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A balanced approach to building agile supply chains

H.S. Ismail and H. Sharifi
The University of Liverpool Management School, Liverpool, UK

Abstract

Purpose – Parallel developments in the areas of agile systems and manufacturing, and supply chain management led to the introduction of the agile supply chains (ASC) concept. How to achieve agility in supply chain is, however, a subject of question and research. This paper proposes a framework for the development of ASC that is based on the integration of existing supply chain analysis and development models and techniques with those of the supply chain design (SCD) and also the design for the supply chain (DfSC).

Design/methodology/approach – The framework mainly relies on research previously carried out by the authors in the areas of developing agile manufacturing and systems and models for demand network alignment. An extensive literature survey is carried out to support the ideas and derive the constructs of the conceptual model as a basis for further empirical research.

Findings – The model suggest that responding proactively to the market and business environment changes, agility, can be facilitated by simultaneous development of supply chain and the output/product of the chain. The concept of DfSC, built on the success of existing "design for X" techniques, would increase the reactive and proactive capabilities of organisations.

Originality/value – The research provides a theoretical ground for achieving ASC which facilitates reconciliation between two usually separately approaches of SCD and DfSC, as well as suggesting practical solutions for developing agility in supply chains. This view can make the ASC concept understandable and practical, and open a new way of viewing the subject in research circles.

Keywords Agile production, Supply chain management

Paper type Research paper

Introduction

Agility as a new paradigm for enhancing competitiveness has been widely researched since its inception in the early 1990s. The concept, in its various forms, is now recognised as a wining strategy for growth if not a basic one for survival in certain business environments. With contemporary views redefining the unit of competition to be a supply chain or a demand network, the idea of creating agile supply chains (ASC) has become the next logical step and a focal area for researchers. Supply chain agility we define to be the ability of the supply chain as a whole and its members to rapidly align the network and its operations to the dynamic and turbulent requirements of the demand network. The main focus is in running businesses in network structures with an adequate level of agility to respond to changes as well as proactively anticipate changes and seek new emerging opportunities.

Approaches to the area of ASC have typically addressed how to enhance the internal agile characteristics of a firm by getting support from the supply and demand ends of the network. Amongst other factors, these approaches attempt to deal with the physical alignment of a network to the requirements of the market and competition, reconfiguration of production processes within the supply chain, and the resolution of behavioural and relationship issues between the supply chain members. Some of the key issues to be

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examined when addressing what is an ASC and how it can be achieved fall under two main mutually dependent categories; supply chain design (SCD) and design for the supply chain (DfSC). Each of these areas has been subject of research and attention in the recent years, and each has been associated with the capabilities and characteristics required for achieving agility. The research undertaken by the authors in the area of ASC, aiming at developing ideas and providing practical models and solutions to various aspects of the subject, has led to the proposal of an approach to the development of ASC through the two aforementioned approaches. The ongoing work is mainly based on the previous research at the University of Liverpool Management School on "agile manufacturing and systems" and "demand network alignment" both which bear considerable theoretical and practical means supporting the new approach to ASC.

This paper presents a structured conceptual framework to provide a practical approach for implementing new ideas in the development of ASC. It proposes that by focusing on the two aspects of designing supply chain and design for supply chain, as explained above, the road to the successful transition to agility in supply chains is appropriately mapped. The approach will address the strategic issues of determining the supply chain strategy and its level of agility for each and all members based on which of the determinants for design of the supply chain will be derived and implemented. At the same time, a practical approach will be undertaken to interpret the supply chain strategies into supply chain operations strategies and the process of product and processes design to fit the designed supply chain and provide the objectives of the supply chain.

First a quick review of the literature in this area is presented followed by exploring the two main elements mentioned before. A combined view of the two dimensions and how they would contribute to the agility of supply chains will conclude the paper.

