct a study across all 3 units of analysis i.e. *network level (MAK as "Chain Master"), entity level (customers and suppliers of MAK) and individual level.* Only those customers and suppliers in which I have easy access to the participants are selected. Given the broader spectrum of participants and my objective is to collect as much data as possible through structured interviews - likely more than in the second and third research iteration.

Since the second AR iteration was concluded, MAK chief operating officer launched a supply chain initiative to entrench MAK as industry leader for machine tools particularly among the regional manufacturers and as the largest machine tool builder in Singapore. Shortly before this research iteration, MAK have been involved in an organization-wide strategic planning exercise. A number of process productivity and quality gaps are identified as a result of this exercise, which provides an opportunity for the deployment of workflow automation directed at performance management of supply chain at MAK.

7.2. Diagnosing

Unlike STS, which is facing difficulties as an individual organization, the chief operating officer at MAK has the objective to transform MAK into a "virtual organization". The goal from a strategic perspective is to have integration downstream to suppliers and upstream to customers. The chief operating office of MAK has a conviction that given the current consolidation-taking place in the metal tool industry and under the prevailing economic conditions, which show no indications of

improvement in the near term. The only way to survive and hopefully grow the business is through strategic performance management of the supply chain.

Having seen a successful pilot implementation of workflow automation, the chief operating officer of MAK approves the supply chain wide deployment of workflow automation. Once completed, the new channel of communication and interaction will speed up change adoption, quicker turnaround time for reaction to changes in plans and schedules both within and outside of MAK, increase the throughput bandwidth i.e. allow the same people to accomplish more in terms of productivity given the current temporal constraints.

Due to the long production lead times, there is a need at MAK, to enable tracking of the history of all events and interactions, from order confirmation right up till delivery. These records are necessary when customers request for service on parts that have been purchase from 3rd party and used in assembly of the finished products (i.e. parts still under warranty). Also, in order to keep MAK ISO 9000 and QS 9000 standards certification. MAK requires compliance to these standards during administrative and production activities. Historical records of all such events and interactions are to be kept for audit purposes.

7.3. Action Planning

The first step taken by the chief operating officer of MAK is to form the Collaborative Supply Chain Execution (CSCE) Team. This team comprises of mainly the key users and department managers. One manager (Sales) is appointed to the CSCE team from MAK site in India and another manager (Planning) is appointed to the CSCE team from MAK site in China.

The respective General Managers represented the 15 suppliers and contractors, mainly small and medium enterprise (SME) in the CSCE team. Of these 15 suppliers and contractors, 2 of these managers are from Malaysia. The chief operating officer made the decision to include these 2 suppliers in the team, despite the distance (approximately 4 hrs drive to each supplier), as they are key suppliers of MAK.

The CSCE team, a total of 25 people, comprises the workflow virtual team. The CSCE team members are to act as workflow team leaders for their respective workflows to be modeled and deployed with their direct participation. Further, as workflow team leaders, this CSCE team

members, are to act as representative of their functional departments and sites during the modeling phases of the workflows. The CSCE team members are to be trained on a “Train the Trainer” workshop. After a 3-day workshop on Workflow and Business Process Modeling, team members will organize and initiate the workflow team activities. The main criterion for selection to the CSCE team is not seniority in the management but rather process knowledge and “hands-on” job experience.

The project is to be executed in 2 phases. Phase I comprises of 3 days workshop followed by the selection and modeling of events into workflows. Phase II will be the deployment of the workflows (i.e. production run). A roadmap of all the activities and a schedule will be prepared in detail for Phase I and II.

7.4. Action Taking

The CSCE team is formed at the project kick-off meeting. Based on past experience Ms. Emily, VP of Planning is appointed Project Manager. The CSCE team selects all four events and interactions of MAK, related to performance management of supply chains (please refer to Appendix: A). The 4 main events are:

a) Customer Order Processing,
b) Production Planning,
c) Purchasing and
d) Shipping

As Project Manager, reporting directly to the chief operating officer, Ms. Emily presents the project roadmap and the schedule for Phase I and II to senior management at MAK. She also announces the planned 3-day workshop date and location. This announcement is received with some enthusiasm, by the participants. After the 3-day workshop, she selects the prospective candidates to lead the workflow teams and take ownership for the workflows deployment. See Table 7.1. Below, during the assessment stage, the events selected are map as detailed workflow models using the Frontstep BPM (Business Process Modeling) software. These models are then returned to the workflow teams as attachment to messages.

After the modeling phase I is completed (3 months), the project moves on to phase II i.e. workflow deployment. During this phase, with a few exceptions, all activities are performed with workflow automation. All

orders, change request and response from/to the customer i.e. 7,125 in total are recorder in the workflow database.

Table 7.1: Events Summary Table

Event ID	No. of Different Workflows	No. of Users	Mean Cycle Time (hrs)	No. of Sites	No. of Departments	No. of Workflow Messages	No. of Oral Contacts
MAK.E1 (Sales)	107	28	24	2	3	1,875	500
MAK.E2 (Planning)	132	31	42	1	2	1,206	300
MAK.E3 (Purchasing)	255	31	21	15	9	2,913	1,250
MAK.E4 (Shipping)	98	15	30	1	2	1,131	370

7.5. Evaluating

Seven dependent variables are identified in this iteration - the same dependent variables that have been identified in the previous iteration. Three dependent variables are related to the entity unit of analysis namely: *workflow cycle time, demand for leadership skills and cross functional integration.* Another three variables are related to the individual unit of analysis namely: *individual satisfaction, individual commitment and individual learning (i.e. action learning).* The one remaining variable is related to the network unit of analysis namely: *message & response quality*.

7.5.1. Workflow Cycle Time

In this research iteration I did not ask respondents, structured interview questions about the perceive effects of workflow automation on *workflow cycle time*. Instead I look for indirect evidence of this effect in responses to other questions and direct evidence from the analysis of workflow transcripts.

One piece of indirect evidence of the effect of workflow automation on *workflow cycle time* comes from the analysis of responses regarding change adoption. This analysis indicates that approximately 69 per cent of the respondents thought that workflow automation increased change adoption (see Table 7.2, below). The relevant part of this analysis regarding the effect on workflow cycle time refers to the cause assigned by the overwhelming majority of these respondents to the effect; an

increase in *team focus*. Most respondents perceive an increase in team focus as inherent to the workflow automation. The association of this perception with an effect of workflow automation on coordination appears to be mostly due to the fact that team participants tend naturally to use workflow automation for most of their interactions (as indicated in Table 7.1).

Among those who thought that workflow automation decreased change adoption, the main perceive cause is a decrease in the team leader's ability to influence the workflow team, which I believe reflects a decrease in individual influence in general.

Table 7.2: Effects on Change Adoption

Answer	Frequency	Percentage (%)
Decrease	15	15.4
Increase	67	69.1
Had No Effect	10	10.3
Do Not Know	5	5.1
Total No. of Respondents	97	

A few unstructured interview respondents pointed out that a decrease in team interaction (turn-taking) will be a likely result of workflow automation and that this causes a decrease in *workflow cycle time*. According to these respondents a high degree of interaction would have a clear impact on *team focus*, decreasing it (team focus) considerably, and in turn likely increasing the total workflow cycle time. I am not able to find a strong inverse correlation between *workflow cycle time* and *team interaction*, measured as number of workflows or individuals involved

Table 7.3: Mean Workflow Cycle Times

Event ID	Mean Cycle Time w/o Workflow (hrs)	Mean Cycle Time with Workflow (hrs)	Difference Percentage (%)
MAK.E1 (Sales)	60	24	60
MAK.E2 (Planning)	56	42	25
MAK.E3 (Purchasing)	72	21	71
MAK.E4 (Shipping)	36	30	17

This research focus is strategic performance management of supply chain and therefore *workflow cycle time* (refer to Table 7.3, above) is seen as

taking precedence over individual response time. Therefore workflow cycle time is more significant in the discussion of workflow automation effects on one of the main research variables i.e. synchronization efficiency.

I also directly asked respondents, structured interview questions, about their perception of the workflow automation effect on *degree of interaction*. The analysis of the responses indicates that approximately 73 per cent of the respondents are of the opinion that workflow automation decrease degree of interaction (see Table 7.4). The respondents for this effect gave two main explanations with approximately the same frequency each. The first is that workflow automation decrease individual participation control, and therefore the ability of the leader to elicit responses from individuals within a given time. This leads, according to a number of respondents, to an increase in individual response time (turn-taking). The second is that workflow automation leads to a higher focus of the individuals on fewer issues, which in turn leads members to contribute fewer and longer messages.

Table 7.4: Effects on Degree of Interaction

Answer	Frequency	Percentage (%)
Decrease	71	73.1
Increase	18	18.5
Had No Effect	6	6.1
Do Not Know	2	2.1
Total No. of Respondents	97	

The main explanation provided by the minority of respondents who thought that workflow automation increases the degree of interaction is that timid people would participate more due to a reduction in individual contribution stress.

Another body of indirect evidence of an effect that can be related to the variable *workflow cycle time* is gather during unstructured interviews, participant observation, and the probing of answers in some structured interviews. This effect is the one on *individual contribution effort*. It appears that it is more time consuming for participants to contribute in written form electronically than it is to contribute orally.

Moreover, evidence suggests that this hindering effect is relatively drastic. A respondent who perceive her participation in the workflow team as being reduced by workflow automation explained why this

happened: *"… participation for me personally...probably a bit less, because I find writing, much more difficult. I have to think more carefully about what I'm going to say, how I am going to say it, because of the broader spectrum of audience, whereas in a face-to-face meeting it's probably easier to express my views more spontaneously…"* This quote, as some others gathered from unstructured interviews, suggests not only that contribution through workflow automation is challenging, but also that there is a perceive need to prepare the contribution more carefully than in face-to-face meetings.

I believe that writing skills (grammar and language) can be seen as one of the elements of the more general variable *individual computer skills.* Therefore I will consider the perception of this respondent as being related to this general variable in our explanation building process. However, this general negative effect of workflow automation on individual contribution effort, irrespective of individual computer skills, called for further evaluation.

Qualitative evaluation of individual contribution effort in a face-to-face meeting reveals that verbal (language and expression) deficiencies can be compensated by non-verbal cues i.e. hand gestures, facial expression, and so on. Also, the immediate feedback of message from recipients allows for immediate corrective action. An average person can speak at approximately 200 words per minute (Davis, 2002). This is a lot faster than, having the same number of words in writing. An average person can reach typing speeds of up to 90 words per minute. However, it is not only the typing speeds that contribute to the increase in effort. It is the message construct i.e. grammatically and otherwise. Content of the message have to be situated in the context, to eliminate any possibility of misinterpretation due to the asynchronous mode of communication introduced by workflow automation. Further, non-verbal cues have to be replaced by attachments of pictures, diagrams, word documents, and so on, to compensate for any loss in emphasis.

7.5.2. Demand for Leadership Skills

As with workflow cycle time, I did not directly ask structured interview respondents about perceive effects of workflow automation on *Demand for leadership skills*. I instead looked for indirect evidence of this effect from responses to other questions and direct evidence from the analysis of workgroup transcripts.

One of the perceive effects of workflow automation likely to be linked with demand for leadership skills is social cues suppression i.e. the suppression of predominantly non-verbal cues about the social and organizational status of certain members, which may lead members to feel a certain sense of "anonymity" as linked with workflow contributions. To some extent this is supported by structured interview respondents' perceptions about the effect of workflow automation on social cues suppression.

These perceptions are summarized in Table 7.5. Approximately 79 per cent of the respondents perceive social cues suppression as having been increased by workflow automation. On the other hand, approximately 21 per cent saw workflow automation as having no effect on social (non-verbal) cues suppression, arguing that not only they knew the other participants before the workflow team was formed, but also that they could see the sender's name in each of the workflow messages.

Table 7.5: Effects on Social Cue Suppression

Answer	Frequency	Percentage (%)
Decrease	0	0
Increase	77	79.3
Had No Effect	20	20.6
Do Not Know	0	0
Total No. of Respondents	97	

The main explanation given by the respondents who perceive workflow automation as suppressing social cues is the lack of co-presence with other team participants, which typically lead them to read and reply to messages without much consideration about who contributed them. As one of these respondents pointed out; *"Once something has been put in writing it often becomes more anonymous. Some people can use their writing as a front for what they really think, whereas they can't disguise that quite so readily in a face-to-face meeting where the strong negative cues are there, non-verbal cues that they put into the setting ... when their objections are strong you can see the body language"*.

All four workflow team leaders reported social cues suppression as an important workflow automation factor in easing the demand for leadership skills. From the analysis of their statements, it is apparent that this perception relates to the more general perception that the influence that individual can exert on the team is decreased by workflow automation due to what could be seen as a contribution "weight" leveling

effect. This appears to be seen as reducing the amount of stress experience by workflow team leaders and making them feel more relaxed about coordination in a rational and non-personalized manner. The following quote from a workflow team leader, referring to two of her bosses who are also participants of her workflow, illustrates this point; *"Normally if I am in a (face-to-face) situation and with another participant, who is my boss, his opinion counts over mine, when I'm sitting in the same room ... on workflow I feel just as equal - I don't feel that he can influence me or that his opinion will be more important than mine"*.

An analysis of structured interview respondents' perceptions shows that approximately 74 percent of the respondents are of the opinion that workflow automation decrease the influence that individual have on their workflows (see Table 7.6). Respondents indicate that the two main causes of this effect are the *sense of anonymity* fostered by workflow automation and the *lower control over individual participation* in workflow.

Table 7.6: Effects on Individual Influence

Answer	Frequency	Percentage (%)
Decrease	72	74.2
Increase	5	5.1
Had No Effect	18	18.5
Do Not Know	2	2.1
Total No. of Respondents	97	

Conversely, a small percentage of the respondents (about 5 per cent), believe that workflow automation increase the influence of individuals on workflow because, as one of these respondents quite reasonably put it, "*usually there will be a person who states the points clearly (i.e. the manager) and the rest will just response*".

The quote above suggests an interesting question: If individual influence is really reduced by workflow automation, *how can it be easier for a workflow team leader to control the workflow proceedings?* Even though leaders perceive as easier to lead workflow teams than similar face-to face meetings, the analysis of workgroup transcripts of at least one team suggests clearly that this may not be the case. These apparent contradictory outcomes are addressed in the *specifying learning* section of this chapter.

7.5.3. Message and Response Quality

Approximately 65 per cent of the respondents are of the opinion that the quality of message and response has been increased by workflow automation, whereas about 20 per cent of the respondents felt that workflow automation has no effect on this attribute. Conversely, 10 per cent of the respondents thought that workflow automation have decreased the quality of message and response (see Table 7.7, below).

According to the respondents, the two main reasons for the perceive increase in message and response quality are an increase in *individual contribution quality* and *departmental (functional) heterogeneity*. The increase in departmental heterogeneity is perceived as being fostered by workflow automation i.e. lowering the barriers posed by function disruption resulting from coordination and expediting activities. The increase in individual contribution quality, on the other hand, is seen as inherent to the written (multi-media to a lesser extend) communication medium provided by the workflow automation. The following quote from structured interview responses illustrate this perception: *"You think more when you're writing something, so you produce a better quality contribution...but just the longer elapsed time and the opportunity to refine them that would not have been available in a face-to-face situation ... (there is more) time for reflection. Plus, contributions are written down that is the contributions are more clearly articulated than if they are verbally expressed"*.

Table 7.7: Effects on Message & Response Quality

Answer	Frequency	Percentage (%)
Decrease	10	10.3
Increase	63	64.9
Had No Effect	20	20.6
Do Not Know	4	4.1
Total No. of Respondents	97	

There is a majority consensus among the respondents who thought that workflow automation has decrease message and response quality (about 10 per cent) that this decrease has been caused by the lack of immediate feedback and the ambiguity fostered by the workflow automation. One of these respondents, for example, stated that: "*…things are left hanging because with messages sent to people…different people can conclude different things from the same message. At the end of the day, I think, you should have a face-to-face meeting not to leave things hanging*".

I decide to use *equivocality* (Miller, 2005) in this AR iteration to collectively refer to the delay in feedback and higher ambiguity effects observe as a result of asynchronous mode of communication introduce by workflow automation. Equivocality is seen as predominantly a workflow message attribute, hence I decide to assess and discuss it through a new variable added to the research framework in this AR iteration - *message equivocality*. This is done in the *specifying learning* section of this chapter.

7.5.4. Individual Satisfaction

Approximately 40 per cent of the structured interview respondents are of the opinion that workflow automation increased their satisfaction from participating in their workflow teams (See Table 7.8, below). The most frequent explanation given by these respondents for this increase is a corresponding decrease in function disruption. A second explanation, which is directly related to the first, is the increase in departmental heterogeneity fostered by the workflow automation, which according to a number of respondents allowed them to (quote from unstructured interview notes) "... *get inputs from different points of views*..." This has apparently lead some staff to perceive workflow automation as increasing their social contact with others, even though the workflow automation is seen as (quote from unstructured interview notes) "... *less personal...*"

Conversely, about 30 per cent of the structured interview respondents' perceive workflow automation as having decreased their personal satisfaction from participating in their workflow teams. The two most frequent explanations for this negative effect are lack of personal contact and decreased individual influence.

Several respondents see "personal contact" as strongly linked to "co-presence". Some participants with a predominantly Asian background, felt that it is "very important" during a meeting to observe facial expressions as well the body language (non-verbal). One of these members who came from a Chinese background pointed out that: "…*we seldom use written communication in the Chinese culture. If we want to get things done or negotiate something we always sit together…*"

The respondents who reported a decrease in individual influence due to workflow automation shared a common characteristic regarding their relative position in the organizational hierarchy: they are all senior staff at MAK.

Table 7.8: Effects on Individual Satisfaction

Answer	Frequency	Percentage (%)
Decrease	30	30.9
Increase	39	40.2
Had No Effect	20	20.6
Do Not Know	8	8.2
Total No. of Respondents	97	

7.5.5. Individual Commitment

Approximately 44 per cent of the respondents are of the opinion that workflow automation lead to a higher commitment of both themselves and other participants in their workflows to response quality (see Table 7.9, below). The three most frequent explanations given by the respondents for this is an increase in departmental heterogeneity, an increase in team contribution distribution, and the fact that whatever they contributed to the workflow as participants is perceive as likely to become a written record. Several respondents pointed out that this perception is closely linked to the workflow automation being seen as enabling a more efficient record keeping of the supply chain performance.

An increase in workflow departmental heterogeneity is seen as having increased individual commitment because this is seen as having fostered the involvement of most of the individuals of the process (i.e. those who performed functions in the process). A workflow team leader, for example, pointed out that: *"... by targeting the people that I spoke to, such as (names removed), we have people that are in key places who could act as change agents on our behalf"*.

