

DEMAND DRIVEN CONTROL CONCEPTS – FORESIGHT IN THE EFFECTS OF RFID

Torbjörn H. Netland¹, Heidi Dreyer², Jan Ola Strandhagen²

*¹ SINTEF Technology and Society
Department of Operations Management
N-7465 Trondheim*

*² Norwegian University of Science and Technology
Department of Production and Quality Engineering
N-7465 Trondheim*

ABSTRACT

In this paper, based on action research in three case projects, we look into the future of demand driven control concepts for companies in commodity supply chains. The paper describes the development of control concepts from its origin of two-bin based systems up to today's advanced computer based concepts. Future control concepts based on access to real-time information is suggested. A clear trend today is that control concepts are becoming more advanced, automated and intelligent, due to the increasing complexity of the manufacturing environment and increasing customer demand for customised products. In future companies need to become faster, more flexible and more responsive, and the possibilities to meet these requirements are given by innovations in ICT and data capturing technologies such as RFID. The change towards sense-and-respond supply chains requires however a deeper transition than just integration of RFID-captured data in existing processes. New demand driven control concepts are needed.

Keywords: Control concepts, supply chain management, Foresight, RFID

INTRODUCTION

Improving operations and strengthening competitiveness imply a broad and holistic supply chain perspective, involving all companies in the value creating process. From a logistical point of view this forms a complex system, where coordination, integration, and planning and control become essential in order to fulfil customers requirements with effective resource utilisation. More flexible and responsive supply chains are called for in the future (Hugos and Thomas, 2006), and new control concepts, control strategies and control principles are needed (Haeckel, 1999). Radio frequency identification (RFID) will play a key role in future supply chains, as enabler for demand-driven control concepts.

The access to real time information and the sharing of this information is a main element in supply chain planning and control in order to prevent the bullwhip effect (Simchi-Levi et al, 2007). Today, point of sales data and stock level information constitute what is termed as real-time demand data.

Often plans are updated once a day based on routine transactions from the customer, or the supplier can have online access to the customer's inventory system.

However for perishable products and products with limited life cycles, daily demand information updates will not be satisfying. Such supply chains will both have to be responsive through the access to continuously updated event and demand information. Development of RFID and sensor technology is expected to be an important enabler for allowing the capturing of continuously updated real-time information. This will allow the development of new real-time control concepts with a mutual supply chain planning and control integrating both the strategic, tactical and operative level. Thus, for companies involved in fast-moving consumer goods in commodity supply chains, it is predicted that a revolution in control concepts will take place in the next decade.

The purpose of this paper is to point out directions for the future development of control concepts. It focuses on the possibilities given by data capturing technology, and the use of real-time information. This will be done by a rather new and exceptional research methodology combining methodology from foresight and action research traditions as first described by Ramos (2002). In order to stay competitive the need for innovation and development is essential and there is a need for both new methodology and knowledge on control concepts. The following research question is put forward:

RQ: How will future control concepts develop as supply chains use RFID to gain real-time visibility?

THEORETICAL BACKGROUND

The need to control in time and quantity the production and flow of goods is closely connected to the number of different products, the variation of demand and the number of companies in the supply chain. A control concept is the fundamental approach for how to operate, control and coordinate the manufacturing and supply chain system (Vollmann et al, 2005; Simchi-Levi et al 2007). Here we define a control concept as the conceptualisation of a control strategy. Thus, decisions on a control concept includes basic choices on control strategy (make-to-stock, assemble-to-order, make-to-order or engineer-to-order (Brown et al, 1996)), on placement of push and pull boundaries and the customer order decoupling point, as well as on the detailed logic of planning and decision-making (Chopra and Meindl, 2007).