Review of the literature

Seeking solution to respond to the increasing rate of change and uncertainty in the business environment, previously sought in flexibility mainly provided by automation a technology, led to the origination of agile thinking in the 1990s (Nagel and Dove, 1991; Goldman *et al.*, 1995). The idea turned to a new vision for the business and was extensively attended by academics providing theories and practical solutions (Sharifi and Zhang, 1999; Ismail *et al.*, 2001). The 1990s is also associated with the vast interest in the idea of moving the focus to supply chains from single entities seeing supply chains as units of competition (Bowersox *et al.*, 1998; Christopher, 1998). The reason for this lies in facts such as; less interest in vertical integration as an organisational strategy, and increased globalisation and competition (Lummus and Vokurka, 1999). Another driving force behind supply chain management (SCM) is that optimisation of each organisation rather than optimising the chain by integrating its goals and activities with other organisations is most likely to lead to sub-optimisation (Cooper *et al.*, 1997; Lummus and Vokurka, 1999). In other words, traditional supply management and logistics have evolved radically to form new formations and structures leading to the generation of new concepts such as demand chains and demand networks (Harland *et al.*, 1999). Extensive works have been carried out in the area of SCM among which radical approaches to identify and understand the basic constituting elements of demand networks, their DNA (Fine, 1998; Kehoe *et al.*, 2004; Sharifi *et al.*, 2002; Cox *et al.*, 2000).

Parallel developments in the areas of agility and SCM led to the introduction of the ASC concept to transfer the wining strategy of agility to supply chains as the newly

accepted units of business and competition. Preceded by concepts such as virtual corporation and agile web as an organisational framework (Booth and Harmer, 1995) the idea of agility in the context of SCM focuses around "responsiveness" (Christopher and Towill, 2000). It has been suggested by Harrison *et al.* (1999) that an ASC has a number of characteristics including being:

- *Market sensitive.* Closely connected to end-user trends.
- *Virtual.* Relies on shared information across all supply chain partners.
- *Network-based.* Gains flexibility by using the strengths of specialist players.
- *Process aligned.* It has a high degree of process interconnectivity between the network members.

The drivers behind the need for agility in supply chains agility, in a similar way to the agile manufacturing concept, stem from the increasing rate of change and uncertainties in the business environment. The dynamics of the operations extended to supply chains will add to the uncertainties in the business environment and hence the vulnerability of companies (Svensson, 2000). The situation has raised concern over the slow growth of integrated supply chains (Lummus and Vokurka, 1999). In work by Xu *et al.* (2003) the elements behind the need for agility as complexity, uncertainty and heterogeneity are summarised. Van der Vorst and Beulens (2002) suggested some requirements that has to be fulfilled to prevent uncertainty and hence ineffectiveness in supply chains. These include need for clear objective and corresponding performance indicators, means to estimate future system states and in particular information on the environment and current supply chain state. This is in addition to enough information processing capacities, ability to estimate the impact of alternative actions, and enough potential control actions. From a summary of various definitions and proposed concepts with regard to supply chains we can conclude that supply/demand chains/networks are entities developed from the interactive collaboration of a number of companies shaped in a particular way to fulfil a business objective through delivering value to customers and the companies by appropriation. These networks can be either created based on a predetermined design and plan or emerge as the result of spontaneous needs in the course of companies' operations which still is subject to planning and design.

The design of production and distribution systems has been active area of research during the last 30 years (Van der Vorst and Beulens, 2002), and there has been an increasing attention placed on the performance, design and analysis of the supply chain as whole (Beamon, 1998). The literature on the subject of supply chains design has mainly been focusing on the operational level and the physical structure of supply chains. However, a growing attention has been placed on the strategic issues related to the design of supply chain. Work by researchers such as Fisher (1997), Lamming *et al.* (1999), Fine (1998), Cox *et al.* (2000), Kehoe *et al.* (2002) and Sharifi *et al.* (2002) have contributed to the determination of strategic direction, formation and alignment models and implementation methodologies for demand networks. Approaching development and management of demand networks through alignment of strategies and operations within the networks has been a focal point in many recent works. Fine (1998) warns that when firms do not explicitly acknowledge and manage SCD and engineering as a concurrent activity to product and process design and engineering, they often encounter problems late in product development, or with manufacturing launch, logistical support, quality control, and production costs.

