New Concepts in Classification of Supply Chains

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Abstract
This article intends to classify supply chains based on new concepts. We will introduce a new concept called supply network which simplifies the complex process of supply chain as a multidimensional fluid concept. The articulation of supply networks, as an extension of supply chains, seeks to accommodate and explain the commercial complexity associated with the creation and delivery of goods and services from the source of raw materials to their destination in end-customer markets. Supply networks differ substantially according to the type of product being supplied. Eventually we will propose a framework for classifying supply networks; we distinguish a matrix of four types of supply network. This classification supports and develops Fisher's argument that the supply chain for an innovative product should be different from that of a functional product due to differences in demand patterns.

Key Words: Responsive supply chains – Efficient Supply chains - Supply Network

Introduction:

Overview of supply chain management

In the past, the separate companies, and even separate parts of one company, in a supply chain acted in their own best interests, not those of the entire supply chain. Information was not shared among members of the supply chain, and only limited information was provided to the other members of the supply chain that a company dealt with directly. Several factors, however, have emerged that now require companies to use supply chain management as part of their competitive strategy.

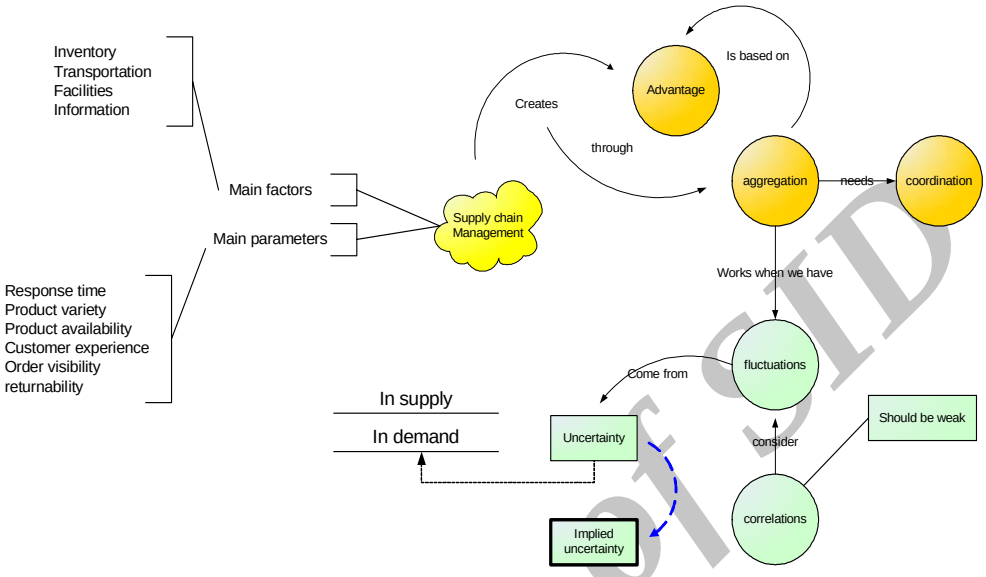
Those factors are:

1. Globalization
2. Increased competition
3. Information technology
4. Shorter product life cycle

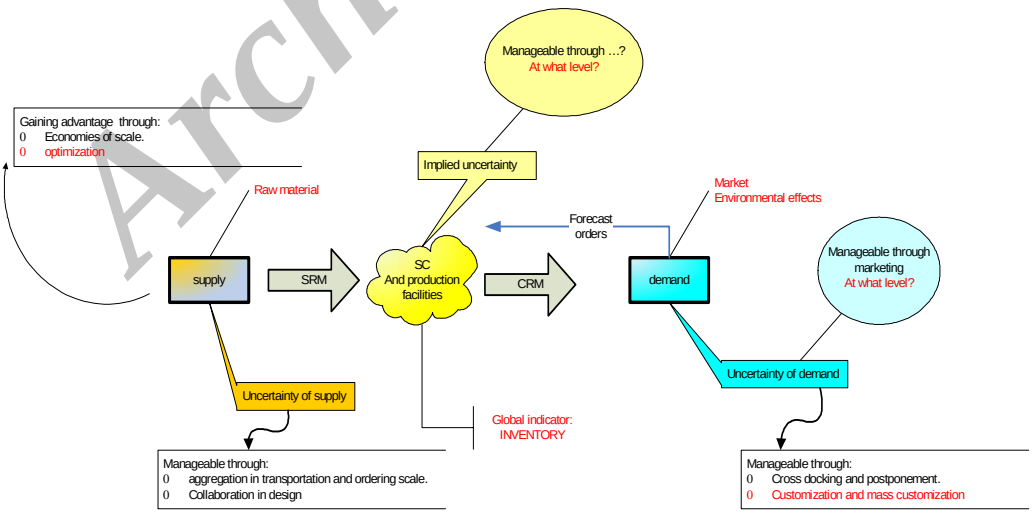
Globalisation has led to new markets, but also to more companies producing and selling the same products. Even established markets have become more competitive as companies identify new ways of winning market share. One way of winning market share is introducing new products, leading to shorter product lifecycles. Finally, information technology has opened up new ways of buying and selling through the Internet and has also allowed companies to obtain and disseminate information much more rapidly than before.