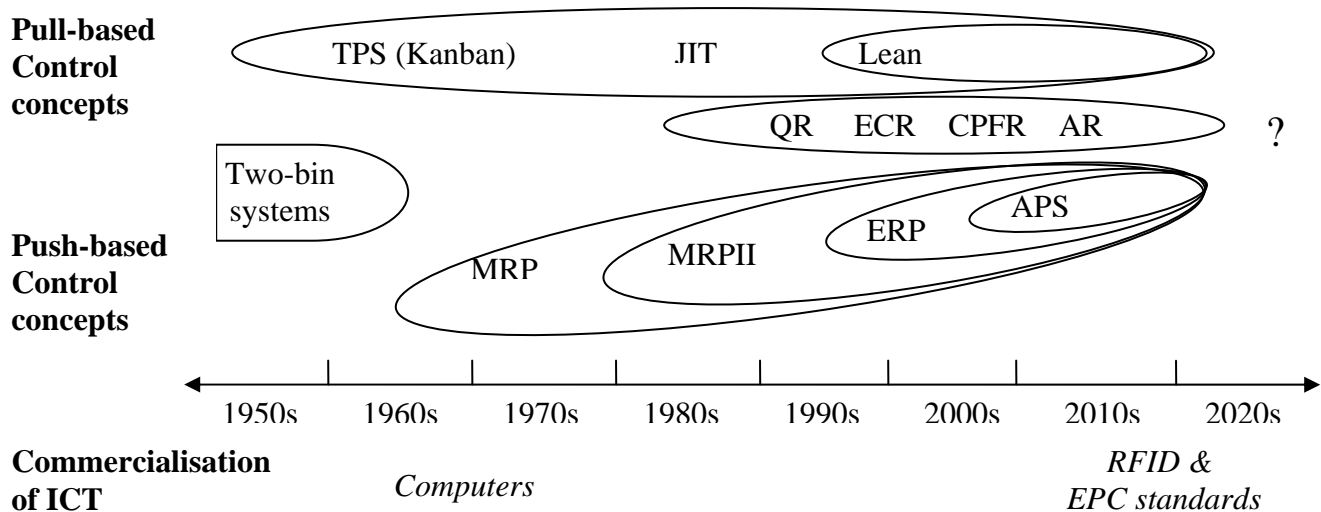


Figure 1A timeline of important historical developments for Control Concepts

Looking fifty years back, when manufacturing operated under less complexity and capacity was regarded as the limitation, when was sold what was produced, and when companies had a much leaner and less variable product range, simple two-bin systems were sufficient to control the flow of components and products. However, as the number of products became larger and more customer specific leading to variability in demand, the need for more advanced control concepts arise. Also, the growing competition and thus the strong cost and price focus lead to lean and resource and cost minimisation operations and planning and control models. This is illustrated in Figure 1. As shown in the figure there has been a development both related to the capacity to handle complexity and scope, and the orientation to more pull-based control concepts.

Push-based Control Concepts

A new paradigm was introduced when computers made their entry (Manetti, 2001). Simple production management mechanisms based on inventory control and later on MRP were put to use. The first manufacturing software dates back to the magnetic tape systems in the 1960s, but true MRP software was first made possible in the 70s, with the introduction of random access memory. According to Vollmann et al (1997) MRP constructs a time-phased requirement record for any part that adds up to a finished product. A MRP production plan is calculated based on three sources of input: The master production schedule, a bill-of-materials and inventory status.

During the 80s the term manufacturing resource planning (MRP II) was introduced, and has since then been used to identify the capabilities of the newest MRP-systems. This way, MRPII is the heir to MRP. Manufacturing Resource Planning (MRP II) is defined by APICS as “a method for the effective planning of all resources of a manufacturing company”. The manufacturing software were all noted MRP II until the 1990s, when the Gartner Group introduced the term enterprise resource planning (ERP), describing software that was integrated both across and within various functional silos in the company. MRP/MRPII is still the most common planning engine for production planning in ERP-systems (Alfnes and Strandhagen, 2000).