According to Van der Vorst and Beulens (2002) the development of capability to redesign the supply chain according to the new circumstances arise during the course of action, for which four elements are proposed including chain configuration (the structure, facilities and means, the parties involved and the roles to be performed in the supply chain), chain control structure (the set of decision functions that govern the execution of operational activities), chain information systems, and chain organisation and governance structures. Fine (1998) suggests that with the new era of temporary competitive advantage three-dimensional concurrent engineering (3-DCE), the simultaneous and coordinated design of products, manufacturing processes, and supply chains should be undertaken. Work by Kehoe *et el.* (2004) proposes a model of demand network alignment supported by methodologies for the design, development and management of demand network, and suggests a DNA model of business operations is suggested. The assertion of the DNA model is that the nature and existence of a supply chain, or network, evolves from the dynamic interaction of two main operational strands namely, a physical/information strand and a relationship strand. The physical and information resources throughout the network should be supportive of the network's strategic orientation, which in turn should be aligned to the market and product needs. The product characteristics, market uncertainty and nature of the product demand have a significant influence on the way the physical and information resources of the network are applied. Effective operation of the physical/information system is then additionally supported by effective operation of the relationships where games and opportunistic behaviour is minimised and trusting relationships operate.

Other strategic alignment models also support the fact that the success of organisational strategy is dependent upon the alignment of environmental uncertainties, strategy, and adopted technology, practices, or systems (Henderson and Venkatraman, 1993; Lufinan *et al.*, 1993). The criticality of coordinated development of product design and manufacturing process design has already been recognised within the manufacturing related studies and various concepts such as "design for assembly, manufacturability, operability, etc." has been introduced (Huang, 1996). In addition to concurrent engineering, there has also been an increasing, and somewhat parallel, emphasis on synchronizing supply chain management decisions with product design decisions, or the "design for supply chain" approach (Hult and Swan, 2003; Joglekar and Rosenthal, 2003; Lee and Sasser, 1995).

Agile supply chains

The theoretical grounds for agility in supply chain follow the same logic applied in the original concept of agile systems and manufacturing. Among the existing frameworks for introducing agility in supply chains is the work given in Van Hoek *et al.* (2001) and Christopher (2000, 1998). Harrison *et al.* (1999) presented a holistic view of the subject leading to practices and application of already proven concepts such as lean thinking, decoupling and postponement is proposed.

Aitken *et al.* (2001) suggested a three level framework bringing together the various strands which contribute to the agile enterprise. In their integrative model the key principles that underpin the ASC such as rapid replenishment; and postponed fulfilment, the individual programmes such as lean production, organisational agility, and quick response, and finally individual actions to be taken are demonstrated in a layered model.

From the definition we proposed before for supply chain agility, and following conceptual frames and methodologies proposed by Sharifi and Zhang (1999) and

Ismail *et al.* (2001) it can be suggested that demand networks to remain competitive should seek achieving a sufficient level of agility which should correspond with the level of change and uncertainty in the overall as well as individual business environment. Determining the appropriate level of the agility and hence the strategy of the supply chain requires a systematic approach.

Zero represents a basic model for the determination of the supply chain strategy and stance with regard to agility of the chain. The model follows the DNA model proposed Kehoe *et al.* (2004) for the aligned development and management of demand networks. Taking into account two main strands of physical/information and relationships/behaviour within the context of SCM as the main areas impacting the structure and operations of the supply chain the model goes on to first derive the market and product strategy using classification and business analysis tools (Figure 1).

This combined with the supply chain strategy determined from the supply chain classification models and tools lead to the direction through which the network shall seek the agility it needs. A complementary methodological model for defining, developing and implementing agility in supply chain is shown in Figure 2.

The model is designed to incorporate the steps required to study and analyse the network, determine the strategies to approach agility within the network, and the means with which the agility can be built with; supply chain agility builder. The analysis phase is comprised of two assessment systems, i.e. SCANNER and SCALE which are based on some generic classification and analysis methods and tools.

The supply chain agility builder is a tool warehouse that provides the practice and applications required to implement the agility strategies and build in the needed capabilities. Among the elements of the SC agility builder is the agile process section in which sub-elements such as (new) product development, and design are included. The