Table 7.9: Effects on Individual Commitment

Answer	Frequency	Percentage (%)
Decrease	22	22.6
Increase	43	44.3
Had No Effect	26	26.8
Do Not Know	6	5.8
Total No. of Respondents	97	

When asked directly for their perceptions about the effect of workflow automation on Functional (departmental) heterogeneity, approximately 82 per cent of the respondents are of the opinion that workflow automation

leads to an increase in this variable in their workflows (see Table 7.10, below). A lower individual function disruption is the overwhelming majority reason for this effect.

Table 7.10: Effects on Functional Heterogeneity

Answer	Frequency	Percentage (%)
Decrease	7	7.2
Increase	80	82.4
Had No Effect	6	6.1
Do Not Know	4	4.1
Total No. of Respondents	97	

Only about 7.2 per cent (7 respondents) felt that workflow automation has decreased workflow departmental heterogeneity. The explanation given by these respondents is an interesting and plausible one. According to them even though workflow automation is "perceive" as increasing the number of departments represented in the workflow, it allows for the inclusion of individuals that would not otherwise be consider as participation because of sheer lack of interest *(for your info only)*. These individuals are, according to these respondents, likely to refrain from actively participating in the workflows, and in turn decrease the "actual" workflow departmental heterogeneity.

An increase in team contribution distribution is seen as associated with individual contribution “weightage” equalization, which made some individuals feel that their "voices" have been "heard". This, in turn, leads several members to feel more committed to the outcomes of their workflows. This feeling is reinforced by the perception of some respondents that, whatever they committed themselves to in writing is more formal than if they have done that just verbally, therefore leading to an increase in their commitment to the workflows proceedings.

7.5.6. Individual Learning (Action Learning)

Approximately 53 per cent (refer to Table 7.11, below) of the structured interview respondents thought that workflow automation have increased individual learning.

Table 7.11: Effects on Individual Learning

Answer	Frequency	Percentage (%)
Decrease	22	22.6
Increase	51	52.5
Had No Effect	24	24.7
Do Not Know	0	0
Total No. of Respondents	97	

These respondents presented three main reasons:

a) *An increase in departmental heterogeneity, which in turn allowed members to draw on a broader knowledge and information base,*
b) *An increase in individual sincerity, fostered by a sense of insulation and anonymity when contributing to workflows, which leads to individuals revealing more about what they knew and could be done and*
c) *An increase in individual contribution quality*

Conversely, about 23 per cent of the respondents perceive individual learning as being decreased by workflow automation. There are two main explanations given by respondents for this effect. One of them is a decrease in *degree of interaction*, which is seen as a consequence of having contributed to a decrease in the amount of knowledge and information exchanged between individuals. The other explanation is an increase in the perceive likelihood of negative personal repercussions accruing from "revealing too much", which leads workflow participants to avoid including in their postings "anything" that could be "damaging" to their future careers. This is supported by the analysis of structured interview responses to a question designed to directly address the issue of workflow automation impacts on perceive personal repercussions likely to accrue from an individual's participation in a workflow (referred to here as individual contribution threats).

This analysis is summarized in Table 7.12, below. Half of the structured interview respondents perceive individual contribution threats as increasing because of the workflow automation. There are two main reasons suggested by the respondents for this effect. One of them is an increase in record keeping *(workflow database)* efficiency, which allows messages to be easily stored, as well as printed out and used against their originators. The other main reason is that sincerity could be misunderstood as bluntness, which is apparently related to the suppression of non-verbal cues.

The quote below of a question and respective answer from one of the interview transcripts illustrates the perception that sincerity can be misunderstood as bluntness in workflow automation, if these are not carefully prepared:
Question: Do you think that writing is more time consuming than making a verbal proposal during coordination or expediting?
Answer: Yes it is more time consuming, because I don't want to come across as being harsh or blunt. Sometimes you think, "I don't agree with that", but to state that without coming across, as being blunt or negative is very difficult. It's hard to word things...

A few respondents also pointed out that harshness is felt deeper and longer in workflow automation, than in face-to-face meetings. One of the workflow team leaders, for example, made the following comment regarding a message from an individual of her workflow team, which she considered particularly insulting: *"…in this instance, where I felt quite put off and quite insulted (the workflow messages) makes it a lot worse because there it is in writing. It is right out there and everybody can see it, and I didn't have the ability to say "get off your high horse, this can't be serious".*

Table 7.12: Effects on Contribution Threats

Answer	Frequency	Percentage (%)
Decrease	17	17.5
Increase	49	50.5
Had No Effect	26	26.8
Do Not Know	5	5.1
Total No. of Respondents	97	

7.5.7. Cross Functional Integration

In this AR iteration I try to study the participants' perception about the impact of workflow automation on the likelihood of diffusion of workflow within the organization by asking two questions. The first question related the impact on the success of a full-blown workflow automation initiative, described as a hypothetical project in which all business interactions and transactions will be executed. The second question related a seemingly critical variable for cross functional integration by means of workflow deployment identified in the third research iteration i.e. *management support*, which refers to the support given by managers.

Approximately 77 per cent of the structured interview respondents are of the opinion that workflow automation would have increased the success of a full-blown workflow automation initiative (see Table 7.13, below). One main cause is given by the respondents to account for this effect i.e. a decrease in function disruption. This will enable workflows to be conducted, as well as allow for a higher departmental heterogeneity in the workflows.

Table 7.13: Effects on Cross Functional Integration

Answer	Frequency	Percentage (%)
Decrease	12	12.3
Increase	75	77.3
Had No Effect	2	2.1
Do Not Know	8	8.2
Total No. of Respondents	97	

Conversely, about 12 per cent of the structured interview respondents thought that workflow automation would have decreased the likelihood of success of a full blown workflow automation initiative. Three main explanations are given by respondents for this perception; *a) a decrease in individual participation control, b) an increase in individual contribution effort, and c) a decrease in personal contact,* all leading in turn to a decrease in individual participation. This picture is very similar to the one, which emerged from the analysis of the distribution of responses in structured interviews when respondents are directly asked about the workflow automation effect on their individual participation in their workflows.

Approximately 48 per cent of the structured interview respondents are of the opinion that workflow automation has decreased their individual participation in their workflows (see Table 7.14, below). A decrease in individual participation control and an increase in individual contribution effort are the most frequent explanations given by the respondents to account for this effect. Conversely, about 43 per cent of the respondents' of structured interview perceive workflow automation as having increased their individual participation. According to these respondents, the main cause is a decrease in function disruption.

Table 7.14: Effects on Individual Participation

Answer	Frequency	Percentage (%)
Decrease	47	48.4
Increase	42	43.2
Had No Effect	6	6.1
Do Not Know	2	2.1
Total No. of Respondents	97	

Approximately 40 per cent of the structured interview respondents' perceive workflow automation as having increased management support for workflows (see Table 7.15, below). The most frequent reason is that managers would be able to take part in the workflows, even if only as "lurkers", and therefore feel more committed towards workflow deployment success. According to these respondents, this would also foster support from managers for future workflow initiatives. Most of these respondents, however, noted that only "democratic" managers i.e. those who are open to participative management approaches would have this type of reaction.

Table 7.15: Effects on Management Support

Answer	Frequency	Percentage (%)
Decrease	10	10.3
Increase	39	40.2
Had No Effect	25	25.7
Do Not Know	23	23.7
Total No. of Respondents	97	

Other reasons given by some respondents to account for the increase in management support is an increase in departmental heterogeneity and the perception that workflow automation lends more formality to the discussion. An increase in formality is seen by these respondents as likely to meet with a positive reaction from managers in general.

A relatively small proportion of structured interview respondents' perceive workflow automation as having decreased management support. The main reason given by these respondents for this is a decrease in *individual participation* that leads to a decrease in cross functional integration by means of workflow deployment. This decrease in individual participation will have a strong negative impact on management support for both decisions made by workflow team and the formation of future teams.

7.6. Research iteration impact on the organization

Approximately one month after the last workflow is deployed; the researcher conducts several unstructured interviews with workflow team leaders and participants of the workflows, as well as with managers at various levels, the heads of the departments, suppliers and contractors involved in this AR iteration. Although coordination outcomes are seen as generally positive by the department heads, it is obvious that a larger number of workflows will be necessary to come up with supply chain wide coordination improvements that would make a strong impression. According to one of these managers, the workflows are "*... a very efficient tool to generate incremental process (e.g. coordination) improvements...*"

Three of the workflow team leaders are very positive about the accomplishments of their workflows, which according to them leads to moderate gains in process quality and drastic gains in productivity. Moreover, these team leaders see their workflows as having benefited the organization by fostering an increase in the amount of process-related knowledge and information exchanged between staff in different departments, particularly while the workflows are being deployed i.e. this effect is seen as having gradually waned after the workflows become operational.

Conversely, one workflow team leader (shipment) is unable to notice any real coordination improvement as a result of the workflows, which leads him to a certain sense of frustration. The team leader, however, seems to view the impact of workflow automation as generally positive. He assigned the lack of success to the nature of the events and interactions targeted by the shipment workflows. He is of the opinion that the shipment coordination workflow would have had similar or worse outcomes had they been conducted through face-to-face meetings.

Some managers noted that the work conducted along this AR iteration have contributed towards the dissemination of a CSCE "culture" within MAK, particularly in the areas staffed by workflow team leaders. One manager, who has been previously, a workflow team leader, declares having incorporated "workflows automation for expense claims and leave applications".

7.7. Specifying Learning

In accordance to the data analysis process described in Chapter 3, the results of the evaluation stage leads to the generation of causal models incorporating relationships between variables. The main independent variable in these models, as in the previous AR iterations, is *workflow automation*. The dependent variables in the causal models are the ones described in the evaluation stage, plus the anchor variables *synchronization effectiveness*, *synchronization efficiency and synchronization competency*.

The remaining research variables in the initial research framework are either discarded, or incorporated in the causal models as intervening or moderating variables together with new variables identified during data analysis. These causal models are discussed next.

7.7.1. Workflow Cycle Time

The variable *workflow cycle time* seems to be directly affected by three other variables: *degree of interaction*, *individual response time*, and *workflow set- up time* (see Fig. 7.1 below). A decrease in *degree of interaction* can be seen as having contributed to a decrease in *workflow cycle time and function disruption* is seen as accounting for a large decrease in workflow cycle time as in comparison to face-to-face coordination and expediting meetings. The same seems to be true for *workflow set- up time.*

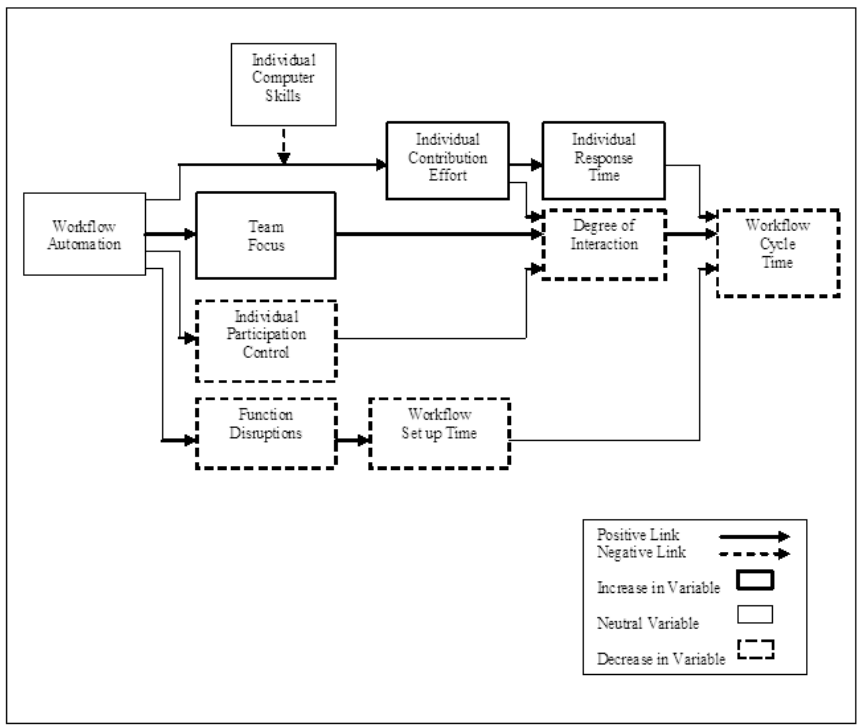
On the other hand, it appears plausible to assume that an increase in individual response time contributed to an increase in *workflow cycle time*. I still believe, particularly based on past experience facilitating face-to-face meetings, that workflow automation effects on *workflow set- up time* and *degree of interaction* has probably offset the effect on *individual response time* in the workflows in this AR iteration, having consequently led to a reduction in *workflow cycle time*.

The analysis of interview responses indicated a majority perception that the variable *degree of interaction* is decreased by workflow automation. This perception is strongly supported by the analysis of workflow messages and responses transcripts, which suggests that this decrease is a drastic one.

An increase in the variables *team focus* and *individual contribution effort*, as well as a decrease in the variable *individual participation control*;

seems to be plausible explanations for this effect, as they are widely supported by interview respondents' perceptions. A decrease in the variable *workflow set up time* is widely supported by a number of comments of interview respondents associating it with one of the most widely felt effects of workflow automation in the context of coordination and expediting - a decrease in *function disruption*.

Fig 7.1: Path Diagram – Workflow Cycle Time



Moreover, the decrease in *workflow set up time* is supported by the perceptions of most workflow team leaders and participants, stated in unstructured interviews, that their workflows are started remarkably quickly when compared with similar face-to-face meetings in which they have participated in the past.

There is strong evidence from the data analysis of workflows messages and responses transcripts that the variable *individual response time* has been considerably increased by workflow automation. The main explanation for this increase is an increase in individual contribution effort fostered by workflow automation, which often leads participants to

postpone their contributions until they have a considerable amount of free time to produce and post a reply to the workflows. This effect seems to have been moderated by the variable *individual computer skills*, as some individuals who saw themselves as slow learners or less able to use some features of the computer based workflow system (e.g. message editing) were less likely to promptly reply to the workflows.

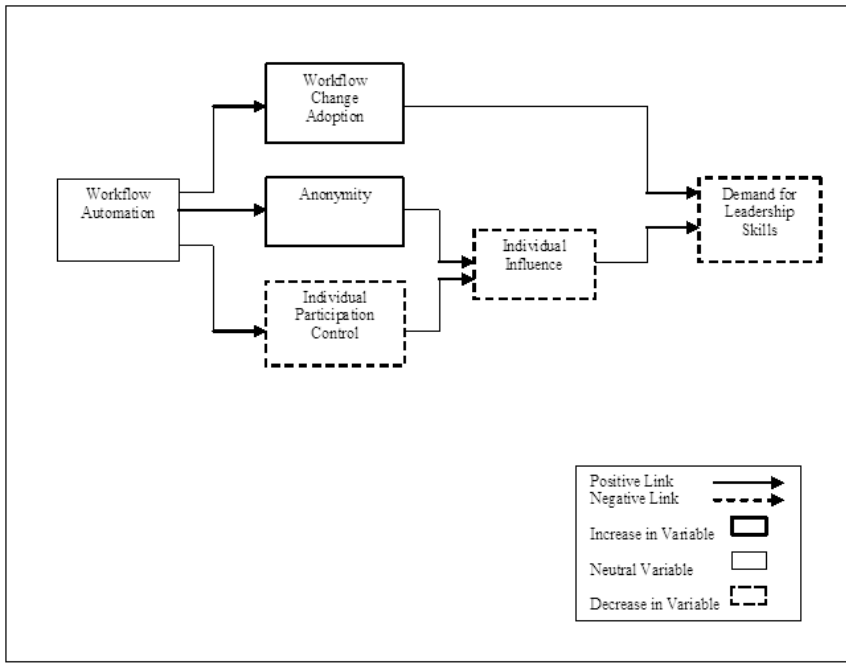
7.7.2. Demand for Leadership Skills

The variable *demand for leadership skills* seems to have been decreased by workflow automation, an effect that appears to be intervened by two other variables, namely *individual influence* and *workflow change adoption* (see Fig 7.2, below). A decrease in individual influence seems to have contributed towards decreasing demand for leadership skills, as team leaders did not have to try to prevent dominance of some members and equalize the contributions from participants in their workflows. An increase in team change adoption also appears to have contributed towards decreasing demand for leadership skills, as leaders did not have to constantly steer their teams along with the workflows.

Frequency analysis of interview perceptions suggests a majority perception that workflow automation fostered an increase in the variable *workflow change adoption*. This effect is illustrated in the causal model as a direct one as most respondents pointed out that it is inherent to the digital medium, rather than linked to any intervening variable. Most of the interview respondents perceive a decrease in the variable *individual influence*, identifying an increase in the variable *anonymity* and a decrease in the variable *individual participation control* as the main reasons for this effect.

However, if individual influence is really decreased, then it is reasonable to assume that the team leader's influence on the workflow will also be decreased. Would not this make it more difficult for the team leader to manage the workflows? Apparently the answer is yes, if the leader tries to exert a high degree of control on the team. Not if the leader focuses on summarizing contributions and providing relevant process-related knowledge and information to the team participants i.e. according to CSCE protocol, what the workflow team leader should really concentrate on.

Fig 7.2: Path Diagram – Demand for Leadership Skills

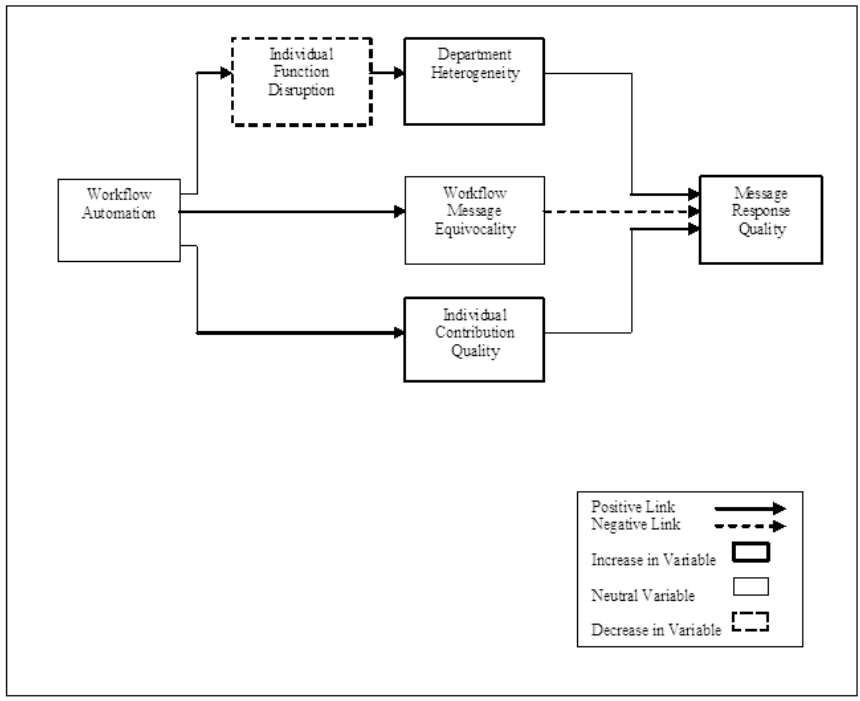


7.7.3. Message and Response Quality

There is enough evidence pointing to an increase in the variable *message and response quality*. The majority perception is that this variable has not been decreased by workflow automation. According to interviewees' perceptions, *message and response quality* is directly influenced by three other variables, namely *departmental heterogeneity*, *message equivocality* and *individual contribution quality*.