Pull-based Control Concepts

In parallel with the development of push-based control concepts, Toyota Production System (Shingo, 1989) and later Lean Manufacturing (Womack et al, 1990) developed. These manufacturing concepts put a focus on value adding and avoiding waste and non-value adding activities, and encouraging a higher degree of demand-driven production. Visual control and Just-In-Time production are the key elements and tools for realising the concept. The basic purpose of lean production is to increase profits by reducing costs through completely eliminating waste such as excessive stocks or work force (Alfnes and Strandhagen, 2000). Traditionally the application has been mainly in shop-floor related areas, and is still with a limited focus and based on the production of predetermined volumes (Kanban quantities). But in the latest decades we have also seen solutions integrating the visual and physical Kanbans with bar coding and electronic information exchange.

A key idea in lean manufacturing is that achieving cost reduction requires production to promptly and flexibly adapt to changes in market demand without having waste and time slack. In line with this, control concepts like Quick Response (QR), collaborative planning, forecasting and replenishment (CPFR), Automatic Replenishment (AR) and Efficient Consumer Response (ECR) have evolved since the 1980s in commodity markets. All these concepts are developed on the philosophy of a common responsibility of fulfilling customer demand though the sharing of order and forecast information and by so improving the information quality used for planning and control (Kollberg and Dreyer, 2006). By making the demand information available earlier more updated planning and control process are

realised. However the planning and control process in these concepts is still done separately for each company, with limited coordination of long term planning activities and strategic development.

RFID as an enabling technology for future demand-driven control concepts

More and more, companies are facing an increasing demand of individualised consumer products, and there is a clear customisation and personalisation trend in commodity markets (Piller, 2005). Moreover, customers ask for a wider commodity offer and more information about product origin. These trends are also already apparent for fast-moving consumer goods (Alfnes et al, 2000). Tomorrow’s winning companies will be able to offer individual customers a broad spectre of customised products tailored to their needs, to the lowest production- and supply-costs, at the right short time. This requires demand-driven control concepts, and Radio-Frequency Identification (RFID) can be an enabling technology for meeting these challenges.

Today, RFID has the potential to involve into the Internet of Things (Glover and Bhatt, 2006), allowing for true demand driven and real-time based control. RFID-tags contain information that can be read from a distance, which considerably increases the number of points where data can be obtained through-out the supply chain compared with today’s barcode-systems. In addition, some RFID-tags can be both read and written to. Combining RFID-technology with sensor technology further enhances the intelligence of such data-capturing technologies. This technology is developing fast, and the use is exponentially increasing in industry. As RFID tags are getting better and cheaper and EPC standards are evolving, new possibilities in the use of RFID for controlling operations arise. Today we are at the beginning of integrating RFID into business workflows and cross company supply chains (Chao and Whang, 2007).

Theoretical framework

Summing up the theoretical background, three essential elements regarding control concepts are put forward as a theoretical framework for discussion (c.f. Table 1)

Table 1 An analytical scheme for future control concepts

<i>Control concepts elements</i>	<i>Content</i>
Planning logic	Is the control concept’s planning logic transaction-based (MRP) or based on a take-one-make-one planning logic (extreme lean)?
Control strategy	Is the control concept based on a make-to-order, assemble-to order, make-to-stock or engineer-to order control strategy? Where is the push-pull boundary and CODP? How far upwards in the supply chain does the actual customer demand influence production?
Control systems	How automated and seamless are the decision, planning, ordering and purchasing processes throughout the supply chain? How integrated and harmonised are the different companies control concepts in the supply chain? How integrated are suppliers and customers?

RESEARCH METHODOLOGY

Ramos (2002) argues for a fruitful bridging between the research methodologies used in respectively action research and foresight studies. Action research and foresight studies are both two relative young research domains. The real-life-close action research has some advantages that clearly would benefit visionary foresight studies, and vice versa. Quoting Ramos (2002, pg.4); “Foresight without action is meaningless, and action without foresight can be dangerous. In short (...) futures studies can be a way for action research to connect its project to the global and temporal in meaningful ways.”