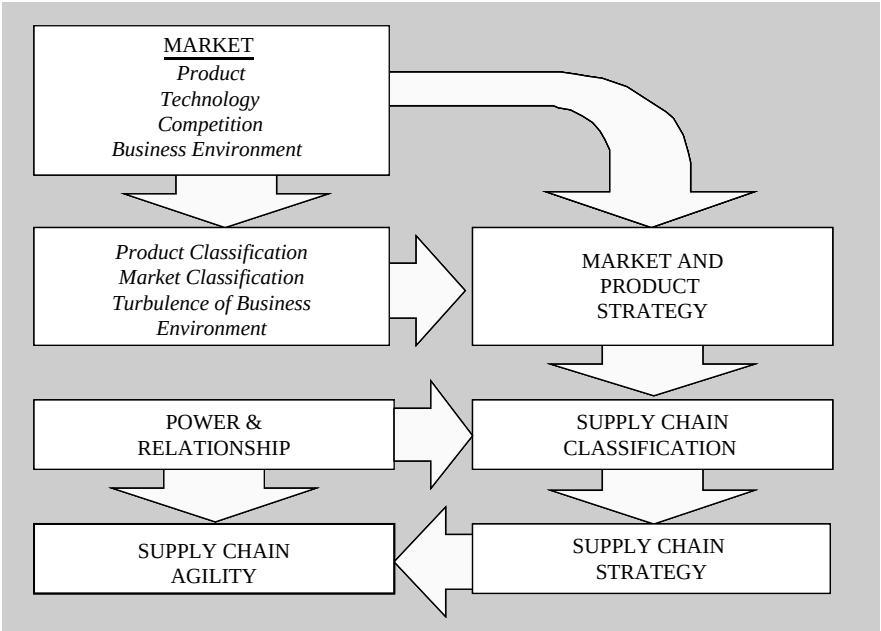

Figure 1.
A framework for ASC

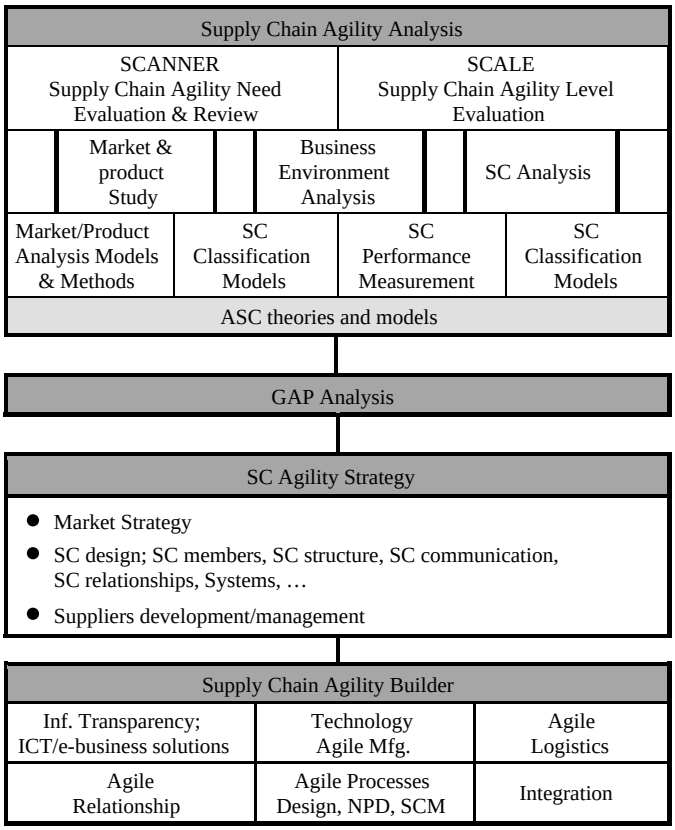

Figure 2.
A model for developing ASC

design element refers to all processes and activities relating to design in the network including design of product, operations process, network structure and management and control elements.

Supply chain design

As a unit composed of various parties with overlapping and conflicting interests, a supply chain is formed and managed and subsequently decomposed or restructured corresponding to specific needs or emerging opportunities in the business environment. If this process is to be successful it needs to be carried out efficiently within the constraints of the intrinsic market clockspeed. Creation or even emergence of such systems should be based on a detailed design process in which the characteristics of the chain or network is identified and implemented. However, the process of designing and creating a supply chain is surrounded by many complexities and ambiguities. The following are a few of these issues:

- If a strategy such as agility is incorporated in the supply chain strategy then how and where this strategy is determined, and how design of the supply chain managed around it is still not fully resolved.

- Resolving value appropriation, power and relationship issues in the supply chain and incorporating it into the SCD.
- How the strategy of supply chain should be implemented through design once identified.
- Operations and processes design to fit the supply chain strategy/design.
- Positively reinforcing performance measurement systems for the supply chain.
- The role of scenario generation and evaluation to improve the proactive qualities of a supply chain.