Causal links between these variables are shown in Figure 7.3, below. Increases in *departmental heterogeneity* and *individual contribution quality* are seen as having fostered an increase in response quality. Conversely, an increase in workflow message equivocality is seen as having contributed towards a decrease in response quality.

Fig 7.3: Path Diagram – Message and Response Quality



The variable *departmental heterogeneity* is seen by most of the interview respondents as having been increased, the main explanation given by these respondents being a decrease in function disruption cause by workflow automation. That is, the lower disruption of individuals' production activities (associated with their functions, hence the term "*Individual function disruption*") allow members from a wider range of different departments to take part in the same workflow, without having to worry about stopping their activities to attend face-to-face meetings.

The variable *message equivocality* is seen as having been increased by workflow automation due to the inherent higher equivocality of the digital medium i.e. selected for workflows as the main mode of interaction. This perception is to some extent consistent with a theory of media adoption known as media richness theory (Lievrouw & Livingstone, 2002), which assigns a lack of immediate feedback and non-verbal cues as the main reasons for higher equivocality.

Interestingly, the clear perception by a number of interview respondents that the variable

Message and response quality is increased by workflow automation seems at odds with the perception that *message equivocality* is also increased. Should a more equivocal medium, such as workflow automation, lead to a perception of decrease in the quality of contributions? Actually not, if one considers that team members can "adapt" to this situation, by trying to compensate a higher medium equivocality with more carefully prepared contributions. This adaptive behavior, which seems to have occurred in the workflows conducted in this AR iteration, is consistent with behavior observed in previous studies (Anderson, 2003) and with predictions of a theory of media adoption known as adaptive structuration theory (May & Mumby, 2004).

7.7.4. Individual Satisfaction

There is no majority opinion as to whether workflow automation caused an increase or decrease in the variable *individual satisfaction*. Interview responses indicated that this variable has been directly affected by four other variables, namely *individual influence*, *individual function disruption*, *departmental heterogeneity* and *personal contact*.

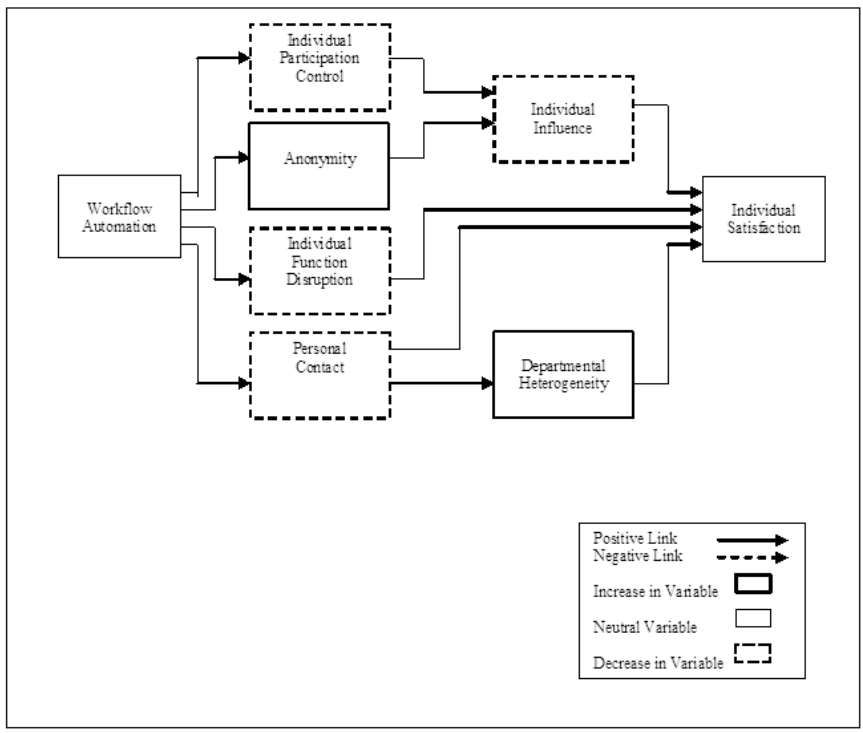
While an increase in workflow departmental heterogeneity and a decrease in *individual function disruption* are seen as having contributed to increase *individual satisfaction*, decreases in individual influence (from the perspective of a participant who wants to have more influence on the workflow) and in personal contact are seen as having contributed to a decrease *individual* satisfaction. These causal links are illustrated in Figure 7.4, below. The effect of *individual influence* on *individual satisfaction* is inferred based on the perception by several individual that their ideas have been "ignored" more easily in the workflow automation than in similar face-to-face meetings. It is interesting to observe that only senior staff expressed this perception, which could suggest a moderating factor (and therefore a moderating variable) related to *rank* in the organizational hierarchy.

However, this idea is discarded when (during further analysis) I notice that several high-rank staff did not express any dissatisfaction related to a possible decrease in *individual influence*. After some reflection, I decide to maintain the link in the causal model, as it suggests quite reasonably and without the need of any moderating variable that only those who would have some influence (particularly from a face-to-face meetings perspective) will be dissatisfied at having *individual influence* decreased.

While the effect of function disruption on *individual satisfaction* is intuitively obvious, as any kind of disruption is usually seen as upsetting. The effect of workflow departmental heterogeneity suggests a more subtle effect of workflow automation. It suggests that workflow automation have the potential to really increase social contact, although not in its normal "personal" sense, throughout the supply chain and perhaps also increase the amount of knowledge and information exchanged across functions. This is, in turn, seen as a source of satisfaction by a number of interviewed respondents.

Other participants however cherished personal contact to the point of being dissatisfied with the need to have to contribute their thoughts through the workflow automation in order to be "heard" by the workflow team as a whole.

Fig 7.4: Path Diagram – Individual Satisfaction



7.7.5. Individual Commitment

Although there is no majority consensus among interview respondents as to whether workflow automation has caused an increase or decrease in the variable *individual commitment*, the responses suggested that this variable is directly affected by four other variables: *team contribution distribution*, *individual participation*, *record keeping (database) efficiency*, and *departmental heterogeneity* (see Fig 7.5, below).

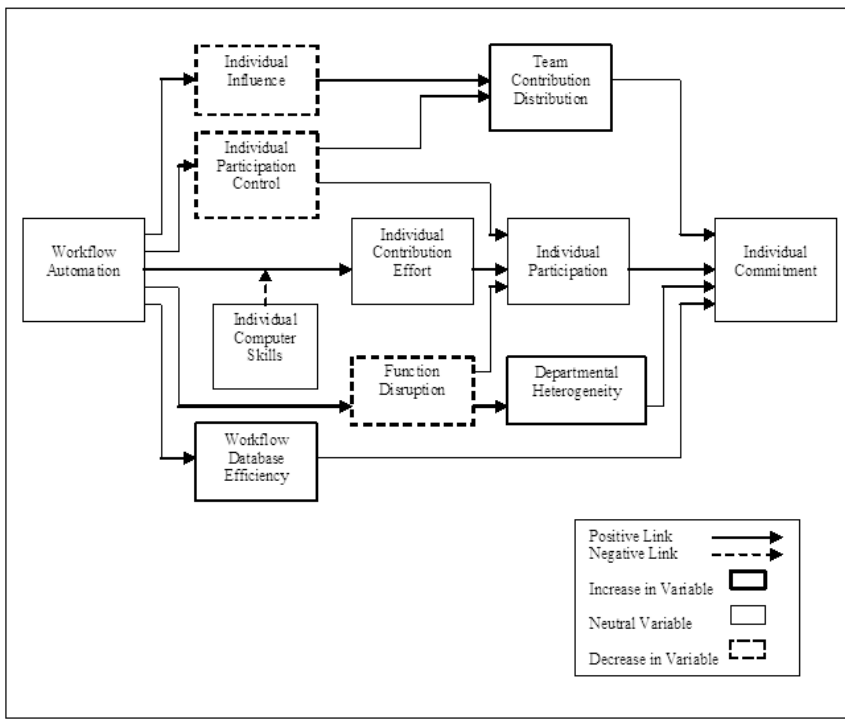
Increases in the variables *departmental heterogeneity* and *team contribution distribution* are perceive as having jointly fostered a higher *individual commitment* by allowing a wider range of staff to freely voice their opinion about coordination matters. This appears to be a social facilitation phenomenon similar in nature to the general increase in motivation and commitment to quality and productivity improvement found in situations where workers from different levels have been given the opportunity to participate in management decisions (Hogg & Cooper, 2003).

Two factors seems to have contributed to an increase in team contribution distribution i.e. a decrease in *individual influence*, which prevented some participants from dominating workflows proceedings, as well as a decrease in *individual participation control*, which prevented leaders from assigning more contribution time (i.e. "air" time, in face-to-face meetings) to certain individuals than to others which, as findings of the first AR seems to suggest, happens quite often in face-to-face supply chain coordination and expediting meetings.

A decrease in the variable *individual participation* (which is not a majority opinion, but just a slight tendency indicated by responses) is seen as having contributed towards a decrease in individual commitment to coordination proposals in two ways: a) decreasing the commitment of individuals who did not participate themselves, in which case this decrease is seen as drastic by most respondents; and b) decreasing the commitment of the individuals who participated but due to the low social motivation provided by the low participation of others. The latter behavior is aligned with the assumption that the degree of individual commitment correlated the degree of social interaction and consensus in team (Hoefling, 2003). The variable *individual participation* itself is seen as having been decreased due to two primary effects of workflow automation, namely a decrease in *individual participation control* and an increase in *individual contribution effort*.

An increase in the variable *workflow record keeping efficiency* is seen as having positively affected individual commitment by adding "formality" to commitments made in postings. This increase seems to be viewed by workflow participants as inherent to the computer-mediated communication medium. Supporting this assumption is the perception by individuals that they have left a "written record" as a result of their participation in their workflows.

Fig 7.5: Path Diagram – Individual Commitment

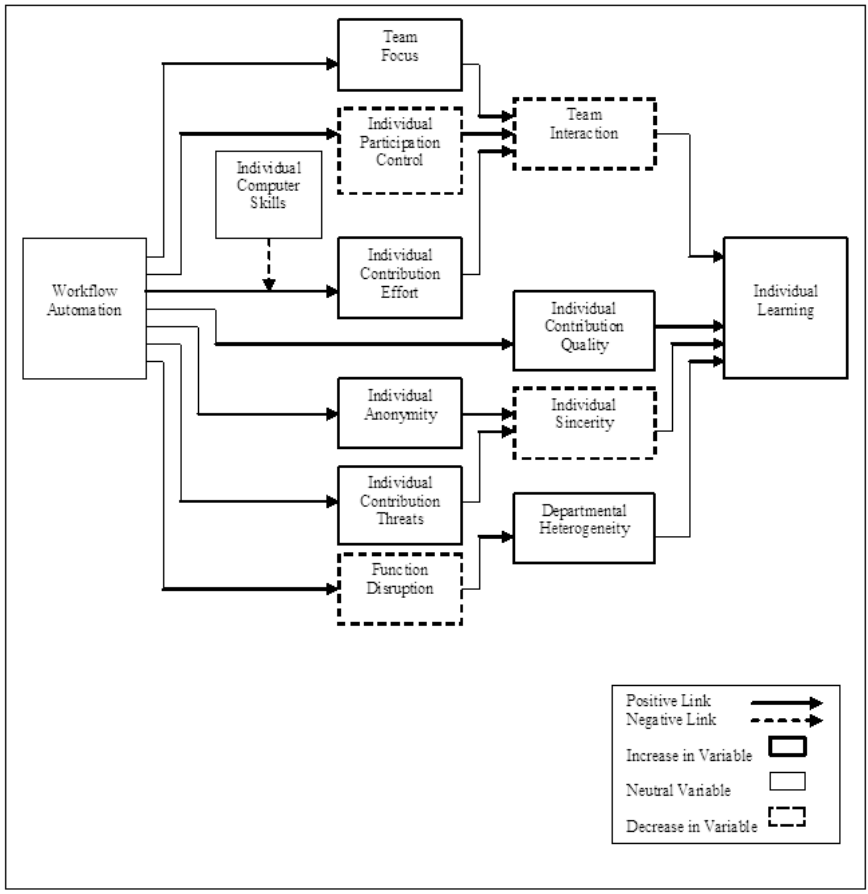


7.7.6. Individual Learning (Action Learning)

According to the perception of the majority of the interview respondents; workflow automation leads to an overall increase in the variable *individual learning*. This increase is perceived as being associated with four other variables, namely *degree of interaction*, *individual contribution quality*, *individual sincerity*, and *departmental heterogeneity* (see Figure 7.6, below). Interviewed respondents' perception suggests that increases in *individual contribution quality* and *workflow departmental heterogeneity* had jointly contributed to an increase in *individual*

learning. These perceptions also suggest that decreases in *degree of interaction* and *individual sincerity* had jointly contributed to a decrease in individual learning.

Fig 7.6: Path Diagram – Individual Learning



Increases in *individual contribution quality* and *workflow departmental heterogeneity* are seen as combining to bring well-structured knowledge and information from a wider range of staff, than will be possible in face-to-face situations. Lower *degree of interaction* and *individual sincerity* will obviously counter this combined positive effect on *individual learning*. While the former effect has been shown beyond much doubt to be associated with workflow automation, the latter seemed to some extent contradictory with the higher *individual anonymity* perceive as being provided by workflow automation.

In fact, while a increase in the perceive *individual anonymity* and isolation fostered by workflow automation leads to some workflow participants feeling somewhat insulated and safer to say whatever they wanted, the majority of interview respondents feel that it is more "dangerous" to contribute through the workflow automation than face-to-face meetings. This latter perception seems to have offset, that of increased *individual anonymity* and isolation perceive by individuals, leading to a general decrease in *individual sincerity*, even though increases in anonymity and isolation are previously seen as important factors in the reduction of individual influence. However, this decrease in sincerity is not enough to offset the positive effect on *individual learning* accruing from workflow automation, even when combined with a decrease in interactions.

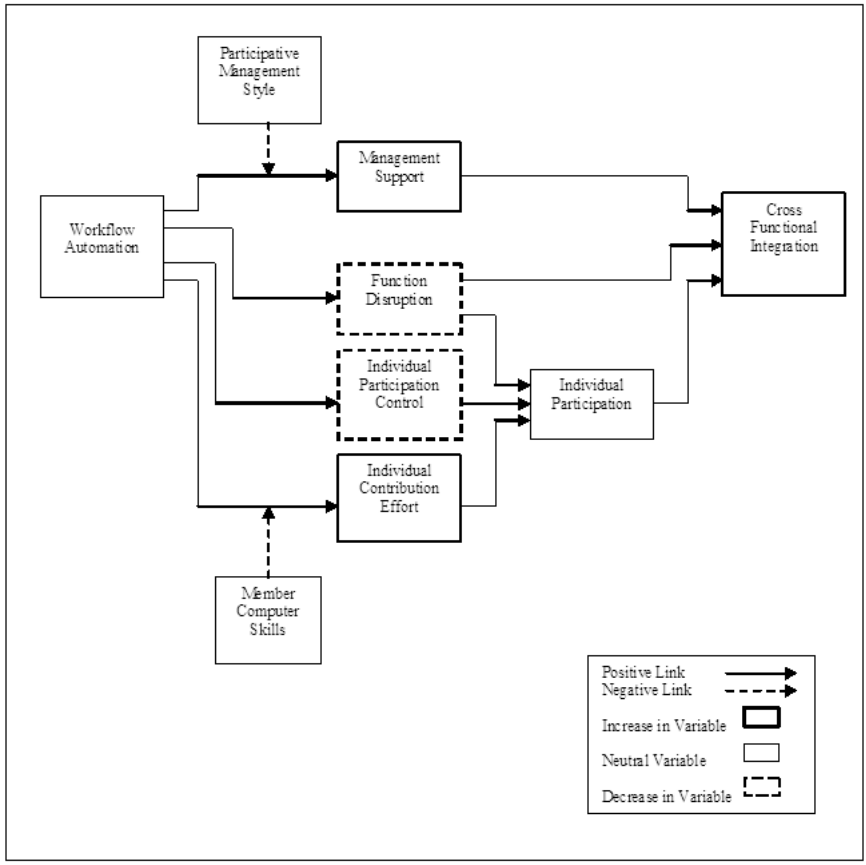
7.7.7. Cross Functional Integration

Most of the interview respondents' perceive workflow automation as likely to increase the probability of success of a hypothetical full-blown cross functional integration by mean of workflow deployment project. The characterization of such a full blown project involves a large number of entities and carried out over a relatively long period of time. The majority of the respondents' perception is a likely increase in the variable cross functional integration.

There seems to be a consensus that three intervening variables will have likely contribute to this, namely *management support*, *function disruption*, and *individual participation*. Apparently, an increase in management support or a decrease in individual function disruption would have equally contributed towards an increase in *cross functional integration*. Conversely, a decrease in *individual participation* would have contributed towards a decrease in *cross functional integration* by means of workflow deployment.

Interviewed respondents' perceptions partially indicated the potential for the variable *management support* to be increased by workflow automation, but not in a conclusive way. This increase seems to be moderated by the variable *organizational commitment to participative management*. However, the main factor in the likely perceive increase in *cross functional integration* is believed by respondents to be the drastic decrease in *individual function disruption* induced by workflow automation.