Foresight studies

Common to all foresight studies is a desire to structure uncertain and complex information about the future into manageable elements so that preparing for the future can be based on science more than pure conjecture. Costa22 (2008) outlines scenario analysis, participatory methods, computer simulations and technology assessment as four typical future study methodologies. According to Richard Slaughter, foresight is “the ability to create and maintain a high-quality, coherent, and functional forward view and to use the insights arising in organisationally-useful ways, for example, to detect adverse conditions, guide policy, and shape strategy and to explore new markets, products and services” (*ibid*). Because the foresight domain lacks a well-accepted and generic methodology, foresight studies exist in a wide variety.

According to Fuller and de Smedt (2008) there is a need for developing the process of information and knowledge creation in foresight studies due to the fact that this in the end will improve the knowledge and insight into the future state. Thus it is more important to develop and broaden the methodology for data and information gathering in the mentioned foresight studies than it is to defend every detail of the result. Expert knowledge plays a key role in foresight studies. However, Inayatullah (2002) and Ramos (2002, 2006) ask for a broader participation in future studies, where as many people as possible are involved in the most meaningful way so that capacity for foresight is not only reserved for “experts”. Action research can be used in foresight studies in order to gain both practitioners and experts knowledge created in a mutual and interactive process. For action research this means “participation with a forward view” (Ramos, 2002, pg. 3).

Action research

According to Greenwood and Levin (1998, pg. 4) action research “is social research carried out by a team encompassing a professional action researcher and members of an organisation or community seeking too improve their situation.” Action research is the practice of both studying and analysing a phenomenon while at the same time participating in developing and improving (Greenwood and Levin 1998). Thus, in action research, the researchers are involved in and facilitate improvement processes in organisations. Together, the action researcher and the other project participants define the problems and work together to solve them. Typically action research has its tradition from, and is commonly used in social science and management and organisation development.

Action research is closely related to *action* and hence changes in present time. Thus, from an action researcher’s perspective, foresight studies might seem “too passive, overly speculative, or simply too grand a scale” (Ramos, 2002, pg. 3)”. However, Ramos (2002, pg. 6) points out several similarities as arguments on why action research and foresight studies should be brought closer together: First, both move through iterative cycles of action and reflection. Second, both rely on explicit methodology. Third, both seek confirmation within a communal context. Fourth, both consider valid and relevant knowledge to live within defined local contexts – as opposed to over-generalised propositions of the universal category. Finally, the forward view in foresight studies as a basis for meaningful social action has a clear parallel to action research’s commitment to social research through social action.

The action research in this study is carried out in three practical case projects part of a 4 million Euro Norwegian research project aiming at creating tomorrow’s intelligent, responsive and efficient supply chains by utilising the full potential of RFID. The case study is presented in the next chapter.

Action research as foresight methodology

Richard Slaughter underlines that “the future is a principle of present action” (Ramos, 2006, pg. 651). This understanding is a key reason why action research has a role to play in foresight studies. Ramos

(2006) summarises eight complimentary points between action research and foresight studies: Participation, social change, knowledge creation, system thinking, complexity, futures visions, democratic commitments and social innovation.

Some attempts to converge the methodologies of action research and foresight studies have been made; One example being Anticipatory Action Learning (e.g. Inayatullah, 2002; Stevenson, 2002), which has been described as the most successful attempt to bridge the two fields (Ramos, 2006). According to Stevenson (2002) Anticipatory Action Learning is “action research modified for foresight”. Another example is Alsan (2008), which in his article on corporate foresight at Siemens Turkey, employs an action research methodology to predict about the future.

Futures studies tend to orient towards top-floor management and “those who have command and control power to steer the direction of an organisation” (Ramos, 2002). In our research on the potential and effects of RFID in the participating companies, we have involved employees on a broad scale from top-floor to shop-floor. Thoughts and ideas expressed during meetings and work shops were marked down and collected. This way, the foresight presented here, builds on opinions from participating researchers and a two-digit number of representatives from several companies, which are collected, compounded and adapted to the theme under study (control concepts) by experts in their field. In short, experience, results and opinions from all participants generated in the three case projects form the basis for this study. A group of experts on manufacturing planning and control has collected, compounded and adapted the output from the cases into the propositions put forward in this paper.