From a market point of view, the main purpose of erecting a supply chain is to meet a market need. On the other hand, the supply chain is also there to support the continual growth of its members. The problem of how agility could be interpreted in terms of supply chain operations strategy and integrated within each member of the network's strategy is probably the main concern within the context of designing and managing an ASC. The frameworks shown in Figures 2 and 3 provide the strategic approach and also building blocks for designing ASC. However, another equally important aspect for the supply chain deign to support the network's agility is how the outputs of the supply chain, being a product or service, shall be designed so that the supply chain features designed provide the required level of agility. This will be the subject of a parallel approach discussed in the following section.

Design for the supply chain

The common practice in supply chain networks is to design the intended output to best fulfil the market requirements. The required supply chain or network for achieving these market objectives is subsequently formed from those available internal resources and external sources that are capable of providing the projected specification and performance needs. Resource and capability constraints are then dealt with during the development of the product through forging some requirements, investment in new resources or search for new external sources.

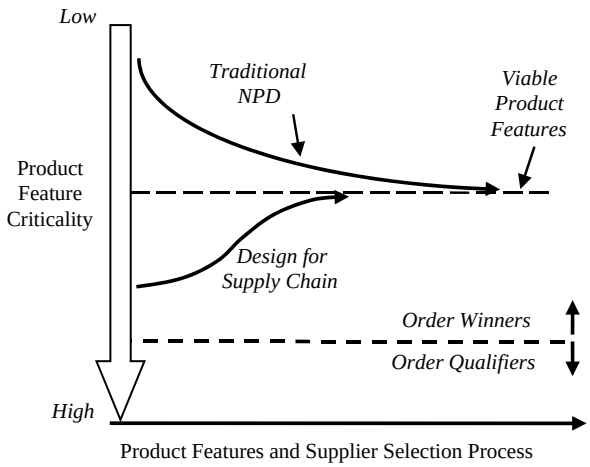

Figure 3.
Feature and supplier selection

Research and practices in the area of new product development have resulted in new approaches at the management level such as "Concurrent Engineering" and at the detailed level such as "Design for Manufacture and Assembly" and "Design for X". Other approaches such as "Postponement" have also emerged to resolve issues arising from operating in a "Mass customised market" with varying lead-times.

These practices have not, however, been developed convincingly enough to resolve many difficulties involved in the process such as the network and its members' limitations, fairness of value appropriation and cost distribution, burden of responsiveness, changing circumstances and demand dynamics, integration of the whole process, and so on. However, the experience from the internal practice of such new approaches in organisations proved very valuable and changed the way managing the design and development process of products is viewed.

This process can be represented as shown in Figure 3 where traditional NPD processes go through a number of internal and external iterative processes to reach a viable product. Initially product features are separated into qualifiers and winners and driven by the desire to maximise on market potential. The initial concept designs are often ambitious encompassing all identified features. This is often a time consuming process and even with the application of concurrent engineering techniques can be exhausting. An approach based on DfSC starts from an achievable point with respect to product features. These features are then extended as the process of collaborating with suppliers and extending the supplier range is carried out. The advantage of this is that at any stage of the concept design the product is achievable as you build up to time and cost constraints. This enables the supply chain to respond quickly to emerging opportunities and enhances the concept of modularity and product/component reuse.

This process changes somewhat depending on the newness of the product and by implication the level of market pull or technology push involved on one hand and the market clockspeed on the other. Using the extended Ansoff matrix as a point reference (Figure 4) there are three main shifts a company can do:

(1) Companies traditionally move from sector 1 to sectors 2 and 3 through cost and operational efficiencies and where possible align their existing supply chain to meet this new shift.

(2) A shift from sector 1 to sectors 4, 5 and 6 involves a redesign or modularisation of the product to capitalise on new opportunities through customisation and product families. A redesign of the supply chain is often required with a shift from cost to flexibility.

New Markets		3	6	9
Existing Market	*New Customers*	2	5	8
	Existing Customers	1	4	7
		Existing Product	Extended Product	New Product

Figure 4.
Extended Ansoff matrix

(3) A shift from sector 1 to sectors 7, 8 and 9 are the most risky but offers the company the opportunity to fundamentally redesign the supply chain to meet the new product needs.