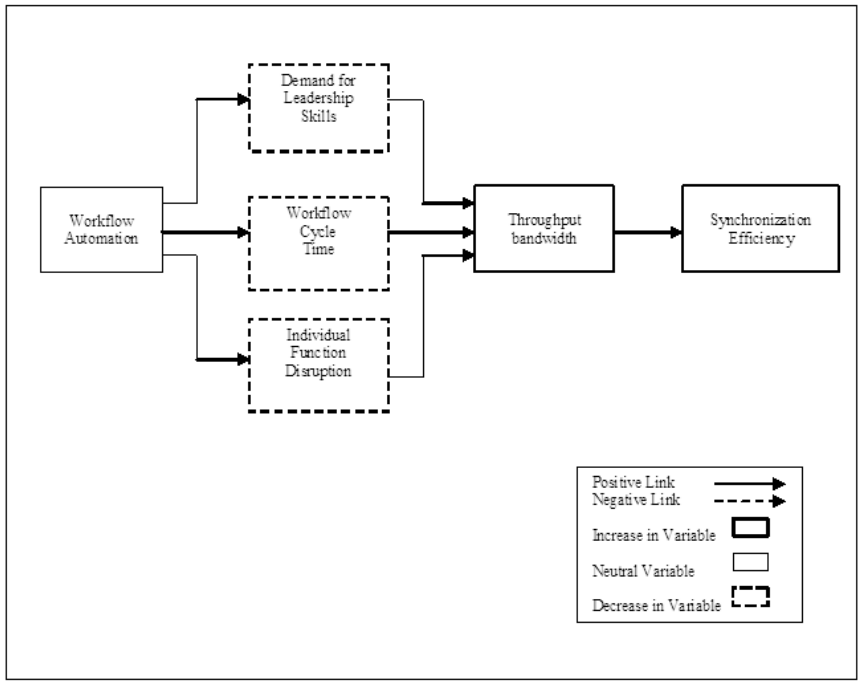
Fig 7.7: Path Diagram – Cross Functional Integration



7.7.8. Synchronization Efficiency

The findings of this AR iteration generally suggest an increase in synchronization efficiency induced by workflow automation. One main intervening variable appears to directly account for this increase is *throughput bandwidth*, which seems to be increased by workflow automation. The variable *throughput bandwidth*, in turn, seems to be directly affected by three other variables - *demand on leadership skills*, *workflow cycle time* and *individual function disruption* - all apparently decreased by workflow automation (see Figure 7.8,below).

Fig 7.8: Path Diagram – Synchronization Efficiency



The increase in the variable *throughput bandwidth* due to workflow automation is inferred by way of analytical deduction. The decrease in the variable *demand for leadership skills* induced by workflow automation apparently allowed staff of lower status, relative to the other managers of their team, to effectively coordinate and control workflows. The decrease in demand for leadership skills is in turn likely to contribute to an increase in the possible number of workflows per unit of time by increasing the number of potential workflow team leaders in the organization.

The decrease in the variable *workflow cycle time* has a direct impact on the possible number of workflows per unit of time because it allows for a quicker start and completion of events. The decrease in the variable individual *function disruption*, on the other hand, fostered by workflow automation potentially allows for the participation of staff (in the workflow) that would not normally be possible otherwise, due to function related time constraints.

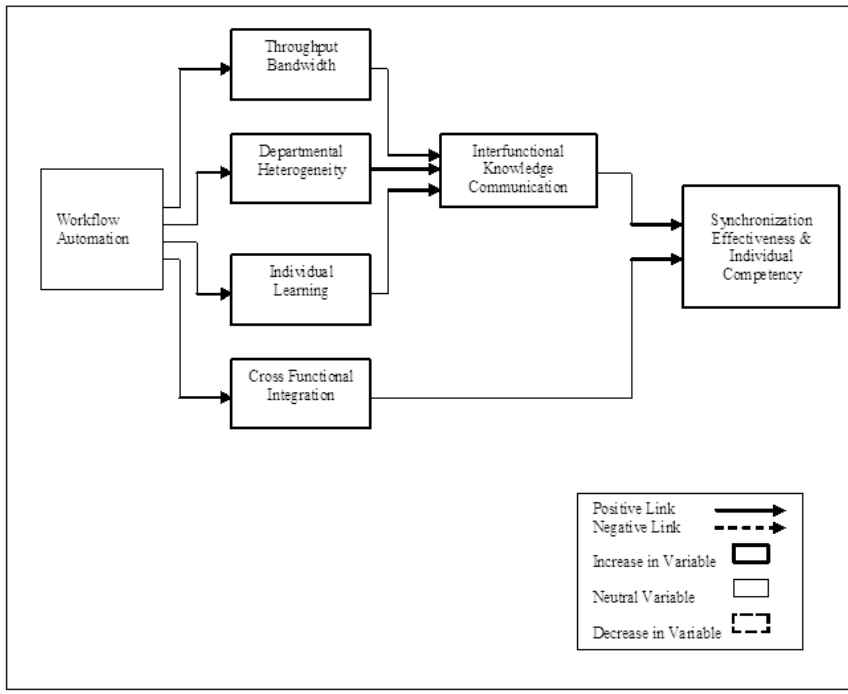
7.7.9. Synchronization Effectiveness and Competency

The findings of this AR iteration generally suggest an increase in the variable *synchronization effectiveness* as a result of workflow automation. This increase seems to result from an increase in synchronization competency i.e. a combined increase in two other variables, namely *inter-functional knowledge communication* and *cross functional integration* (see Figure 7.9, below). A simultaneous increase in variables throughput *bandwidth*, *departmental heterogeneity*, and *individual learning also points to improvements in the supply chain manager's competency in terms of inter-functional knowledge sharing.*

The study of events and interaction mentioned above also suggests an information exchange threshold in ordinary workflows (i.e. routine, support and strategic), above which knowledge exchanges are likely. This threshold is estimated, based on the analysis of 200 discrete exchanges of knowledge and information within the events and interactions of this AR iteration, at approximately 15 per cent i.e. for each 20 discrete information exchanges approximately 3 knowledge exchanges are necessary for reasons such as to provide clarifications and sharing of problem solving ideas in the supply chain.

The study suggests that the increase in inter-functional knowledge communication fostered by workflow automation has the potential to "push up" this information exchange threshold, which can *per se* lead to an increase in supply chain coordination, productivity and quality (Pauleen, 2003).

Fig 7.9: Path Diagram – Synchronization Effectiveness



7.8. Comparison with previous iterations

This iteration of the AR cycle leads to findings that are considerably different from those arrived at in the first AR iteration. Similarly to the third, this fourth research iteration has a slightly narrower intervention scope than the first AR iteration from a supply chain perspective. While the first iteration involved the whole supply chain, this iteration involved just one manufacturer i.e. MAK (including 2 remote sites) and only 15 supplier organizations. Also, I did not conduct a benchmarking in this iteration. The findings regarding workflow automation effects on strategic performance management of supply chain however are generally consistent with those from the first iteration.

The frequencies of responses regarding perceptions of workflow automation effects on the same variables in the third and fourth iterations are found to have a strong correlation between them. The coefficients of correlation (Pearson) between the frequencies of respondents who perceive those variables as having been increased and decreased by

workflow automation were r = .89 and r = .88 respectively (Refer to Appendix: G). These strong correlations indicate a general consistency of the perceptions by structured interview respondents across the third and fourth research iterations, and therefore the likely external validity of conclusions based on these perceptions.

Regarding the 10 main dependent variables i.e. the findings of this AR iteration are also consistent with those arrived at during the third iteration, with 3 exceptions. One of these exceptions is *individual commitment*, which is perceive (by a narrow margin) as having been increased by workflow automation in the third AR iteration. During this AR iteration, however, I am not able to ascertain beyond much doubt whether there has been a decrease or increase in this variable. Another exception is *cross functional integration*, which is seen as decreased in the third AR iteration, and increased in this AR iteration. Finally, the third exception relates to the variable *synchronization effectiveness*, which is seen as having been increased by workflow automation in this AR iteration.

While the first exception seems to have been caused by a small variation in response frequencies, the second could perhaps be assigned to differences in the organizational cultures of STS and MAK. The most decisive difference seems to be a difference in general support likely to be given to cross functional integration by means of workflow deployment by management, higher in MAK and lower in STS. Still, this support seems to be moderated by the degree of management commitment to *participative management approaches*.

I am not able to establish whether this commitment is high enough to lead to an increase in *cross functional integration*. Even though staff perceptions in general pointed slightly towards this direction, this is not what is suggested by the second AR iteration, carried out in the same organization as this AR iteration i.e. MAK, but with a narrower scope. In the light of the findings from this and the first iteration, I could speculate that *cross functional integration* is more likely to occur at lower levels in the organization (operational rather than strategic), if top management is not committed to participative management style. This would then explain higher workflow effectiveness due to a higher inter-functional knowledge communication and supply chain coordination, productivity and quality improvements of gradual and incremental nature.

There is a decrease in the complexity of the causal models in the fourth AR iteration (partially measured based on the number of variables in the causal diagrams), in comparison with those generated in the third AR iteration. The mean number of variables per diagram dropped from 9 in the third iteration to 7 in the fourth iteration; a drop of 1.0 standard deviations. Particularly noteworthy were the simplifications in the causal models depicting the relationship between workflow automation and the variables:

a) Message and Response Quality, from 9 to 6; and
b) Individual Satisfaction, from 11 to 8; i.e. a decrease of 3 variables, or a drop in complexity of more than 1.5 standard deviations;
c) Cross functional integration, from 12 to 7; i.e. a decrease in both cases of 5 variables, or a drop in complexity of 2.5 standard deviations.

The main reason for these decreases in model complexity seems to have been the simpler and more straightforward explanations given by interview respondents in this AR iteration resulting in the elimination of the intervening variables present in third AR iteration.

7.9. Chapter summary and concluding remarks

This chapter reports on the fourth iteration of the AR cycle whereby 4 workflow events are studied over a period of 6 months. The organization in this research iteration is MAK, the same Japanese Machine Tool company where the second iteration have been conducted. 97 staff from MAK Singapore, India, China and 15 different suppliers' representatives participates in the workflows deployed in this AR iteration. From a supply chain performance perspective, this AR iteration contributes towards:

a) Increasing coordination quality (moderately) and productivity (drastically), as a result of the workflows deployed,
b) Increasing the amount of process-related knowledge and information exchanged between staff in different departments, particularly while the workflow deployment is in progress i.e. this effect gradually waned after the workflows are operational,
c) Enabling coordination of supply chain as routine continuous improvement cycle by means of workflow deployment.

Indirect evidence gathered in this research iteration suggests that the variable *workflow cycle time* has been decreased by workflow automation. This variable seems to be directly affected by three other

variables: *degree of interaction, individual response time*, and *workflow set up time.*

A decrease in interaction can be seen as having contributed to a decrease in *workflow cycle time*, as participant interaction seems to account for a large part of face-to-face meetings in general and coordination meetings in particular. The same appears to be true for *workflow set up time.* On the other hand, it appears plausible to assume that an increase in individual response time contributes to an increase in *workflow cycle time.* Past experience in facilitating face-to-face coordination meetings suggest that the workflow automation effects on *workflow set up time* and *individual interaction* has probably offset the effect of *individual response time* in the workflows, having consequently lead to a decrease in *workflow cycle time.*

The variable *demand for leadership skills* seems to have been decreased by workflow automation, effect that is intervened by two other variables, namely *individual influence* and *workflow change adoption.* A decrease in individual influence seems to contribute towards decreasing *demand for leadership skills*, as team leaders did not have to worry about preventing some individuals from delaying *(or dominating)* the workflow proceedings. An increase in *workflow change adoption* also appears to contribute towards decreasing the demand for leadership skills, as team leaders did not have to steer their teams constantly to the workflow goals.

There is enough evidence pointing to an increase in the variable *message and response quality*, the majority perception in interviews is that this variable has not been decreased by workflow automation. According to interviewees' perceptions, message and response quality is directly influenced by three other variables, namely *departmental heterogeneity*, *workflow message equivocality* and *individual contribution quality*.

Increases in departmental heterogeneity and individual contribution quality are seen as having fostered a higher message and response quality. Conversely, an increase in workflow message equivocality is seen as having contributed towards a decrease in message and response quality.

There is no conclusive evidence suggesting that workflow automation caused either an increase or a decrease in the variable *individual satisfaction*. Some evidence indicated that this variable has been directly affected by four other variables, namely *individual influence, function disruption, departmental heterogeneity and personal contact.*

While an increase in departmental heterogeneity and a decrease in function disruption seems to contribute to increase in individual satisfaction, a decrease in individual influence (from the perspective of an individual who wanted to have more influence on other team members) and in personal contact apparently contribute towards a decrease in individual satisfaction.

Although there is no concluding evidence as to whether workflow automation has cause an increase or decrease in the variable *individual commitment*, this AR iteration suggests that this variable is directly affected by four other variables: *Team contribution distribution*, *individual participation*, *workflow record keeping efficiency*, and *departmental heterogeneity*.

Increases in the variables *workflow departmental heterogeneity* and *workflow message contribution distribution* seems to have jointly fostered a higher individual commitment by allowing a wider range of staff to freely voice their opinion about coordination and expediting of supply chain performance. A decrease in the variable *individual participation* is seen by interviewed respondents as having contributed towards a decrease in individual commitment to change proposals, particularly from the point of view of those whose participation is reduced by workflow automation. An increase in the variable *workflow record keeping efficiency* is seen as having positively affected individual commitment by adding "formality" to commitments made in workflows.

Workflow automation seems to lead to an overall increase in the variable *Individual learning*. This increase appears to be associated with the impact on this variable of four other variables, namely *degree of interaction*, *message and response quality*, *individual sincerity*, and *departmental heterogeneity*. The evidence gathered suggests that an increase in message and response quality and departmental heterogeneity has jointly contributed to an increase in individual learning. The evidence from this AR iteration also suggests that a decrease in interaction and sincerity has jointly contributed to a decrease in individual learning.

Most of the interviewed respondents' perceive workflow automation as likely to increase the variable *cross functional integration*. There seems to be a consensus that three intervening variables would likely contribute to this, namely *management support*, *function disruption*, and *individual participation*. Apparently, an increase in management support or a decrease in function disruption would have equally contributed towards an increase in *cross functional integration* by means of workflow

deployment. Conversely, a decrease in individual participation would have contributed towards a decrease in *cross functional integration.*

The findings of this AR iteration generally suggest an increase in synchronization efficiency induced by workflow automation. One main intervening variable appear to directly account for this increase i.e. *throughput bandwidth*, which seems to be increased by workflow automation. This intervening variable, in turn, seems to be directly affected by three other variables - *demand on leadership skills, workflow cycle time* and *function disruption;* all apparently decreased by workflow automation.

The findings of this research iteration generally suggest an increase in the variable *synchronization effectiveness* as a result of workflow automation. This increase seems to result from a combined increase in two other variables, namely *inter-functional knowledge communication* and *cross functional integration by means of workflow deployment.*

Chapter 8: Conclusion

Following, the detailed description of the four iterations in chapters 4, 5, 6 and 7 of this AR study, this chapter presents and discusses the findings and implications. Since the findings of this research are considerably lengthy (refer to Appendix E for a complete list of variables identified), I decide to summarize it according to two classification schemes:

a) **Degree of Reliability** (Section 8.1): by apparent degree of intensity i.e. the strength of the workflow automation effects observed.
b) **Degree of Applicability** (Section 8.2): by apparent degree of external validity i.e. how likely are the workflow automation effects to be observed in other organizations.

In Section 8.3, I consolidate the findings where I derive a causal diagram comprising effects from Section 8.1 (i.e. comprising effects that were drastic and about which I have high confidence) and Section 8.2 (i.e. comprising effects that were generic). This causal diagram provides the basis to answer the overall research question: *How are efforts to manage strategic performance of supply chains affected by workflow automation?*

Specific implications and possible prescriptions for managerial practice that follow from interpreting the consolidated findings are discussed in Section 8.4. A critical evaluation of the still open research issues and a discussion of suggested next steps (Section 8.5) conclude this study.

8.1. Degree of Reliability

I classify workflow automation effects on strategic performance management of supply chains, according to apparent degree of intensity, as *drastic or marginal.*

Drastic effects are those that lead to a 50 percent, or more, increase or decrease in an apparently reliable measure of a variable. This is calculated as the ratio between the highest and the lowest value of that measure i.e. either (value after workflow automation) divided by (value before workflow automation), in the case of an increase in the variable, or (value before workflow automation) divided by (value after workflow automation), in the case of a decrease in the variable. Drastic effects can be seen as those in which the ratio between the measure of the variable

before and after workflow automation is at least 1.5 and above (i.e. a 50 per cent or more increase or decrease). As there is no control groups in this research, the "value before workflow automation " part of the equations is either estimated based on users' perceptions of performance, or, in some cases, industry standards and financial (benchmarking) data.

Marginal effects are those, which led up to a 1.5 or less increase or decrease in the variable (i.e. up to a 50 per cent).

Whenever measures for a variable are not available, I estimate the apparent degree of intensity of the effects based on the analysis of the recorded perception of most of the respondents i.e. statements containing the words "a lot" or "strong", when referring to a workflow automation effect, are taken as indications that the effect is actually a *drastic* one. Given my deep involvement with the respondents and the environment being studied, the same goes for a number of other expressions, "very much", "quite a lot" etc., whose meaning in most cases suggested an obvious class choice (i.e. drastic improvement). Such expressions as "slightly", "mildly", "somewhat", "considerably" are more indications of a marginal improvement.

Since I neither define measures for all variables, nor test the reliability of any of the measures devised, the present classification must be seen as explanatory and non-rigorous summarizations of the results. Given this, I tried to improve the clarity of this classification, by also splitting the effects according to our confidence in *high confidence* and *low confidence*.

I have high confidence in effects that resulted from the explanation building process described in Chapter 3 and either:

a) Have been perceived by most of the respondents in the third and fourth iterations, and validated through data triangulation with either participant observation perceptions or unstructured interview notes or workflow transcripts.
b) Have been perceived by most respondents in one of the iterations and supported by hard evidence, particularly seemingly reliable measures of the variables e.g. the measure *time spent on expediting* for the variable *function disruption*
c) Have been indicated by most of the respondents in a non-induced way i.e. when no mention of the variable or effect was made

I have low confidence about effects which did not meet these criteria, but that have been observed in at least two of the research iterations. Other effects are left out of this classification.
Table 8.1, shows a summary of the findings, as effects of workflow automation on research variables, classified according to apparent intensity and degree of confidence as discussed above.

I am generally more confident about the effects that resulted from the direct characteristics of workflow automation on strategic performance management of supply chains. I am less confident about indirect effects i.e. intervening variables and those that are contingent on individual behavioral patterns.

The classification of effects relating to variables is based on the analysis of trends of responses in structured interviews. The effects shown on these variables are the result of a majority consensus among respondents (i.e. more than 50 per cent) in any of the iterations, and in the case of a variation in the trend of responses across the third and fourth iterations; I went with the result derived from the larger sample i.e. fourth iteration.

Table 8.1: Degree of Reliability

		Confidence	
		High	**Low**
Intensity	Drastic	Function Disruption Participation Control Efficient Database Individual Influence Degree of Interaction Individual Response Time Throughput bandwidth Cost of Workflow Demand for Leadership Skills Workflow Cycle-time Individual Contribution Effort Message Quality Response Quality Cross functional integration **Synchronization Efficiency**	Team Focus Workflow Set up Time Participant Segregation Personal Contact Management Support Individual Commitment **Synchronization Effectiveness**
	Marginal	Workflow Change Adoption Site Heterogeneity Individual Contribution Threats Function Heterogeneity Workflow Decentralization Individual (Action) Learning **Synchronization Competency**	Individual Contribution Quality Individual Anonymity Individual Stress Individual Sincerity Individual Satisfaction Individual Participation Team Contribution Distribution

8.2. Degree of Applicability

I classify workflow automation effects, according to their apparent degree of external validity, as *generic* and *contingent*. Generic effects are those, which do not seem to depend on specific characteristics of the socio-technical context being observed to occur. These are mostly those 'effects' which either:

a) Have been found to be inherent to the communication medium provided by the workflow automation system
b) Have been seen as following from generic effects in a decisive manner by the respondents
c) Have been seen as non-moderated by other factors, which is typically evident by a strong agreement between respondents on a small number of causes, and the non-existence of moderating variables in the causal diagrams

Contingent effects are those that do not meet the requirements to be considered generic effects.