Because of these changes, companies have been forced to be more competitive. One way to be more competitive is through supply chain management. By coordinating all supply chain activities, companies can ensure that the customer obtains the desired product at the desired time for a competitive price. Furthermore, companies in the supply chain can minimize costs over the

entire supply chain, thus benefiting all the members. Supply chain management is, therefore, defined as “the integrated coordination of all components of the supply chains – from raw materials to the final customer – so that information and materials flow smoothly.”
These working factors and related concepts can be shown in diagrams below to facilitate mutual effects and interactions:



Advantages and tools for managing SC are shown as bellow:



Types of supply chains

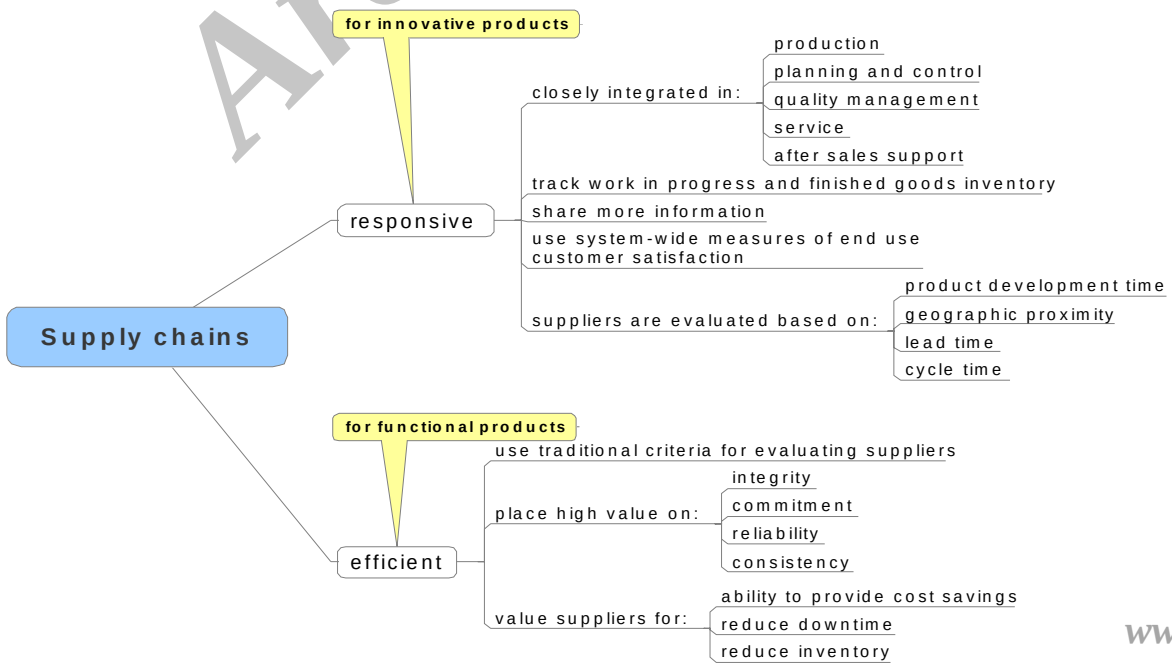
Supply chains are not only described by their structure, but also by their competitive focus. Here we consider two major types from a competitive focus perspective – responsive and efficient. The type of supply chain that is most appropriate in a particular situation will be determined by the characteristics of products that move through the supply chain.

1. Responsive supply chains

Some product groups, such as fashions or technology, are characterized by frequent innovation. These innovations can make product demand unpredictable and require the entire supply chain to respond quickly as new products are introduced and as demand changes. At the same time, the supply chain must be able to transmit information quickly among its members. The information may include not only information about customer responses to new products, but also information about what customers would like to see in future products. So we conclude that in industries where we have a high level of innovation and we need faster response.
A particular type of supply chain, known as a responsive supply chain, is needed to meet these retirements. Members of such a supply chain are selected based on their speed and flexibility and their capacity to provide information from the marketplace to supply chain members. For example, responsive (also called innovative) supply chains are frequently used in the fashion industry.