CASE STUDY

Five companies, ranging from producers to wholesalers and retail shops, are involved in the foresight study. Figure 2 illustrates the three case projects from which foresight is attained, and the main parties involved.

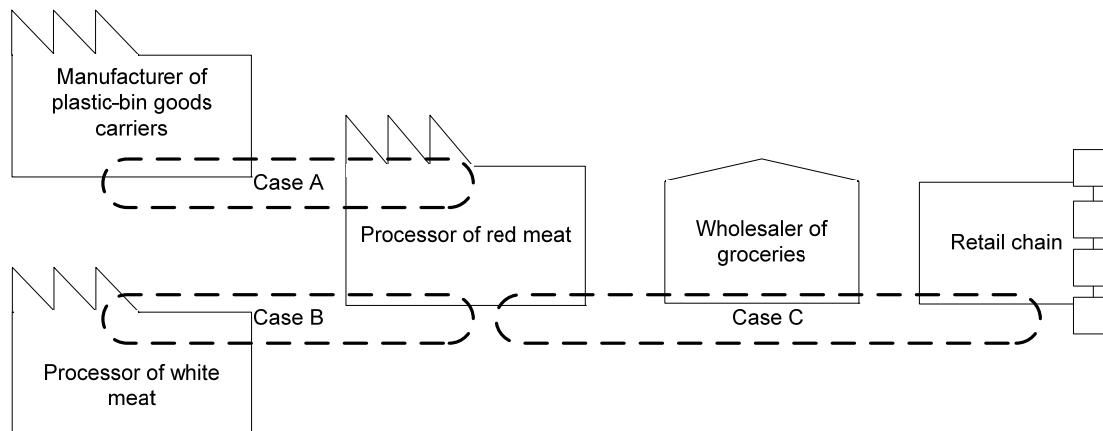


Figure 2 Action research in 3 case projects

Together the three cases cover a complete supply chain in commodity markets. The participation of the wholesaler of groceries and retail shops adds closeness to the end-market and thus closeness to real demand. Table 2 lists descriptions of the three case projects under study.

Table 2 Case descriptions in the case study

Case no	Case description
Case A	New control concepts by utilising RFID in the supplier-customer-relationship between a manufacturer of plastic-bin goods-carriers and a processor of red meat - Typically 1000 plastic-bins are shipped every year from the plastic-bin manufacturer's

<p>Case B</p> <p>Case C</p>	<p>factory to the meat processor's ca 30 different factories all over Norway</p> <ul style="list-style-type: none"> - Since 2007 RFID-tags are moulded into every bin <p>New control concepts by utilising RFID in the supplier-customer-relationship between a processor of white meat and a processor of red meat</p> <ul style="list-style-type: none"> - Chicken meat farce is shipped from a white-meat processor's factory to a sausage production line in a red meat processing factory (belonging to the same corporation) - RFID-tags will be fitted to the farce carrier-bins <p>New control concepts by utilising RFID in the supply chain-relationships between a processor of red meat, a wholesaler of groceries and retail shops</p> <ul style="list-style-type: none"> - Meat products are shipped from the meat processing factory via a cross-docking wholesaler to several retail shops in South-Western Norway - RFID-tags are moulded into plastic-bin carriers (delivered by the company in case A) that carry the goods from the meat factory up to the goods are placed in shop shelves
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DISCUSSION

Based on the theoretical and methodological frameworks put forward in this paper, foresight stemming from the action research in the case projects is discussed here.

Planning logic

The planning logic differs between the case studies due to the different products that are sold (farce, plastic bins and meat) and the different supply chain relationships. However, all companies have implemented ERP-systems with MRP as the dominant planning engine. Table 3 sums up the main discussion on planning logic in the three cases.