Workflow automation effects identified in this research are classified according to their apparent degree of external validity as shown below in Table 8.2:

a) **Generic:** relates effects that are not moderated by organization or individual characteristics,
b) **Contingent on organizational characteristics:** relates effects that are apparently moderated by specific organizational characteristics, such as hierarchical rigidity and
c) **Contingent on individual characteristics:** relates effects that seem to be moderated by specific individual characteristics, such as degree of personal acceptance of the technology

I refrain from trying to pinpoint the specific characteristic defining *effect contingency* because I will not have enough evidence from this research to support such a classification. However, this does not prohibit drawing at least one important conclusion and some implications from this classification, as discussed below.

One interesting conclusion that can be drawn from the summary in Table 8.2 is that most of the *contingent* effects are the ones related to the impact of workflow automation on the variable *synchronization effectiveness*, whereas most of the *generic* effects relate to the impact of workflow automation on the variable *synchronization efficiency*. This conclusion is also supported by causal diagrams, particularly in third and fourth iteration.
This suggests that workflow automation effects on *synchronization effectiveness* are more likely to depend on specific characteristics of the socio-technical system in which the workflow system is operating, than the effects on *synchronization efficiency*.

Further, the distribution of variables associated with contingent effects are more "skewed" to the "Contingent on Individual" part of the table, suggesting that *synchronization effectiveness* is more likely to be contingent on specific individual characteristics more than on organizational characteristics. This association between synchronization effectiveness and the supply chain manager's competency is evident from the 2nd AR iteration onwards of this study.

Table 8.2: Degree of Applicability

		Workflow Automation Effects				
		Synchronization Effectiveness	Synchronization Efficiency	Synchronization Competency		
Supply Chain Level	Network	Team Focus Workflow Set up time Cost of Workflows	Function Disruption Participation Control Workflow Cycle Time Degree of Interaction Demand for Leadership Skills Throughput bandwidth	Personal Contact Individual Contribution Effort Individual Response Time	Generic	External Validity
	Entity	Site Heterogeneity Functional Heterogeneity Workflow Decentralization Cross functional Integration Management Support	Workflow Change Adoption Efficient database	Individual Influence Individual (Action) Learning	Contingent on Organization	
	Individual	Individual Anonymity Individual Contribution Threats Individual Participation Message & Response Quality Participation Segregation	Team Contribution Distribution	Individual Commitment Individual Satisfaction Individual Stress Individual Sincerity Individual Contribution Quality	Contingent on Individual	

8.3. Path Diagram – Synchronization Efficiency

I consolidate the findings in Figure 8.1 below, where I derive a causal diagram comprising effects from Table 8.1, quadrant I (i.e. drastic and about which I have high confidence) and from Table 8.2, comprising effects that were generic. Only the intervening, "intermediated effects" of the workflow automation on one of the anchor variables i.e. s*ynchronization efficiency* is shown in the figure. Since the effect on the variable *synchronization effectiveness and synchronization competency* are neither drastic nor high in confidence and are also found to be not generic, therefore only effects linked in some way with the variable *synchronization efficiency* are shown.

The explanatory causal model in Figure 8.1 indicates that workflow automation causes a large decrease in the organizational costs associated with workflows. Synchronization efficiency is defined as the ratio between the *throughput bandwidth* i.e. the number of possible workflows per unit of time and the organizational cost of workflows. Therefore, this decrease in cost contributes, by definition, towards an increase in the variable *synchronization efficiency*

Organizational *throughput bandwidth* seem to be moderately increased by the combination of a significant decrease in workflow cycle time and the demand for leadership skills. A significant decrease in workflow cycle time led to a significant increase in the workflow *throughput bandwidth*. On the other hand, a significant decrease in the demand for leadership skills leads to a significant increase in the number of staff being able to lead workgroups in the organization (particularly lower status staff relative to other workflow users). It gives virtually everyone in the organization, not only managers, the chance to lead workgroups and therefore significantly increases the number of workflows that can be active concurrently (*multi-tasking)* in the organization.

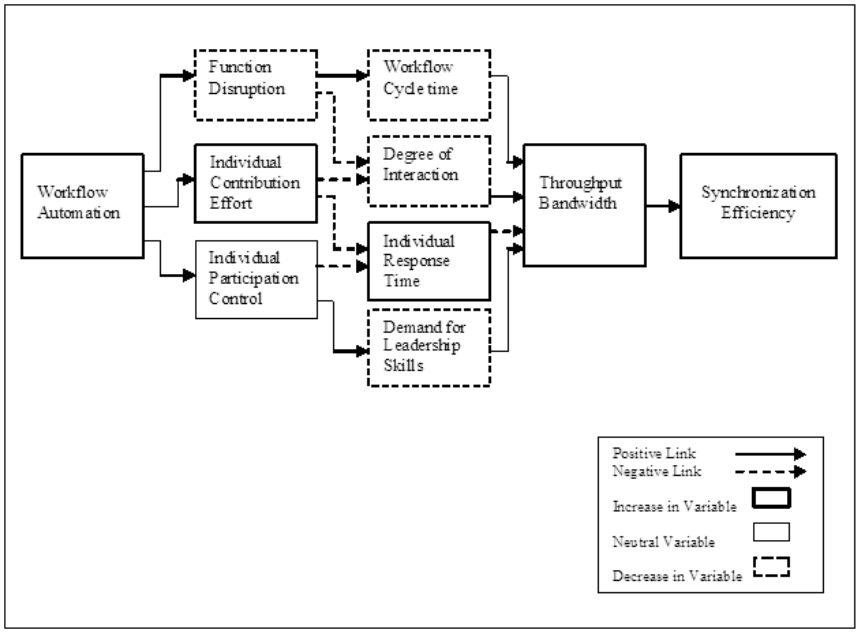
The main cause for the large reduction in the demand for leadership skills is a large reduction in individual participation control. Individual participation control is defined as the degree of control that team participants (whether they are managers, leaders or facilitators), has on the participation of other individuals. Participation control can lead to both an increase in the participation of a timid individual, and a decrease in the participation of a particularly dominant individual. Very little control can be imposed on individual participation through the workflow automation. Therefore, participants could exert very little influence on each other's participation. Conversely, in face-to-face meetings, an

individual can deeply influence the participation of others by direct interaction e.g. by directing a question to an individual, interrupting an individual's contribution and controlling turn taking.

Since this ability to influence other participants is available to everyone in face-to-face meetings, it is a widely accepted norm in organizations that there must be a team leader who will exert more participation control than others. This control is typically aimed at increasing productivity e.g. ensuring objective focus and the opportunity for everyone to participate and contribute. Those seen as able to legitimately apply this type of control are the ones who have some formal authority over the others in the team, typically managers. This limits the number of simultaneous face-to-face meetings in an organization to roughly the number of managers with enough time to lead, during a given time period. On the other hand, this limitation is virtually eliminated with workflow automation.

A large decrease in the variable *function disruption* leads to a large decrease in *workflow cycle time* by allowing participants to interact at convenient times and react in asynchronous mode**.** A large decrease in function disruption combined with a large increase in individual contribution effort and a large decrease in individual participation control, led to a large decrease in the degree of interaction. That is, the low disruptiveness of the workflow automation, combined with little participation control and the extra effort required from individuals to contribute messages, led to a large reduction in the number of messages and responses.

Fig 8.1: Path Diagram - Synchronization Efficiency



A large increase in individual contribution effort combined with a decrease in individual participation control leads to a large increase in individual response time. That is, individual delays their responses (replies) because they cannot be forced to respond and also, it took more time for preparation. These are seen as moderating the large gains in workflow throughput bandwidth.

8.4. Implication for Strategic Performance Management

Discussing this research implication for managerial practice involves stretching the research findings, regardless of the level of internal and external validity, beyond the limits of its exploratory design. If I cannot, by design, assess causality, I also cannot make recommendations that involve manipulations to affect a desired change. The recommendations here therefore should be seen as explicated hypotheses, as concrete to-be-tested procedures for improvement of use and deployment of workflow automation.

Throughout this research the focus has been on unraveling of the factors and relations that link different aspects of workflow automation to

strategic performance management. However, the same issues that applied to strategic performance management of supply chains also apply to other areas of strategic performance in business. The following (to-be-tested) recommendations, organized along the lines of the "expected managerial contributions" put forth in Chapter 1, Section 1.3; therefore apply both to strategic performance management of supply chains and other strategic business processes.

a) The SPI Model will enable an integrated approach to *(i)* ***Problem structuring*** *(ii)* ***Problem solving*** *and (iii)* ***Learning*** *for managers on potential threats and problem to strategic performance of supply chains:*

This study is identifies the main process flows in a supply chain. Key characteristics are derived from these process flows. From these key characteristics of the process flow, process inhibitors are identified as a "class" to categorize all potential threats and problems. Thus the potential threats and problems classified are actionable and within the span of control, of the member supply chain entities.

I summarize the findings on potential threats to strategic performance of supply chains along the research iterations in Table 8.3, below. This provides guidance to the manager on the handling of the different buckets (class) of risk. Further, when face with one of the potential threats, which team i.e. S & OP or MPS, will need to be alerted. It is then the responsibility of the respective teams to resolve the issue and put in place measures to prevent (or procedure to handle) such an occurrence in the future. This table is by no means exhaustive, managers are encouraged to add or delete the potential threats as appropriate for their operating environment.

Table 8.3: Summary of Potential Threats to Supply Chains			
S & OP Team Accountable)		MPS Team (Accountable)	
Uncertainty	**Equivocality**	**Complexity**	**Variability**
Disasters	Workflow issues	MPS – Change Triggers	Delivery/Shipment
Shift in Demands	Response delays	Engineering Change Notice	Quality
Forecast Error	Service level Compliance	Data Accuracy on Inventory	Human Error
SLEPT Factors*	Exception Handling	Data Accuracy on Capacity	Batch Tracking
Product Cost	Expediting Needs	Supplier Issues	Maintenance (MTBF)
Distribution Strategies	Geography & Time	Multi-level BOM	Packaging (Size/Weight)
DIFOT monitoring	Interface & Integration	Shop Floor Layout	Services Disruptions
		Lead Time Issues	
		ATP, CTP & PTP**	

* Social, Legal, Economic, Political and Technological
** ATP – Available to Promise, CTP – Capable to Promise, PTP – Profitable to Promise

b) *The SPI classification will provide a systematic and structured manner of addressing (i.e. communicating) potential problems and risk to strategic performance of supply chains. Once classified, each class will have its own type of impact on strategic performance of supply chains and consequently the resolution for it:*

Table 8.4 – 8.7 below, are examples of risk mitigation strategies for the respective buckets (i.e. risk class), compiled based on data collected along the 4 iterations of this AR study. This tables are by no means exhaustive, managers are encouraged to add their own experiences drawn from their respective industries and operating environment.

Table 8.4: Uncertainty	
Potential Threats	**Risk Mitigation**
Disasters	Create contingency plans and training for "readiness of action" on those plans
Shift in Demands	Hedging and Buffers (i.e. stock or resources placed at strategic locations)
Sales Forecast (Errors)	Focus on Process Improvement not Forecast Accuracy
SLEPT Factors	Regular monitoring of the relevant factors and periodic "What-if" simulation
Product Cost	Factors of Production contribution to Product cost. Study causes and plan action.
Distribution Cost	DC Locations, Transportation, Taxes, Proximity to market
DIFOT monitoring	• Incentive for DIFOT • Economics of Transportation/Shipment/Handling/Storage

Table 8.5: Equivocality	
Potential Threats	**Risk Mitigation**
Workflow issues	Establish standard protocol and "rules of engagement"
Response delays	Asynchronous means of messaging support
Service level Compliance	Training and Certification
Exception Handling	Cases for Escalation process, person(s) to be alerted and Follow-up
Expediting Needs	Urgent case handling procedures, person(s) to be alerted and Follow-up
Geography & Time	Conference calls, language, person(s) to be contacted, follow-up with written email to confirm actions or understandings.
Interface & Integration	Standard user interface, intuitive and short learning curve

Table 8.6: Complexity	
Potential Threats	**Risk Mitigation**
MPS – Change Triggers	• Identify change triggers and conduct Root-cause analysis. • Create knowledgebase for future reference
Engineering Change Notice	• Root-cause analysis, • Frequency of Change analysis • Impact of Change i.e. cost, reliability, compliance, etc;
Data Accuracy on Inventory	ERP opening balance and transaction posting up-to-date
Data Accuracy on Capacity	ERP routes, work center and WIP posting up-to-date
Supplier Issues	Supplier performance monitoring and preferred vendor certification
Multi-level BOM	Simplification, Standardization and Rationalization of BOM and parts list
Shop Floor Layout	• Shop floor safety, cleanliness, discipline, etc; • Bottleneck resources identification • Ergonomics and work-study application
Lead Time Issues	• Dynamic lead time management • Postponement strategy (Modules/Sub-assemblies/Configurations) • Vendor Managed Inventory (VMI)
ATP, CTP & PTP	ERP Data Accuracy and transaction posting up-to-date.

Table 8.7: Variability	
Potential Threats	**Risk Mitigation**
Delivery/Shipment	Route planning, packaging, handling equipment
Quality	Man or machine failure, Material quality (Incoming), In-transit handling
Human Error	• Training Needs/ skills/Competencies • Review Job specifications/Work study/Industrial Engineering
Batch Tracking	RFID or Bar-Coding Technology
Maintenance (MTBF/MTTR)	Preventive maintenance and Proper operating procedures
Packaging (Size/Weight)	Packaging for Deliver vs. Packaging for Consumption
Services Disruptions	• Alternatives means of Transport/Shipment e.g. airfreight • Contingency plans (i.e. "what if...") • Substitution (e.g. Incoming Material Quality)

c) *Workflow automation will enable communication and coordination by means of asynchronous message delivery and action triggers. This in turn reduces conflicts and miscommunications e.g. between sales and operations. Thus improving the working environment:*

As already stated in Chapter 1, Section 1.1; what distorts the supply chain performance so badly is response time i.e. the lengthy delay between the event that creates the change (demand shift) and the time when the factory (supply side) finally responds to this message (Schroeder & Flynn, 2001). Asynchronous communication mode eliminates the geographical and time zone barriers in communication. One no longer needs to be physically connected to transact business. Asynchronous communication enabled by workflow automation allows information flow to continue asynchronously, thus reducing messaging and response delays. The explanatory causal model in Figure 8.1 supports this explanation.

A supply chain is a network of autonomous entities, linked together by a relation of interdependence and interaction, to achieve the goal of the meeting customer demand. The supply chain as a whole, having emergent properties, may in principle be able to survive in a changing environment if it has processes of *communication and*

coordination which could enable it to be agile and quick to response to shocks from the environment. Such a process is called a Meta Process i.e. process about other processes (Afsarmanesh et al., 2004). Meta-processes are for ongoing alignment of the basic business processes that are common to most manufacturing organizations e.g. production. Workflow automation (i.e. communication and coordination) is applied (as an example) to production through the meta-process MPS (Master Production Scheduling), which the production manager carries out to improve order promising and deliver performance to customers.

This research findings guided the setting of goals in supply chain to a hierarchical relation of *Delivery* focus at the Sales flow (i.e. Strategic) and *cost* focus at the Operations flow (i.e. Performance excellence). In supply chains this relationship is complementary and interdependent. Focusing on *delivery or cost* alone will not guarantee survival of an enterprise in current conditions of intense market competition. An enterprise cannot be achieving *delivery* for all customers' orders and still be cost effective without performance excellence. For an enterprise, being 'synchronized' with the customer primarily means that the enterprise is focus on meeting the demand first i.e. delivery and then to meet the demand in a most cost effective manner.

d) Workflow automation will enable inventory (i.e. right quantity at the right time and right place) to be substituted by information (i.e. the right information at the right time and the right place) resulting in cost reduction of inventory holding:

Inventory to protect the organization against uncertainty of demand, in the form of safety stock and buffers, is not an asset. It is a liability (Goldratt, 1986). Its purpose is to protect *throughput*. Excess inventory hurts quality and increases product cost. How can throughput still be protected without all the excessive inventory build-up (in the form of safety, channel and obsolete stock) in the supply chain?

One of the most striking transformations of society is the increasing importance of information in providing solutions for those problems that were once completely mechanical. For example, a nineteenth-century farmer who wished to provide a cushion against the failure of his wheat crop would plant some fields with corn. However today's

farmer sells options i.e. bits of information on pieces of paper - to provide a guaranteed income if the crop fails. Where thirty years ago a “speed-demon” seeking extra performance would bore out the cylinders of his car engine, put on dual exhausts and a four-barrel carburetor versus a modern “speed-demon” simply removes the microprocessor chip that regulates fuel injection and timing, and replaces it with a chip that sacrifices fuel efficiency, low emissions, and reliability for power.

In the context of supply chain management, inventory i.e. the right quantity at the right time and the right place can be substituted by information i.e. the right information at the right time and the right place. Therefore, if information flow preceding the material flow is correct and timely, excess inventory i.e. waste can be eliminated from the entire supply chain. The research findings support the shift of efforts to managing the information quality i.e. data quality in terms of timeliness, correctness and accessibility as opposed to the focusing efforts on optimization of inventory holding levels. Once, information flow is improved excess inventory i.e. waste will be eliminated.

8.5. Research Implications

Validity of study: The significance and importance of managerial research is not a function of the degree of statistical significance reported in the findings as in quantitative studies nor the clarity and insightfulness of ethnography as in qualitative studies. The significance and importance of management research derives from a variety of factors related to both its context and its findings (Darke et al., 1998). These factors reflect *timeliness, innovation, demand, and appropriateness*, as well as more conventional parameters such as accuracy, reliability and validity (Johnson & Duberley, 2000).

The management and computing context in which this research is carried out is one that reveals increased interest in strategic performance of supply chains as a competitive strategy. In particular, internet based supply web (virtual team) environments may provide one of the most appropriate contexts for the application of workflow automation in strategic performance management of supply chains. In conjunction with the recent proliferation of wireless telecommunications infrastructure, it becomes apparent that interaction via computer is an emerging area of importance for research and practice in management. Further, as the field of computer supported cooperative work (CSCW) grows; the

implications and opportunities for workflow automation become increasingly clear (Papp, 2001).

The specific problem context for this study was discussed in Chapter 1 and 3. I will restate here briefly. Since it is being proposed that, "*Workflow automation be deployed for managing strategic performance of supply chains"*. Attention is drawn to those aspects of the medium and the use of the medium that may affect the strategic performance management process. In supply chain, workflow interaction among participants is the medium through which communication, cognitive and collaborative activities transpire.