It seems that it is possible for such approaches to be formally introduced in the management of supply chains and provide practical means for designing the products and processes "for" the supply chain as the unit of business and competition. A number of recent publications (Lee and Sasser, 1995; Forza *et al.*, 2005; Joglekar and Rosenthal, 2003; Fixson, 2005; Petersen *et al.*, 2004) in the area of integrating design, process and supply chain have emerged. These range from a focus on a single attribute (e.g. lead-time) to extending product ranges through replaceability and common interfaces. The adoption of an approach based on "Design for Supply Chain" has to be defined and managed expertly. The downside of adopting it blindly is the suppression of ideas that do not fall within the supply chain capabilities. The approach should also go beyond the limited financial assessment of "make or buy".

Figure 5 shows how the front end for the DfSC model would function. The process is still driven by market needs or the voice of the customer translated to product feature. However, it includes a number of key stages involving the alignment of features to the

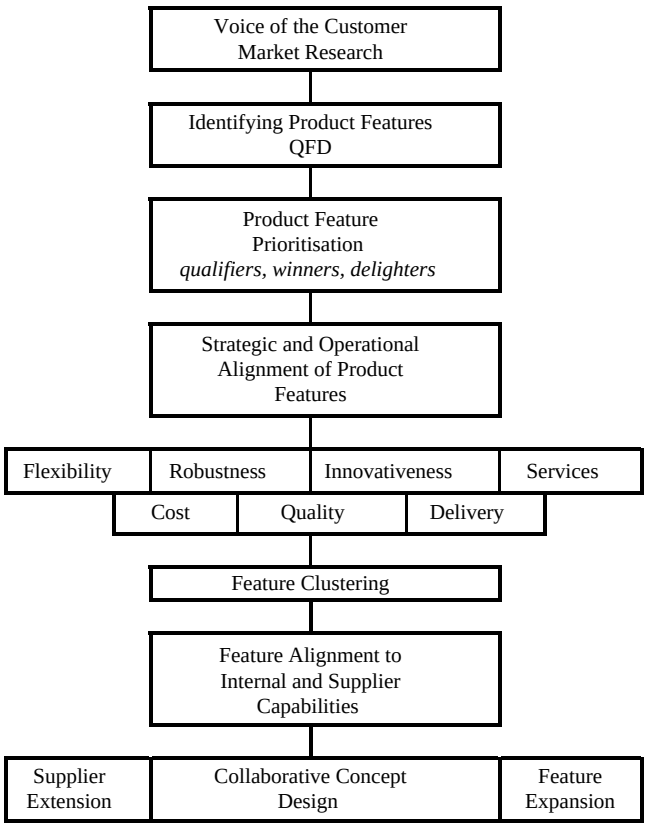

Figure 5.
Front end of DfSC process

basic strategic and operational supply chain properties of cost, quality and delivery and the extended properties of flexibility, robustness, innovativeness and service. These properties are derived from Miltenburg (1995) in defining manufacturing strategy and operational requirements. Feature clustering and alignment is subsequently carried out to ascertain what can be achieved immediately if time is critical and what is possible to achieve if cost is not a constraint.

Balanced approach to agility in supply chain

The aim of the proposed framework is to map out a dynamic structured approach for developing ASC that can respond rapidly to new market opportunities. The framework is based on integrating the two complementing viewpoints discussed above, i.e. the design of the supply chain and the DfSC as shown in Figure 6.

The integration of these two viewpoints is influenced by a number of internal and external key factors which affect the supply chain strategy and how the proposed approach can be formulated and applied. The key factors are numerous but generally can be grouped as follows:

- *Market and business environment factors.* Market factors cover aspects relating to the size of market, level of competitions and type of market/industry amongst others. It also takes into account the stage in the product life cycle in which the market is currently operating as well as rate of new product introduction. From a customer point of view, it considers the level of customer involvement in specifying product specification/features (requirements) as well as the position of the company in the supply chain with respect to the end-user. The business environment factors cover aspects that include legislative, economic, social and environmental factors that impact on the company's ability to operate and meet its intended strategy.
- *Product factors.* These include the product complexity and level of technology and innovation involved in developing and manufacturing the product. Also to consider under product factors are the level of services involved in supporting the product from to distribution and after sales support. The complexity of product features is also dependent on the level of certainty with respect to those qualifiers and order winning factors that differentiate the product.
- *Company.* The company factors are predominantly concerned with the company's internal capabilities. These range from the ability to understand the dynamic nature and requirements of its markets to efficiently and effectively satisfying these requirements. It also considers the company's ability to identify a strategy and rapidly rally both internal and external resources to support it.