Table 3 Planning logic in the three case projects

Planning logic	Foresight
Case A	With RFID on every bin in use, new bins will be manufactured on a need-one-make-one planning logic (extreme lean), where new bins are made at the moment old ones are put out of business or an extended need is identified somewhere in the supply chain. The MRP lead-time calculation logic will be outdated and replaced by more demand driven logic based on a combination of advanced forecasting techniques combined with real time demand and IT systems.
Case B	In the future farce will be pulled to the meat processing factory as the real-time demand for sausages is identified at retail outlets. It is theoretical possible to produce sausages from slaughtering to packaging in less than 24 hours (given availability of chicken). In the future the production of sausages will not be transaction-based as today through 4-5 ERP-systems upstream the supply chain. Instead visibility to real-time demand will be balanced with supply capacity for the chain as a whole and create a seamless pull-system throughout the chain.
Case C	The different roles and different ownerships in the supply chain of commodity meat products are not likely to change. However, the cooperation between the different partners will be revolutionised through a common visibility platform tracking all movements of RFID-labelled products. The different ERP-systems will outplay their role as the central engine for planning and control simply because they do not optimise the total chain revenue.

Based on this it is proposed that *the control concepts of the future will be based on full access to real time demand information and not the lead time calculations in today's MRP-logic*. The MRP-based approach of today builds on a traditional mass production strategy, and will not be sufficient to handle the low volumes and demand variety that will characterise future markets. The built-in simplifications in the MRP-logic, like for example fixed lot sizes, fixed lead times, assembly oriented product-structures, and lack of capacity constraints, result in delays that can not meet the future

demand for quickness and individualisation. Instead, access to real-time end-consumer demand, inventory levels and products flows will enable mathematical optimised control concepts. Information and communication technology (ICT) business intelligence will play a significant role together with information quality and the sharing of information between the actors.

Control strategy

In all three cases the control strategy is a combination of make-to-order and make-to-stock strategies for the manufacturers involved; in the sense that all “orders” in the three cases is based on forecasts. Historical information about demand together with actual orders is put into the ERP-systems, which generates production plans. Thus, a true pull-driven system with real-time demand is not realised. Table 4 sums up the discussion in the three respective case projects.

Table 4 Control strategies in case A, B and C

Control strategy	Foresight
Case A	With RFID on all bins, the plastic bin manufacturer will have visibility into all the movements and positions of its sold plastic bins from moulding starts to the bins are received by the red-meat company. The red-meat company will have complete visibility of all its ca 2.000.000 bins spread over 40 sites in Norway. Vendor Managed Inventory and automated replenishment can be realised and the plastic bin manufacturer or a third-party can start leasing plastic bin management to the meat company. Thus the control strategy will move towards a true make-to-demand system based on real demand for plastic bins.
Case B	With RFID on all meat carriers no link to end-consumer demand is realised. However, when RFID is extended to create visibility into all movements of bins and meat down to end-consumer, new control strategies will arise. The CODP will move upwards in the chain, even all the way back to slaughtering of chicken. Also in this case Vendor Managed Inventory can be realised. The control strategy of chicken sausage will be a make-to-demand process where the order stems from today’s actual demand and not forecasted historical data.
Case C	In the future, total visibility of point-of-sale information together with total visibility of capacity through the supply chain will make production of red meat much closer in item to consumption. Results are less waste, shorter lead-times, better and fresher products and faster cash-to-cash cycle. The control strategy will hence move towards a true make-to-demand strategy, where actors in the supply chain do not need to send and confirm orders; the visibility makes all partners see the demand for their products in real-time. Automated replenishment can be implemented and thus allow a more efficient supply process.

Based on this it is proposed that a *great quantity of fast-moving consumer goods will be made on a make-to-demand basis in the future*. This means control concepts will be based more on pull and less on push. Make-to-demand is even more pull-driven than the traditional concept make-to-order. In a make-to-demand control strategy no “orders” are sent and confirmed between companies in a supply chain; all parties see the demand for their products through total visibility. The customer-order decoupling point (CODP) will shift upwards in supply chains. New roles and areas of responsibility will arise between actors in commodity supply chains, where actors close to the customer will carry less inventories and quickness is optimised. Lead-times will be shortened.