The primary events observed for this research on workflow automation effects on strategic performance management of supply chains are the *messaging and response* elements in the context of transactional communications that reflected cognitive and cooperative activities which may represent a process of inter-functional collaboration. Other sources of data are the assessments of the outcome from the cooperative task and the responses to questionnaires and interviews revealing subjective impressions of the team experience.

Although interpretation of the communication content are essentially a qualitative assessment, it does involve counting and categorizing of items, which then took the form of numeric values assigned to dependent variables. Similarly, the responses to the questionnaires and the categorized responses to interview questions are quantified. These values are then transformed to descriptive statistics to facilitate the classification of the effects of workflow automation. In the context of strategic performance management of supply chains, the graphical and numeric presentation of the findings at the descriptive level is sufficient for the purposes of this study. They strongly suggest that there are differences in the level of *cognitive and cooperative activity* that occurred during strategic performance management process of supply chains. They also suggest that the mode of asynchronous interaction affects synchronization efficiency and quality of the outcomes for tasks such as the order promising, production scheduling and goods delivery.

For studies in which testing of specific hypotheses is the objective, inferential statistical procedures are used to determine whether observed differences between groups are due to the factors being investigated, or whether variation due to chance or other factors is responsible. Since these procedures have strict requirements for experimental control, independence of variables, and assumptions of random sampling, they are

neither appropriate nor necessary for the warranting of contribution in this study.

As noted at the beginning of this section, the significance and importance of this study are not based on the statistical significance of the findings. Rather, they are a function of contextual and theoretical factors that guided the research and support its relevance. The contexts and theories, which provided the focus for this study, have been presented. These factors of context, theory, and the general representation of this study, along with the specification and elaboration of its methods and outcomes, provided the necessary basis for validity and warranting of the contributions (Gorard, 2002).

Research limitations: Research findings drawn from the first iteration of the AR cycle may have been biased by the nature of my active intervention in the organization. This intervention may have biased the research findings by affecting the workflow users to behave in an artificial way, exactly what I wanted to avoid i.e. my key reason for the selection of action research method in the first place. For example, my access to the chief operating officer, may have led staff to use the workflow automation more intensely than they would have otherwise done, as staff were asked both to participate and to use the workflow automation to communicate and coordinate their activities. Although I understand that my intervention might have biased the research findings, I believe that the context created by my intervention have been documented in detail to allow for its replication in similar circumstances.

The research findings based on the second, third and fourth research iterations may have been biased by my involvement with the organizations studied and by the small samples of some units of analysis. My presence may have led the workflow participants to behave in an artificial way. I tried to minimize this source of bias by refraining from influencing the content of the workflows. Several workflow participants declared that they were unaware of my involvement, until they were asked to be interviewed.

The small sample of some units of analysis might have distorted some conclusions. It should be noted, however, that findings based on comparisons across organizations and events are based on smaller samples (N=3 and N = 4, respectively) than those based on the comparisons of respondent perceptions (N = 214) and workflow message (N = 11,535). Moreover, all findings are supported by multiple sources of data; notably participant observation, unstructured and structured

interviews, and workflow messages transcripts. Nevertheless, I believe that the findings in this study should be seen as descriptive and preliminary.

Opportunities for future research: Data must be processed to make useful information and information must be organized and understood to form knowledge. Further, knowledge must lead to action in order to be of value to human existence. The findings and implications of this study, qualified by reasonable validity constraints and formulated as an original contribution to knowledge, provide grounds for further study into the cognitive and cooperative activities that occur in strategic performance management of supply chains.

"What are the effects of collaborative solutions on strategic performance management of supply chains?" It was this question that started the thesis, led to the research design, guided the analysis and structured the discussion. Three manufacturing organizations were studied along 4 iterations, using AR guided by Gowin's Vee. The research resulted in the development of the strategic performance inhibitors model that led to the refinement and classification for strategic performance inhibitors. Workflow automation effects were grouped into two classes i.e. degree of reliability and degree of applicability. Further consolidation of the effects from these two classes in the form of a causal diagram provides the basis to answer the research question.

One of the main contributions of this research has been to describe these effects through causal models based on data collected, building upon and extending existing theoretical models. Even though a number of context-dependent models were developed, the effects reported in this research, have been exploratory and interpretive, some of them depicting effects that appear somewhat generic, no rigorous assessment was made as to the actual intensity of these effects. This calls for more research, particularly of a predominantly quantitative (but not necessarily positivist) nature. Testing this extended models, employing strategic performance inhibitors developed and used in this study, is the next step to come to prescriptive conclusions regarding the effects of workflow automation on strategic performance management of supply chains.

Appendix A: Workflow Events

1. Introduction

In this appendix, with reference to Figure A1 below, is outlined a description of each of the workflow events and interactions of the AR iterations in this study. Event description comprises:

a) **Objective:** why the workflow automation is deployed, typically in the form of a general problem faced by the manufacturing and supplier organizations in which the workflow is to be deployed and related coordination pressures faced by the organizations to be involved in the study,
b) **Modeling**: how the workflow is model, what functions are included to take part in the definitions of workflow, routings, escalation processes and rules of engagement,
c) **Features**: general features of the workflow such as cycle time, total number of interactions, number of individuals involved, number of workflow messages, response quality and proportions of total time spent by participants on coordination and expediting by means of workflow and face-to-face meetings,
d) **Interactions**: how each of the transactions is conducted and
e) **Results:** what are outcomes of the workflows in terms of actual workflow performance and short-term organizational implications?

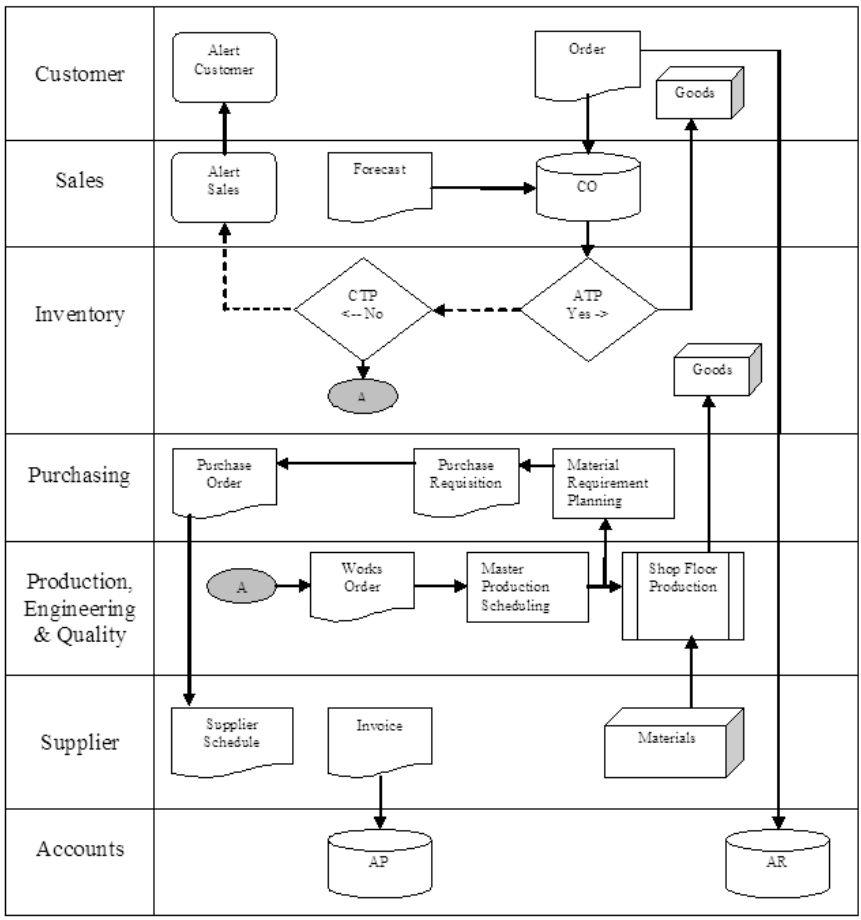
2. Event 1: Customer Order Processing

2.1. Objective

This event is a representation of the interactions of the sales department on the one hand, with the customer i.e. customer facing functions and on the other with Engineering and Production i.e. back office functions. During this interaction, the customer forms an impression of the manufacturer's service level. It is during this stage in the relationship that the customer has many questions that need to be answered. At the same time, the customer would also like to share information on the problems that they are trying to resolve with the manufacturer's products. Information availability and accessibility on the part of the sales department (at the manufacturer's organization) is crucial to ensure a successful order closing (i.e. making a promise).

This event is also selected from the research perspective in that, if the first step is correct, The subsequent actions and interactions will be both amicable and smooth for all parties i.e. customer and manufacturer. Supply chain performance management starts with the customers demand. Becoming aware from a cognitive standpoint, of what the customer *actually* wants is the first step. In this step an offer is made i.e. in terms of price, quantity, delivery date and quality. Acceptance of the offer constitutes a contract. Non-conformance of these terms shall constitute a breach of the legal and contractual obligation. Therefore, it is important to be certain of the *situated capability (Capable-to-Promise: CTP)* at the point of sale i.e. order closing.

Figure A1: Workflow Process Diagram



2.2. Modeling

The sales manager is appointed to take leadership of the customer order processing workflow team. The team has ownership for these workflows. The routing of the workflow starts with a request for quote coming in from an external party i.e. customer or sales channel. The sales will attach this request with the sales costing worksheet and forward to planning for delivery date promising. After confirmation of the delivery date from planning, the product delivery date with quantity and price is sent via workflow by sales to the customer. If there are no requests for changes or clarifications, the order is confirm by the customer to the sales (i.e. manufacturer) via the same workflow. The sales department personnel forward the same workflow with the confirm order to the planner. The parties involved in this event and therefore workflows are:

a) Customer Service, Sales and Planning departments of manufacturer or/and
b) Manufacturer's purchasing department and Supplier's sales and planning departments.

Some of the key components of modeling the workflows are triggers for setting up of alerts and escalation. Triggers are software components that automate the workflow process of alerting the parties concern based on *condition* settings of the workflow system. Escalation is an alert based on *temporal constraint* settings of the workflow e.g. if the request from sales for delivery date is not updated to a workflow within 24 hours, the planning department manager automatically gets an alert (i.e. an email message) requesting attention. Rules of Engagement are behavioral protocols based on the supply chain service level agreement (SLA). Parameters of triggers for alerts and escalation are setup based on these SLA protocols.

2.3. Features

The workflow for customer order processing is integrated with inventory management and production planning modules of the ERP software. This enables data to be accessed from a central repository. This workflow capability is seen as a first level of integration amongst the different functions, processes and people. This is cross functional integration is achieved through *data integration.*

Therefore, with the right authorization, sales can now independently make promises on order fulfillment to customers' based on stock availability and allocations. In the case where stock is not sufficient, there

is no need to telephone or request the planner for a face-to-face meeting to coordinate and expedite production. The sales only need to trigger a workflow. The planner will need to response with the delivery dates (CTP). The planning department is obliged to response within the standard times agreed in the Rules of Engagements. This can vary based on Customer type, Order type, Product type, Delivery Date and Priority Code.

2.4. Interactions

In the quotation/estimated order stage, the first interactions are mainly between the customer and sales department (i.e. manufacturer) for orders that could be fulfill by stock on hand i.e. available-to-promise (ATP).

Second interaction takes place in cases where there is not enough on hand quantity; interaction with the planners on CTP became necessary. When it comes to CTP, there is always a need to resolve the conflict in the interface between the sales and planning functions. Sales function, under competitive pressure would want to meet the customers' demands. In some cases especially where the customer is not willing to pay extra for shorter lead times. However, the planning department, under the constraints of material requirements, capacity limitations and current backlogs has to propose a delivery date further out to the future.

The third interaction takes place between the sales and planning departments upon order confirmation. The customer order has to be cross-referenced to the Job order (or works order). The planning and production departments execute based on Job orders. This allowed for better planning schemes and utilization of the resources e.g. furnace capacity, machine set-up time, skill set and production constraints. However, when sales wants to track the progress of a customer order, planning and production functions are disrupted from their routine production activities to get work in process (WIP) data requested by sales for tracking purposes. Workflow enables this to be done asynchronously without individual function disruption. A workflow would remain active until such time that a customer order is dispatch. Triggers will sent out alerts based on exception conditions, thereby keeping all in the workflow informed of any potential problems.

2.5. Results

A qualitative evaluation of the workflows, based on sales and planning workflow participants' perceptions indicates a slight increase in the

perceive quality and productivity of the communication and coordination process, and a partial solution to the resolution of the conflict of interaction between the sales and planning functions.

The workflow team leaders perceive the outcome of the workflows as generally positive, and noted that the asynchronous mode of communication enabled by workflow automation has allowed the planning department staff to tackle a number of problems, that in the past were not given any attention. This has been mainly due to individual function disruptions and busy schedules preventing attention to find alternative solutions or "workaround" to customer order fulfillment problems.

The customer perception of the workflow deployment is that the promised dates are more realistic i.e. upon order confirmation, the probability that delivery will happen is higher. Another observation from the customers' perspective is that the manufacturer's planning department indeed exercise due diligence based on factual data (i.e. MPS), before making any promise of delivery.

3. Event 2: Production Planning

3.1. Objective

This event is a representation of the interaction the planners have with the production (i.e. capacity) and purchasing (i.e. materials) functions. Upon receipt of the confirm order, the result of negotiations between the customer and manufacturer (i.e. sales and planning functions). The planner generates a Job order (works order) to authorize production to schedule (i.e. MPS) and sequence the work centers and operations based on the standard routing. At the same time, based on the product bill of material (B.O.M) an MRP run generates the material requirements. The list of materials to be purchased is sent to the buyer.

Due to the dynamic nature of production activities and need for up to date information on materials and capacity, during these interactions, usually there is a lot of "finger pointing" as errors in data consequently leads to scheduling problems. The planners have to consider the current capacity loads, material availability, machines status, and so forth; all this variables adds to the complexity of scheduling coupled with the ever changing production flow of activities. As changes happen, all parties

need to be informed and be “in-sync”. This in itself can be a challenge. Coordination activities to realign the MPS to changes have always cause disruption of production activities.

3.2. Modeling

The planner is appointed to take leadership of this production planning workflow team. The team has ownership for these workflows. The routing of the workflow starts with the order confirmation from the sales department. Upon order confirmation, the planner will commit the planned resources i.e. capacity and material that were allocated to this customer order at the quotation stage. Any changes in the production situation are given consideration at this point. The data on work centers and B.O.M is used for the scheduling and sequencing of Job orders through the work centers and operations.

The functions involved in this event and therefore workflows are: planning, production purchasing and engineering. This is very much an internal integration workflow. If any production variable is reported outside the acceptable tolerance against the set standards, then triggers in the workflows will send off alerts to all parties, calling for attention and action. In cases where the issue in production is so intense, as to affect the promised delivery dates, sales department will also be notified along with the other participants of the workflow.

3.3. Features

The workflow for Production planning is integrated with engineering database. Enabling data accessed on B.O.M and Routes by planners. This workflow integration clarifies the data owners from the data users’. A clear distinction of the roles and responsibilities can now be established as interactions during the production planning and scheduling stages take place.

The workflow is also enabled to handle the Engineering Change Notice (ECN). This ECN is seen as the most disruptive activity both for planning and execution. ECN are introduced to the system, as and when, the customer or engineering needs to correct or contain a product or process quality related problem.

3.4. Interactions

The first interactions are mainly between the planners, production supervisors and buyers. The production supervisors in the study organizations have usually have been around on the production floor for many years. Likewise, the buyers, having their own set of purchasing objectives to achieve i.e. lower purchase price, quantity discounts on purchase, better payment terms and so forth. For the planners, getting the production supervisors and buyers, to coordinate and expedite customers' orders (i.e. changes to schedules) in a face-to-face meeting is very challenging and stressful. It is also one of the main reasons for high turnover of staff in the planning departments of both MAK and STS.

The second interactions are mainly between the planners, production supervisors, and buyers and engineering for ECN related matters. Although necessary, ECN activities are seen as disruptive to both planning and production. Authorization of ECN is a mandatory requirement. Each time an ECN activity arises; many working hours will be lost on non-productive discussions caused by managers with influence over the coordination and expediting team dominating the meetings.

3.5. Results

A qualitative evaluation of the workflows, based on the planning, production and engineering staff perceptions indicated an increase in the efficiency of communication and integration of the activities of the different functions and to a lesser extend an increase in the quality and productivity of the planning and ECN process.

The workflow team leaders i.e. planners, perceives the outcome of the workflow as personally less stressful in implementing change and expediting. The asynchronous mode of communication enabled by workflow automation reduces individual function disruptions and allowed for easy tracking of the events and interactions. Written messages are seen as commitments that could be used as evidence in future meetings as compared to verbal means of communications. There seems to be a shift of some stress from the planner to production supervisors and buyers. Workflow requires a written form of justification and clarification on part of the production supervisors or buyers in cases of non-agreement to expedite or reschedule.

4. Event 3: Purchasing

4.1. Objective

This event is a representation of the interactions of the purchasing department i.e. buyer with production planners, suppliers and subcontractors.

The planners issue purchase requisitions for materials and parts, to be purchased based on MRP, to the buyer. The buyer then has to source the materials, parts and services given the parameters of quality, quantity and time these are required at the shop floor. The best price, without compromising on the other parameters, is the buyers' key performance index (KPI). Both MAK and STS have group and certified all suppliers to tier 1 or tier 2. The motivation for this certification came about through the EDB LIUP (Economic development Board, Local Industry Upgrade Program) initiative.

This interface i.e. purchasing communication and coordination, has been the source of miscommunication between the planners, engineers and production personnel internal to the organization and the suppliers, contractors and service providers outside the organization. The buyer not having sufficient technical knowledge as the engineers and production personnel requires the participation of these people when having face-to-face meeting with the suppliers and subcontractors. Engineers and production personnel see such meetings as a "waste of time" and a disruption of their routine functional activities.

4.2. Modeling

The buyer is appointed to take leadership of this purchasing workflow team. The team has ownership of these workflows. The routing of the workflow starts with a purchase requisition from the planners for direct material. For indirect material i.e. production maintenance the purchase requisition comes from production supervisors. For process/machine related parts i.e. die, tools and spares the purchase requisition comes from engineers.

The purchase requisition is routed via the department head and upon approval; it is directed to the respective buyer. The buyer then sends the purchase order to a particular supplier i.e. tier 1 or 2. In the case that it is

a new product/part/service, at least 3 quotes are solicited. The Purchasing Board Meeting is convened and a supplier is selected.
The parties involved in this event and therefore workflows are: Planner, production supervisors, engineers, buyer and the supplier organization. The workflows are set up with 4 main criteria:

a) The right quantity
b) The right time (delivery date)
c) The right quality, and
d) The right price

If any of these criteria is violated, a trigger sends a message to all parties concerned, alerting them of the potential problem and compelling corrective action to be taken. Based on the performance, the suppliers are certified as tier 1 supplier. Violating the performance criteria too often gets supplier demoted to tier 2. Preference is given to Tier 1 suppliers.