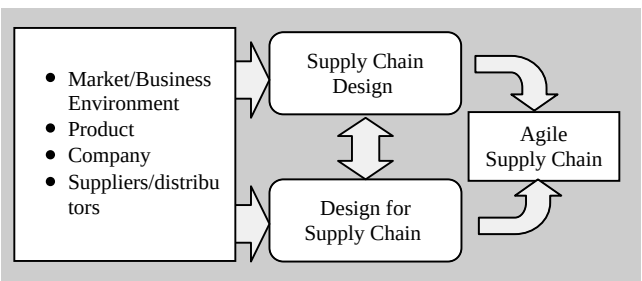

Figure 6.
Agility in supply chains through SCD and DfSC

- *Supply chain.* The supply chain factors cover suppliers' capability and availability. They also cover how it operates, its speed and level of effort required to set it up, align and maintain it. It also addresses the nature and level of communication required, level of trust, and balance of power in the supply chain. Critical is the supply chain's responsiveness and resilience to changes both within the supply chain and in the business environment.

The proposed approach integrates designing the product and the supply chain while taking into account the impact of the above factors. This approach starts by assessing key product features. Each of these is assessed across three measures of attractiveness. The first measure is from a customer point of view and is based on how the product features meet their requirements. These can be split into qualifiers, winners and delighters. The second is from a company point of view and is based on the company's internal capabilities, strengths and effective use of resources and knowledge. These are ranked in terms of how they meet the company's financial and strategic targets. The third is a supply chain view, also based on capabilities and strengths but includes the effort and time required to set up and maintain the supply chain. In this context, agility stems from the ability to rapidly provide the customer with a sufficient level of attractiveness within the time and cost constraints of company and supply chain available capabilities. This is achieved by reaching the correct balance between the three measures of attractiveness across all product features.

The ongoing research is now investigating the issues in the following areas for introducing agility into supply chains:

- exploring and validating the conceptual frame and methodology introduced for developing ASC;
- defining a generic and holistic approach to the design of supply chain, and determining elements contributing to this practice;
- developing practical approaches and methods to carry out design of products for supply chain; and
- the interaction of SCD and DfSC to support strategic implementation of agility in supply chain.

Summary

Agility is now becoming a qualifying characteristic for supply chains in order to succeed as units of competition. Developing ASC goes beyond simplistic solutions such as inserting certain capabilities in individual organisations in isolation or at best to partially align or coordinate operations along the supply chain. Supply chains need to reflect the requirements of the market and the business environment. Accordingly, they need to be designed incorporating flexible mechanisms to respond effectively to the changing dynamics of the business environment. For this to succeed, a calculated approach is required to the design of products with particular attention to the characteristics of the supply chain and it dynamics. The two aspects of SCD and DfSC, discussed in this paper, interact with market, supply chain, business environment, technology, and with each other to support the dynamic characteristics of ASC. In this paper a number of models and methods are introduced to conceptualise the idea of a holistic approach to ASC. Further work is under way to explore the concepts and develop practical solution for developing ASC.

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About the authors

H.S. Ismail PhD, BSc, MIEE, CEng is a Senior Lecturer at the University of Liverpool Management School. Hossam has numerous publications in the areas of Manufacturing Systems Design, Simulation and Modelling, Agility, Mass customisation, Decision Support Tools, Intelligent Design and Feature recognition. Hossam is Director of the Agility Centre, a business help centre funded from Objective One for Merseyside to develop agility tools and methodologies to assist manufacturing-based Merseyside-based SME's. Hossam has supervised eight knowledge transfer programmes and he has four major research and development projects in design and manufacturing. Hossam is also responsible for a successful MSc programme in e-business strategy and systems at the Management School; a programme that is specifically aimed at manufacturing industry. H.S. Ismail is the corresponding author and can be contacted at: hsismail@liv.ac.uk

H. Sharifi PhD, MSc, BSc is a Lecturer in e-Business and Operations Management at University of Liverpool Management School. With a number of years of industrial experience he completed a PhD study in manufacturing strategy (agile manufacturing) at Liverpool University. Dr Sharifi has worked as a research fellow at Liverpool for a few years. He is also an associate of the Faculty of Industrial Engineering at Iran University of Science and Technology, Tehran, Iran. Hossein has published widely in the area of agile manufacturing some of which have been highly referenced. His research interests are in the area of Lean and Agile manufacturing and systems, supply chain and operations management, and e-business models and systems particularly in e-government.