Control systems

Today, all the companies in the three supply chains have their own control systems which in some cases contrast each other. For example, the red meat processor in case B is optimising its processing capacity, which does not optimise the revenue of the white-meat sausage sales. In all cases information

is not shared in real-time, which adds a lot of uncertainty to data. Thus, decisions are often made on out-of-date and incomplete information. All cases have a low degree of seamlessness and automation in decisions, planning, ordering and purchasing processes. Table 5 sums up the main discussion points on automation of control systems in the supply chain.

Table 5 Control systems in case A, B and C

Control systems	Foresight
Case A	ICT systems will be seamless integrated. Full visibility of plastic bins for both partners in the value chain. Automated bin management: No need to order and confirm orders on plastic bins. In this way the supply chain will be optimised from a global perspective.
Case B	ICT systems will be seamless integrated. Meat processing capacity, demand for sausages and supply of farce is optimised from a global perspective. Transactions are automated and in real-time. Managers will do divagation-management and not detailed planning, based on automated notification of system failures.
Case C	In the future there will be automated order processes from retail outlet to the meat manufacturer. There will be no more need for procurement; Meat manufacturer own its meat until it is purchased by the customer. The wholesaler cross docks the products in a fast and flexible manner.

Based on this it is proposed that *control management and operations will be marked by automated transactions in real-time in the future and shared general control concepts for entire supply chains will arise across company boundaries in the future.*

Purchasing departments will not do purchasing but sourcing, and sales departments will not need to place orders, because the automated control system let all actors know their actual demand in real-time. Instead purchasers and sellers will adjust parameters in the control system (e.g. data on forecasting, price, relationships, lead times etc.). Moreover, decision support will be integrated in the control information systems, and not be separate systems like today. Managers will not control what is actually working, instead their competence will be fully utilised to solve challenges and prepare for tomorrow.

The trend towards more competition between supply chains rather than between single companies will continue. New and tighter cooperation models in supply chains will arise where visibility and accuracy of data restrain the lack of trust between actors. The access to updated and true data upwards in supply chains is likely to improve agility in whole supply chains. I.e. changing demand patterns will be quickly recognised and production will be quickly adaptable to this changing demand. Because companies are part of several (and shifting) supply chains, umbrella organisations for supply chains are not likely to arise. However, new ICT architectures will allow true integration of systems along the supply chain and lead to complete virtual integration.

CONCLUSIONS

As consumer demand develop into personalisation and intelligent data-capturing technologies arise, new demand driven control concepts will evolve. RFID and sensor technologies will enable real-time surveillance capabilities which will revolutionise today's control concepts. RFID enables the possibility of having access to all information about end-consumer demand, all stock-levels and all movements across the supply chain in real-time. When all companies across supply chains have real-time access to the end-consumer demand, and all companies know the real-time status of the products through-out the supply chain, the authors propose that the following three changes will evolve towards Demand Driven Control Concepts:

- 1) Future control concepts will be based on full access to real time demand information and not the lead time calculations in today's MRP-logic

- 2) A great quantity of fast-moving consumer goods will be made on a make-to-demand basis
- 3) Future control management and operations will be marked by automated transactions in real-time and shared general control concepts for entire supply chains will arise across company boundaries

Implications for managers

The foresight put forward in this study gives insight into how managers will control their companies and supply chain operations in the future. Foresight studies contribute to raising awareness in industry about the competition of tomorrow.

Limitations

Much more research is called for in regard to preparing for the control concepts of the future. Foresight studies based on action research have several limitations. First and foremost, expert's opinions always involve inaccuracies and possibilities of bias. Second, the issue of scientific validation in foresight studies has always been problematic (Ramos, 2002). Third, the methodology per se is very young. On the other hand, foresight results are very easy to verify as time pass by.

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