4.3. Features

The workflow for purchase order processing is integrated with inventory management and engineering drawing database. This enables buyers to attach technical drawings of component to purchase orders. Multi-media capability of the workflow enables clear explanations and remarks on materials, parts and components to be purchased without any need for a face-to-face meeting with the suppliers. There is no need for the buyer to be an interface between the engineer and the supplier. No data is lost in the transfer of the information to different parties

The workflow also provided an efficient database on the history of supplier performance i.e. in terms of message quality, response time, workflow cycle time, inputs from supplier on improvements and delivery in full and on time (DIFOT).

4.4. Interactions

The first interactions are mainly between the planners, engineers and buyers. These interactions did cause some frustration on the part of the engineers, mainly due to the buyers' strong emphasis on cost factor and not having first completely evaluating the technical details. Often times, technical details are not conveyed with the same intensity, to the suppliers, as the engineers would have liked. It is evident at MAK and STS, that the buyers, although from a technical background, did not have the same level of technical competency as the engineers. This often times

resulted in the engineers having to meet with the suppliers at short notice, causing disruptions to their functional routines.

The second interaction took place between the buyers and suppliers. After, the order has been awarded to a supplier. Often times, the suppliers after having returned to clarify the scope of supply with the engineers, requested the buyer for a change in the price, delivery date and so forth. This request for change (variation order) is made on the basis of new data made available by the engineers that impacts the scope of supply. Such variation orders happen only too often, causing frustration on the part of the buyer.

4.5. Results

A qualitative evaluation of the workflows, based on the purchasing and engineering participants' perception indicated a decrease in message equivocality. There is no compromise in quality of information i.e. context or content, during the transfer of message from the engineers to the suppliers. These also as a consequence reduce disruptions in the routine functional activities. The relationship between the engineering and purchasing department is seen to be improving.

The workflow team leader (buyer) perceives the outcome of the workflows as positive. He noted that, the multi-media functionality combined with the asynchronous mode of communication has been very effective in resolving his communication and coordination problems both with the engineers and suppliers. The buyer also experience fewer confrontations from both sides.

The suppliers' perception of the workflow, as an external party, is that they could better integrate with manufacturer (i.e. MAK in the fourth AR iteration) for a long-term partnership built on mutual trust. The suppliers felt that they are getting all the information necessary directly from the source. Their quotes are more realistic, based on written messages.

5. Event 4: Shipping

5.1. Objective

This event is a representation of the interaction of the shipping department and the customer. During this interaction, there is a transfer of

goods title to the customer. This event signals the completion of a sale or contractual obligation on the part of the manufacturer. The customer now has to decide to accept the goods and make payment. If the goods are indeed up to the customer's quality levels, he accepts them and makes payment. If however, the goods fail the incoming quality control of the customer. Then the goods are rejected.

The manufacturer's goal is to ensure that the customer accepts all deliveries. Rejection of goods is a very painful process for both parties. The manufacturer has to rework the products, this adds to cost of production. Goods are not only rejected for quality reasons, but also incorrect quantity, incorrect delivery date, incorrect packaging and so forth. This waste due to goods rejection can be avoided by taking positive action upstream during customer order promising, planning, production and purchasing activities. For the customer, such rejections may impact negatively the customer's own order fulfillment workflow.

It is too late for any purposeful action, to find out at the delivery stage, that the delivery cannot be accepted. A mechanism to ensure that all deliveries planned shall be accepted, have to be put in place to avoid "waste". There is a need to synchronize the manufacturer's finished good quality procedures with that of the customer's incoming quality standards.

5.2. Modeling

The Quality Control (QC) Manager is appointed to take leadership of the shipping workflow team. The team has the ownership of these workflows. Order confirmation from sales to production planning initiates the workflow. At this point, engineering will submit as attachment to the workflow i.e. all quality control compliance measures. The QC manager then has to organize the QC function to ensure compliance i.e. material receipts, in-process QC, Sub-assembly QC and so forth.

The parties involved in this event and therefore workflows are: customer, sales, engineering, production, purchasing and QC. The workflow is initiated by the workflow team leader upon receipt of order confirmation from sales. This workflow does not come to completion until the goods are delivered and accepted by the customer. Return good are handled within the same workflow until such time as rework and repair has made the goods deliverable or the order is replaced or cancelled.

5.3. Features

The workflow for delivery is incorporated into the QC process. Quality needs to be built into the product right from the start. This workflow compels engineering to adhere closely to International Standards Organization (ISO) and Quality Standards (QS) requirements. By starting at the beginning of the planning and production processes, the “waste” due to rejection, rework, repair and scrap will be eliminated.

The workflow has also been integrated with the quality control system. Any non-compliance or variance from the standard set on the trigger. A message to all parties concerned will be transmitted. This alerts the workflow team of the potential problem and corrective action can be applied. The workflow also provided an extensive knowledge base of past problems. Including the resolutions adopted by the manufacturer and accepted by the customer’s incoming QC.

5.4. Interactions

The first interactions are mainly between the QC, purchasing, engineering and production supervisors. Quality controls means and methods are clarified. These are documented and approval is needed from the customer’s incoming quality control. Once this is approved by the customer’s incoming QC, all purchasing and production activities can be initiated i.e. a flag is set in the workflow system.

Second interaction is mainly between the QC and engineering of the manufacturer and the customer’s incoming QC. This interaction is to negotiate the degree of compliance and deviations to the standards. This negotiation requires empirical data, technical drawings, past performance records, certifications and so forth. Multi-media functionality allows for these specific types of documents to be attached and routed along the workflow.

Third interaction is mainly between QC and production of the manufacturer and customer’s incoming QC, after goods are rejected and return to the manufacturer. Remedial actions are proposed to the customer’s incoming QC for acceptance. Rework can only start upon customer’s incoming QC acceptance of the proposed remedial actions.

5.5. Results

A qualitative evaluation of the workflows, based on the QC and production participants' perception indicates a moderate improvement in the coordination of the internal QC function to that of the customer's incoming QC. This could be that not all customers incoming QC adopt similar means and methods of measure. However, the same people feel that it is a good start, in the long-term, significant improvements are expected.

The workflow team leader (QC Manager) perceives the outcome of workflows as positive, in so far as a means of communication and coordination. There is less disruption when communicating with the customer's incoming QC and engineers in the asynchronous mode enabled by workflow. There is also the opportunity to conduct proper sampling and study before responding. Fault reporting and corrective action proposals are also disseminated more efficiently to all in the workflow team

The customer incoming QC perception of workflow for cross functional integration with manufacturer (i.e. MAK in the fourth AR iteration) is seen as positive.. They felt that with the written messages and attachment, it is much easier than talking over phone and getting information by fax. Organizing face-to-face meeting has been proven in the past to be both time consuming and disruptive to routine operational work.

Appendix B: List of Questions Used

This is the list of questions used in the 2nd, 3rd and 4th iterations of the AR cycles. The questions are design to identify effects arising from the deployment of workflow automation i.e. collaborative solution on strategic performance of supply chain and are based on the research framework developed during the first iteration of the AR cycle. These are in addition to the questions that are part of the research framework (Chapter 3). The questions are split into four sections: *contextual questions, network unit of analysis related questions, entity unit of analysis related questions and individual unit of analysis related questions.*

1. Contextual questions

S/No	Question asked
1	What is your name?
2	What is your function in the organization?
3	Have you participated in face-to-face coordination/expediting meeting before, approximately how many?
4	Have you participated in an automated workflow before? Approximately how many?
5	How many hours (estimate) did you spend participating in these workflows? That is including message reading and preparation and other oral i.e. phone calls and casual discussions at the cafeteria with other participants.

2. Network unit of analysis

S/No	Question asked	Variable
1	Sometimes it is difficult to gather people from different departments and to get them to work together in a "team" due to problems such as different timetables, lack of communication, and distance. Did the use of workflow automation make it easier or harder to have individuals from different departments working together at short notice? Why?	Functional heterogeneity
2	Sometimes individuals need access to information concerning certain activities, e.g. how many ECN are authorized this month, in order to continue with work. Fetching information may be disruptive to the individuals' routine function. Did the use of workflow automation improve or impair ready access to information relevant to the workflows? Why?	Information access
3	Did the use of workflow automation improve or reduce the quality of the response in terms of completeness? Why?	Quality of Response
4	Did the use of workflow automation increase or decrease interaction in workflow team? Why?	Interaction
5	Sometimes, in groups, social cues - such as cues suggesting a participants status within the organization - will affect the way individual contributions are viewed by the team. Did the use of workflow automation increase or decrease the social cues in the workflows teams? Why?	Social cues suppression

3. Entity unit of analysis

S/No	Question asked	Variable
1	A structured teamwork can be characterized as being focus on the team goal and not drifting off i.e. customer synchronization and following a smooth and continuous path, from problem definition to solution implementation. Did the use of workflow automation leads your workflow team to work in a more or less structured way? Why?	Team formation for collaborative workflows
2	Sometimes, in teams, ideas from individuals at higher managerial levels (e.g. QC Manager) are taken in higher regard by team participants than those proposed by individuals at lower managerial levels (e.g. Internal Sales Coordinator). Did the use of workflow automation help with leveling the influence of individuals from different managerial levels in your workflow team? Why?	Hierarchy suppression
4	There are several costs involved in running a workflow, such as those resulting from disruption of regular activities, and time spent in meetings. Did the use of workflow automation reduce or increase the operational cost of coordinating and expediting? Why?	Enabling cost
5	In your opinion, will managers give more or less support to workflow deployment (e.g. allocation of subordinate staff time, budget contribution for implementation)? Why?	Management support
6	In your opinion, will the use of workflow automation increase or decrease the likelihood of success of a full-blown cross functional integration through workflow deployment to improve strategic performance of supply chain at MAK? Why?	Organizational success of a process-focused improvement

4. Individual unit of analysis

S/No	Question asked	Variable
1	Sometimes an individual has an opinion, which is contrary to other members' and he or she wants to impose his or her opinion on the team. Did the use of workflow automation make it easier or harder for individuals to dominate or impose their views on the team? Why?	Influence
2	Did the use of workflow automation increase or decrease individual participation in the workflows? Why?	Participation
3	Is the use of workflows likely to increase or decrease individual repercussions, in the organization, of the opinions expressed by the participant in the workflow messages and responses? Why?	Repercussions

Appendix C: Authorization (Organizations)

The following letter and authorization form are sent to the chief operating office of the organizations participating in this study. The goal is to obtain a written acknowledgment that these managers are aware that this study is being conducted in their organizations. Further an authorization to acknowledge the participation of the organization in this study for publication of the study findings in research journals.

1. Letter

(Title and name of chief operation officer or general manager)
(Position description)
(Name of the organization)
(Date)

Ref: Authorization for acknowledgment of participation

Dear (*title and surname of chief operating office*),

Between (study start and end dates) I will be observing the deployment of workflow automation comprising of staff from (*names of the departments/suppliers that will participate in the study*) at (*name of the organization*). These workflow teams have seven to fifteen members each, and their goal is to select, analyze and model a number of inter-functional workflows at (*name of the organization*) in order to improve supply chain synchronization efficiency, effectiveness and supply chain manager competency. Prior to running the workflow teams, I will also seek authorization at the local level i.e. with heads of department.

During the facilitation of the workflow teams I will be collecting research data in the form of interviews, participant observation and workflow transcripts. I will also sought authorization to use these research data in academic publications from the participants themselves.

I would now like to ask you to please fill out the authorization form enclosed and return it in the self-addressed envelope provided, indicating that you authorize the participation of (*name of the organization*) to be acknowledged in any thesis or academic publication resulting from this study. Acknowledging the participation of (*name of the organization*)

will disclose to the readers of the publication that the research data is collected at (*name of the organization*).

Yours sincerely,

_____
Wilfred Rachan, PhD Student
University of Leiden

2. Authorization form

(Date)

Authorization for Acknowledgment of Participation

I hereby acknowledge that Wilfred Rachan in collaboration with staff of (*name of the organization*) have collected research data between (*study start and end dates)*, during his research study on "The Effects of Collaborative Solutions on Strategic Performance Management"

The sources of the research data collected will remain confidential. Whenever the research is discussed in a thesis or related academic publication the name of the person contributing any piece of data will be disguised or removed.

I do / do not (please strike out one) authorize the participation of (*name of the organization*) to be acknowledged in any thesis or academic publication resulting from this research. I understand that if I do agree with this acknowledgment. The readers of the publication will know that the research data was collected at (*name of Organization).*

_____
(Title and name of chief operating officer)
(Position description)
(Name of the organization)

Appendix D: Authorization (Individuals)

The following letter and authorization form are sent to individual participants of the organizations participating in this research project. The goal is to obtain authorization to use research data contributed by those participants in research publications in association with this study finding.

1. Letter

(Title and name)
(Position description)
(Name of the organization)
(Date)

Ref: Authorization for acknowledgment of participation

Dear (*title and surname*),

Between (*study start and end dates*) you participate in (*description of the nature of participation of the individual*) at (*name of the organization*). During this participation, I will be collecting data (*description of the research data collected i.e. workflow messages, responses, coordination, expediting and interview transcripts*) contributed by you.

I would now like to ask you to please fill out the authorization form enclosed and return it in the self-addressed envelope provided, indicating that you authorize the research data contributed by you to be used in any thesis or academic publication resulting from this research. The research data i.e. object of this authorization will remain confidential and will not be used by any person other than the researcher.

Yours sincerely,

_____
Wilfred Rachan, PhD Student
University of Leiden

2. Authorization form

(Date)

Authorization for the Use of Field Research Data

I hereby authorize the study data contributed by me in the form of (*description of the research data collected i.e. workflow messages, responses, coordination, expediting and interview transcripts*) to be used by Wilfred Rachan. The research data is collected during the facilitation of workflow modeling and deployment at (*name of the organization*).

The research data i.e. object of this authorization will remain confidential and will not be used by any person other than the researcher. Whenever the research is discussed in a thesis or a related academic publication, the name of the person contributing any piece of data will be disguised or removed. No information identifying its originator will be published in any report based on the research data i.e. object of this authorization.

_____

(Signature)

_____

(Name - capital letters please)

_____

(City and date)

Appendix E: Table of all Variables Identified

1st Iteration	2nd Iteration	3rd Iteration	4th Iteration
37 new variables identified	30 new variables identified	5 new variables identified	No new variables identified
Event	Barriers to Collaborate	Interfunctional Knowledge	
Uncertainty	Formation of Teams	Management Support	
Workflow deployment	Individual contribution effort	Cross Functional Integration	
Geographic and Time Diff.	Service level Agreement (SLA)	Threats to Management	
Interaction	Written message	Throughput Bandwidth	
Equivocality	Degree of Interaction		
Multi-media	Computer skills		
Informed decisions	Set up Time		
Quality of Response	Participation Cost		
Response time Delay	Disruption Cost		
Synchronization Efficiency	Delay cost		
Synchronization Effectiveness	Set up Cost		
Synchronization Competency	Personal Contact		
Coordination skills	Individual influence		
Days of Inventory	Demand for Leadership		
Service Level	Function Disruption		
Days of A/P	Workflow Cycle Time		
Days of A/R	Workflow Change Adoption		
Cash	Anonymity		
Profit	Individual Participation Control		
Assets utilization	Individual Influence		
Cost of Coordination	Individual Stress		
Site Heterogeneity	Team Contribution Distribution		
Department Heterogeneity	Individual Commitment		
Efficient Database	Individual contribution quality		
Turn Taking	Individual Sincerity		
Response time	Individual Learning		
Reaction Time	Workflow Decentralization		
Individual Satisfaction	Individual participation		
Enabling Cost	Individual Participation Threat		
Sequential Delays			
Function Disruption			
Demand for Leadership Skills			
Personal Contact			
Team Focus			
Busy Schedule			
Message Quality			

Appendix F: Descriptive Statistics

Input to Statistics program for calculation of coefficients of correlation (Pearson):

AR Iteration	3rd Iteration		4th Iteration	
EFFECTS	Decrease	Increase	Decrease	Increase
Individual Influence	-45	11	-74	5
Message Quality	-7	80	-10	65
Change Adoption	0	63	-15	69
Satisfaction	-29	33	-31	40
Commitment	-13	72	-23	44
Learning	-7	51	-23	53
Heterogeneity	0	93	-7	82

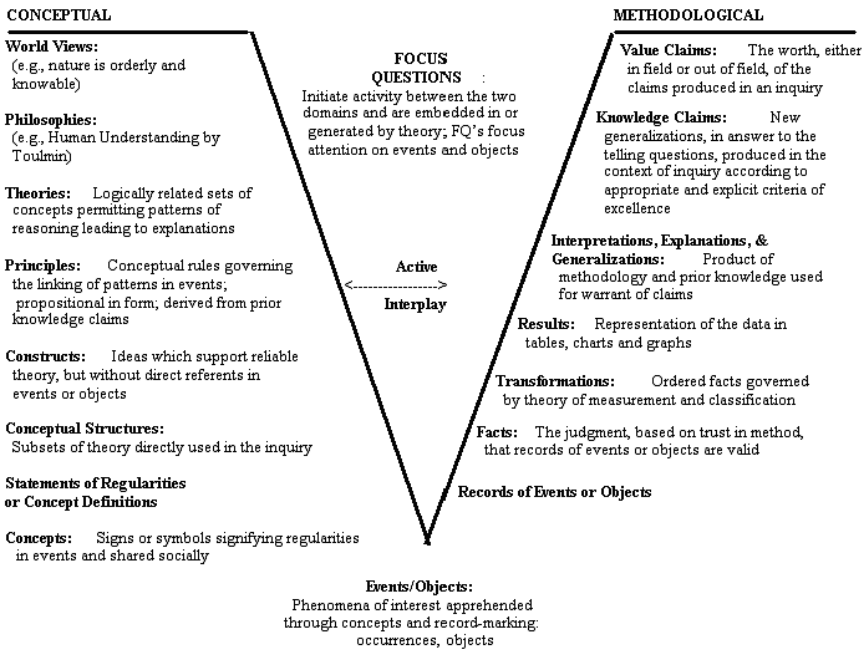
(r = the Pearson product-moment correlation coefficient)

Output from statistics program:

1. Frequencies of respondents who perceive those variables as having been increased: r = 0.89

2. Frequencies of respondents who perceive those variables as having been decrease: r = 0.88

Appendix G: Gowin's Vee



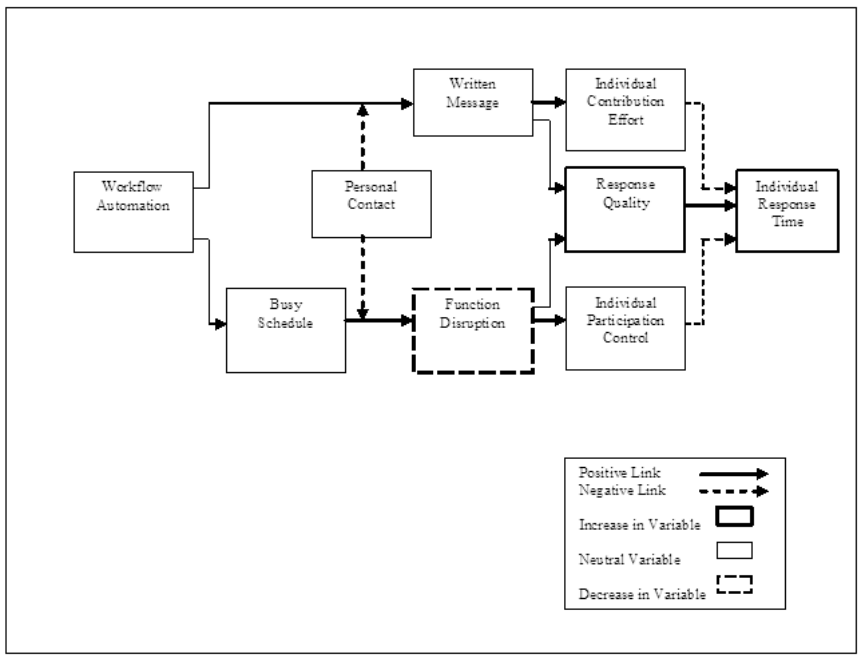
Appendix H: Deriving Explanations

Variable 1	Workflow Automation
Variable 2	Response Time
Effect	Workflow Automation increases Individual Response time
Confirmatory Evidence:	
1	Among structured interview respondents 65 percent perceive workflow automation as having increased Individual Response time (TB4).
2	Two participants found it difficult to use workflow automation because of a busy work schedule coupled with limited computer skills, which caused a time constraint on responding to messages. Danny (FN, pg.42) and May (IT4, pg. 9).
3	Three participants noted that there was little or no personal "touch" in written messages and response, which they saw as negative. Emily (IT7, pg.9), Joseph (FN, pg. 45) and Jessica (FN, pg.47)
Disconfirmatory Evidence:	
1	Among structured interview respondents 23 percent perceive workflow automation as having no effect on Response time. 12 percent as having reduce Individual Response time (TB4)
2	Three participants perceive as being better organized and better informed in workflow automation environment to response to workflow messages. Ronald (IT1, pg.8), Samuel (IT4, pg.6) and Vidya (IT9, pg.5).
3	Four participants noted that completeness of response to workflow messages could not have been achieved without workflow automation. This level of quality response, in a face-to-face coordination meeting would have required more time for clarifications with the consequence of being frustrated. Chong (IT1, pg.9), James (IT5, pg. 4), Lyn (IT7, pg.6) and Ferdi (IT4, pg.8)
Explanation building:	
E1	Workflow automation allows people to interact without having to compete for airtime and at their own pace. This leads to a reduction in individuals' function disruption. On the other hand, some members perceive this characteristic of workflow automation i.e. asynchronous mode of communication as contributing to the increase in response time
E2	Workflow automation leads to lower control of individual participation, i.e. on whether individual response or not and after how long. This can lead to a lower level of participation. This plus the fact that the workflow system filters social cues and does not allows for personal "touch" can lead to the perception that workflow automation increases individual response time.
E3	Workflow automation reduces individuals' work disruptions, caused by answering phone calls, unscheduled meetings and ad hoc problem solving. These allow participants with busy schedules to plan with better certainty. The perception that a reduction in uncertainty would have not otherwise occur, leads to the perception that the quality of response is improved. However, this improvement resulting from a written message is more demanding on the individual i.e. contribution effort, leading to an increase in individual response time
Model Construction:	
E1	*Explanation E1 led to the path linking the variable* ***Workflow automation, written messages, Individual contribution Effort and increase in Response time.***
E2	*Explanation E2 led to the path linking* ***Workflow automation, written messages, personal contact, function disruption, individual participation control and increase in Response time.***
E3	*Finally, explanation E3 led to the path linking* ***Workflow automation, busy schedule, function disruption, quality of Response, and increase in Response time***

Causal links between variables are represented with an arrow pointing towards the direction of the causal link. Each arrow is drawn with a solid or dotted line. A solid line indicates that the causal link is positive, i.e. that an increase in the variable at the beginning of the link will contribute to an increase in the variable at the end of the link; a dotted line indicates that the causal link is negative.

Research variables are represented by rectangles with the name of the variables in the middle. Rectangle borders could be either normal solid, bold solid, or dotted. Normal solid borders indicate a neutral effect on the variable they represent, that is, neither an increase nor a decrease in the variable. Bold solid borders indicate an increase in the variable; and dotted borders a decrease

Ref: Chapter 6, Fig 6.6: Path Diagram – Individual Response Time



Appendix I: SAM - Benchmark Report

SIC code specific to the SAM industry and net sales range is data input to BenchmarkReport.com and with this data, a comprehensive search i.e. banking database of over 50,000 companies in more than 600 four-digit SIC codes to identify, the relevant peer group i.e. companies that manufacture similar products and produce roughly the same annual revenue as SAM. The output is a report.

This report is a financial benchmark of SAM performance against that peer group. Based on the balance sheet and income statement financial data input when the report is generated, BenchmarkReport.com will identify how SAM is performing in a number of key financial ratios. Again, referring to the database of companies, a report is generated identifying how SAM's peers are performing in these ratios for comparison.

The balance sheet and income statement data of this peer companies yield a variety of ratios and comparative statistics. These metrics can indicate where discipline and/or investments on the part of SAM may result in a better bottom line and a stronger competitive position. The values are divided into four groups of equal size, often called "quartiles." The groups are classified into 3 categories of performance:

Upper Quartile	Above which you are performing better than 75% of your relevant peer group
Median	Above which you are performing better than 50% of your relevant peer group, and below which you are performing worse than 50% of your relevant peer group; and
Lower Quartile	Below which you are performing worse than 75% of your relevant peer group.

1. Data (Input)

Company Name: SAM
Currency Code: USD
SIC Code: 3564
Date of Submission: August 2008
No. of peer companies used for comparison: 12

1.1. Assets	
Cash & Equivalent	39,500,000
Trade Receivables	72,000,000
Inventory	59,900,000
Current Assets	149,000,000
Total Assets	287,500,000
1.2. Liabilities	
Trade Payables	86,000,000
Current Liabilities	100,005,000
Total Liabilities	214,300,000
1.3. Income	
Net Sales	386,700,000
Cost of Goods Sold	305,400,000
Operating Expenses	59,400,000
All Other Income & Expenses (net)	5,900,000

2. Reports (Output)

2.1. Operating Percentages (as percentage of Net Sales)			
Gross Profit	SAM	21.0	
	12 Peer Companies (Median)	28.6	
Operating Expenses	SAM	15.4	
	12 Peer Companies (Median)	21.6	
Operating Profit	SAM	5.7	
	12 Peer Companies (Median)	7.0	
Other Income (Expense)	SAM	19.6	
	12 Peer Companies (Median)	2.2	
Profit Before Tax	SAM	25.3	
	12 Peer Companies (Median)	4.8	

2.2. Days of Inventory

Fewer days is better: Inventory is not an asset. It is a liability. Its purpose is to protect throughput. Excess inventory hurts quality and increase product cost. Days of inventory are based on Inventory "turns". One turn equals 365 days, and five turns equal 73 days. It pays to attack inventory with religious zeal.

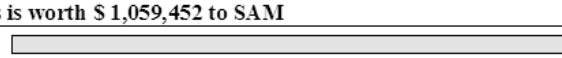
Each day of inventory is worth $ 836,712 to SAM

SAM	72	
Upper Quartile	37	
Median	62	
Lower Quartile	72	

2.3. Days of Receivables

Lower is better: Receivables are simply no-interest cash loans you extend to customers. Their only valid purpose is to encourage sales. Days in excess of terms raise your costs and increase your risk of cash loss. Faster collections is vital to a company's cash flow

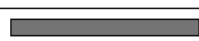
Each day of receivables is worth $ 1,059,452 to SAM

SAM	68	
Upper Quartile	54	
Median	59	
Lower Quartile	62	

2.4. Days of Payables

Higher is Better, but Pay When Promised: Payables are simply cash lent to you at no interest. It is best to conform to internal policy on payables. Negotiate terms to keep your payables as long as you can. Pay when promised, but no earlier.

Each day of payables is worth $ 836,712 to SAM

SAM	103	
Upper Quartile	38	
Median	33	
Lower Quartile	16	

2.5. Assets Turnover Ratio

Higher is Better: Assets Turnover Ratio is a measurement of the productive use of a company's total assets. Largely depreciated fixed assets may cause a distortion of this ratio. Productive use of assets in maximizing sales is a valid measure of any management team's effectiveness

SAM	1.3	
Upper Quartile	2.2	
Median	1.7	
Lower Quartile	1.1	

2.6. Return on Assets Ratio

Higher is Better: Return on Assets Ratio expresses the pre-tax return on total assets and management's effectiveness in employing resources to drive bottom line profits.

SAM	34.0	
Upper Quartile	12.0	
Median	5.9	
Lower Quartile	3.9	

2.7. Current Ratio

Higher is Better: Generally, the higher the Current Ratio the greater the "cushion" between current obligations and a company's ability to pay them. The composition and quality of current assets is a critical factor that bankers use in the analysis of any company's liquidity.

SAM	1.5	
Upper Quartile	3.2	
Median	2.5	
Lower Quartile	1.2	

2.8. Quick Ratio

Higher is Better: Sometimes referred to as the "acid test," the Quick Ratio is a refinement of the Current Ratio. This ratio is a more conservative measure of liquidity and expresses a company's ability to cover its current liabilities by its most liquid assets

SAM	1.1	
Upper Quartile	2.1	
Median	1.3	
Lower Quartile	0.8	

2.9. Working Capital Ratio

Higher is Better: The Working Capital Ratio is a measure of how efficiently working capital is being employed. It is a reflection of the margin of protection for current creditors. A ratio too low may indicate an inefficient use of working capital, while a ratio too high may indicate over-trading.

SAM	8.0	
Upper Quartile	31.9	
Median	5.5	
Lower Quartile	4.1	

2.10. Debt-to-Equity Ratio

Lower is Better: Highly leveraged companies (those with heavy debt in relationship to business net worth) are usually more vulnerable to business downturns than those with lower debt-to-equity ratios. Considered the most important leverage ratio, evaluators of a company's worth study the Debt-to-Equity Ratio closely.

SAM	2.9	
Upper Quartile	0.6	
Median	1.6	
Lower Quartile	13.5	

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Samenvatting (Summary in Dutch)

Deze studie beschouwt de effecten van collaboratieve oplossingen op strategisch prestatie-management van toeleveringsketens ('supply chains'). De bevindingen zijn gebaseerd op gegevens verzameld bij bestaande fabrieken. Dit stelt ons in staat om de onderzoeksvragen in hun context te beschouwen, zowel wat betreft academische relevantie (vooraanstaand eerder onderzoek op aanverwante gebieden) als praktische bestuurlijke relevantie.

Volgens Kaplan & Norton (1996) zijn er vier strategische doelstellingsperspectieven, gericht op achtereenvolgens: a) financiën, b) de klant, c) interne processen, en d) ontwikkeling en leren. Strategische plannen dienen ten minste de vier hierboven genoemde perspectieven af te dekken teneinde effectief te zijn bij het besturen van de onderneming voor succes op lange termijn. De 'supply chain' discipline dekt alle vier doelstellingsperspectieven af, en heeft veel te bieden voor het behalen van goede prestaties, verhogen van concurrentiekracht en het verzekeren van duurzame winstgevendheid. Het is om die redenen dat voor deze studie het supply chain perspectief centraal staat.

Hoewel alle modellen uit de literatuurstudie zowel de operationele als strategische aspecten van de supply chain performance betreffen, biedt geen enkel model een expliciete verbinding tussen de beide aspecten. Om de onderzoeksvraag te operationaliseren is het absoluut noodzakelijk dat een verbinding wordt gemaakt tussen de strategische en operationele aspecten van de supply chain prestaties. Workflow automatisering levert hiervoor de basis, resulterend in een model dat de supply chain interacties en transactie-dynamiek kan vastleggen. Het doel van het model is om de knelpunten te verminderen door middel van informatiestromen die de communicatie en coördinatie verbeteren in de supply chain. Betere communicatie en coördinatie maken het mogelijk voorraad te vervangen door informatie waardoor de voorraad wordt verminderd en voorraadkosten in de gehele supply chain verminderen.

De vier supply chain-processen waar dit onderzoek zich met name op richt zijn zijn a) verkoopprognose, b) communicatie (waaronder coördinatie), c) planning , en d) productie (inclusief levering). Gerelateerd aan deze vier supply chain-processen zijn vier strategische prestatie-remmers, te weten

a) onzekerheid van de verkoopprognose, b) dubbelzinnigheid in de communicatie, c) complexiteit in de planning en d) variabiliteit in de productie. Het einddoel is om alle strategische prestatie-remmers op een geïntegreerde manier te verminderen , waarbij de omvang van de reductie kan verschillen tussen de vier strategische prestatie-remmers.

Om de onderzoeksvraag te beantwoorden is een proces-georiënteerde onderzoeksbenadering gekozen die rekening houdt met de volle rijkdom van organisatorische interacties en toch geen onnatuurlijke invloed uitoefent op het onderwerp van studie. Vanuit deze gedachte is een aantal organisaties in Singapore met de hulp van Singapore Manufacturing Federatie (SMaF) bezocht; geen enkele organisatie kon echter worden gevonden die met behulp van workflow automatisering de strategische prestaties van hun supply chain beheert. Hierdoor werd de mogelijkheid van het gebruik van non-interventionistische aanpak van het onderzoek, zoals case study of survey-onderzoek, vrijwel geëlimineerd. Derhalve is een Action Research (AR) benadering gekozen.

De eerste iteratie van de AR cyclus volgt een exploratieve aanpak en biedt de empirie om de initiële kennis op te bouwen. Deze kennisverzameling draagt bij aan de inzichten vanuit de literatuurstudie en vormt de basis voor de formulering van een gestructureerd onderzoekskader voor gegevensverzameling en -analyse. Dit kader bestaat uit drie eenheden van analyse (netwerk, entiteit en individu) en een set van het onderzoeksvariabelen rond deze eenheden van analyse. Aansluitend is een instrument gekozen en verfijnd (Gowin's Vee heuristiek [Novak & Gowin, 1984]) dat de latere iteraties van de AR cyclus structureert zodat de doorlooptijd hiervan reduceert wat nodig is door de niet-gecontroleerde omgeving.

De bevindingen zijn weergegeven volgens twee classificatiesystemen: a) de mate van betrouwbaarheid (de mate van intensiteit, de kracht van de waargenomen workflow-automatisering effecten), b) de mate van toepasbaarheid (externe validiteit, in hoeverre de automatisering van de workflow effecten worden waargenomen bij andere organisatie-instellingen).

In dit onderzoek ligt de nadruk op het ontrafelen van de factoren en relaties die de verschillende aspecten van workflow automatisering verbinden met strategisch performance-management van supply chains. Echter, dezelfde punten zijn ook van toepassing op andere gebieden van strategisch performance-management in het bedrijfsleven. De volgende aanbevelingen, gepresenteerd als "

praktische management bijdragen" zijn derhalve zowel geldig voor strategisch performance-management van supply chains als voor andere bedrijfsprocessen:

a) De bevindingen van dit onderzoek maken een geïntegreerde aanpak mogelijk voor managers van (i) probleemstructureren (ii) probleemoplossen en (iii) leren, betreffende mogelijke bedreigingen en problemen ten aanzien van strategische prestaties van supply chains.

b) De voorgestelde indeling van de strategische prestatie-remmers (onzekerheid, dubbelzinnigheid, complexiteit en variabiliteit) biedt een effectieve manier van communiceren en de aanpak van mogelijke risico's voor strategische prestaties van supply chains. Deze classificatie biedt managers een middel om eerdere problemen als kennis te structureren zodat dit kan worden gebruikt door de organisatie indien deze geconfronteerd wordt met nieuwe uitdagingen.

c) Workflow automatisering maakt communicatie en coördinatie door middel van asynchrone aflevering van berichten en actie triggers mogelijk. Dit vervaagt de grenzen van geografie en tijd en verbetert de synchronisatie efficiency drastisch, dwz de juiste volgorde van communicatie en coördinatie binnen de supply chain.

d) Workflow automatisering maakt het mogelijk dat voorraad (dwz de juiste hoeveelheid op het juiste moment en de juiste plaats) kan worden 'vervangen' door informatie (dat wil zeggen de juiste informatie op het juiste moment en de juiste plaats), resulterend in een daling van de voorraden en daarmee een vermindering van de voorraadniveaus en de daarmee verbonden kosten binnen de supply chain.

Curriculum Vitae

Wilfred Rachan was born on September 16, 1959 in Singapore. In 1998 he received his M.B.A. degree with a focus in Strategic Marketing from Hull University (U.K.). Wilfred Rachan completed his M.Phil. degree at Maastricht School of Management (The Netherlands) before enrolling in the PhD program at Leiden University (The Netherlands) in 2005.

Wilfred Rachan started as a computer programmer at Nippon Miniature Bearing Company in 1981 on an IBM 360. This was the beginning of a long journey in Computer Programming and Information Processing. In 1991, Wilfred Rachan was appointed head of the Commercial Systems Division at Siemens-Nixdorf. This was the start of a shift in focus from technical functions to management. He has also held Lecturer positions at the German-Singapore Institute (now part of Temasek Polytechnic) on Production Management Information Systems (Diploma Level), at Singapore Institute of Purchasing & Materials Management (SIPMM) on Supply Chain Management (Diploma Level) and at Adult Education Center (AEC) on Action Learning (Postgraduate level)

Since 2006, Wilfred Rachan has been intensively involved in supply chain management and market development of software solutions for Collaborative Work, Fleet Management (Marine) and Cargo Management Systems. This involvement in supply chain management also created an opportunity to travel on business to many cities around the world, offering an international exposure on the challenges to supply chain performance arising from differences in economic circumstances, geographical location and culture.

Wilfred Rachan's involvement and interest in solving problems relating to supply chain performance and implementing solutions resulted in the development of several models and frameworks for use in business management. He has (co-)authored multiple international refereed conference and journal publications and one paper has been Top-Paper for the category "Supply Chain: Inventory" in 2008 on the Social Science Research Network (SSRN). This professional working experience plus an interest in "Action Learning" application in education have culminated in this thesis. His current research interest includes "Strategic performance management of supply chains", "Management of risk in Supply chains", "Collaborative workflow automation systems" and "Action learning in executive education". Wilfred Rachan is also an active speaker at conferences and seminars on "Action Learning in executive education".