2. Efficient supply chains

A very different type of supply chain is needed for products that are standard functional items such as commodities. These products have long product life cycles and stable, predictable demand. They are also often characterized by low profit margins. For these products, the supply chain must focus on operating efficiently to minimize costs. Such supply chains are known as efficient supply chains, and the members are chosen based on their ability to keep costs down and to minimize inventory in the system. The grocery industry is one group that is characterized by efficient (also called functional) supply chains. Here in this diagram we have a comparison of the two types of the supply chains.



So we classify supply chains based on the products they support as inherently functional or inherently innovative. They differ in practices used and thinking. High performers among innovative-product supply chains use practices that enhance revenues more than high performers among functional product supply chains. They are more likely to engage in supply-chain management to enhance revenues. Finally, we should say that the practices and reasons for engaging in supply-chain management that distinguish high performers from low performers are different for functional-and innovative-product supply chains.

Toward a classification scheme

First we need some operational definitions for industries according to our approach towards SCM as follows:

The criteria we use to design our operational definitions are defined as follows:

- Push vs. pull approach
- Potential implied uncertainty level
- Potential aggregation level
- Aggregation capability
- Efficiency based approach applicability
- Uncertainty in demand
- Uncertainty in supply
- Potential level of customisation or mass customisation
- Potential level of coordination

Before starting to classify industries it is better to define industry as a whole for two senses of meanings, then using a structured list of definitions for branches of industries we continue:

1. Industry: the people or companies engaged in a particular kind of commercial enterprise.
2. Industry, manufacture: the organized action of making of goods and services for sale.

These structured definitions for industries are as follows:

Sense one

Industry -- (the people or companies engaged in a particular kind of commercial enterprise; "each industry has its own trade publications")

=> Aluminum business, aluminum industry -- (manufacturers of aluminum considered as a group)

=> Apparel industry, garment industry, fashion industry, fashion business, rag trade -- (makers and sellers of fashionable clothing)

=> Banking industry, banking system -- (banks collectively)

=> Farm Credit System, FCS -- (a cooperative nationwide system of banks and associations providing credit to farmers and related businesses; originally capitalized by the federal government but now owned by its members and borrowers)

=> Hawala -- (an underground banking system based on trust whereby money can be made available internationally without actually moving it or leaving a record of the transaction; "terrorists make extensive use of hawala")

=> Automobile industry -- (the manufacturers of automobiles considered collectively)
=> Aviation -- (the operation of aircraft to provide transportation)
=> Chemical industry -- (a manufacturer of chemicals)
=> Coal industry -- (a producer of coal)
=> Computer industry -- (a manufacturer of computers)
=> Construction industry, housing industry -- (an industry that builds housing)
=> Electronics industry -- (a manufacturer of electronic products)
=> Entertainment industry, show business, show biz -- (those involved in providing entertainment: radio and television and films and theater)
=> Film industry, movie industry, screenland -- (those involved in producing and distributing movies)
  => Bollywood -- (the film industry of India)
  => Hollywood -- (the film industry of the United States)
=> Growth industry -- (an industry that is growing rapidly)
=> Lighting industry -- (an industry devoted to manufacturing and selling and installing lighting)
=> Munitions industry, arms industry -- (an industry that manufacturers weapons of war)
=> Oil industry, refining industry, oil business -- (an industry that produces and delivers oil and oil products)
=> Plastics industry -- (an industry that manufactures plastic articles)
=> Market, securities industry -- (the securities markets in the aggregate; "the market always frustrates the small investor")
  => Bear market -- (a market characterized by falling prices for securities)
  => Bull market -- (a market characterized by rising prices for securities)
  => The City -- (used to allude to the securities industry of Great Britain)
  => Wall Street, the Street -- (used to allude to the securities industry of the United States)
  => Money market -- (a market for short-term debt instruments)
=> Service industry -- (an industry that provides services rather than tangible objects)
  => Management consulting -- (a service industry that provides advice to those in charge of running a business)
=> Shipbuilding industry -- (an industry that builds ships)
=> Shoe industry -- (an industry that manufactures and sells shoes)
=> Sign industry -- (an industry that produces signs)
=> Steel industry -- (the industry that makes steel and steel products)
=> Sunrise industry -- (a new industry that is expanding rapidly (especially telecommunications or electronics))
=> Tobacco industry -- (an industry that manufactures and sells products containing tobacco)
=> Toy industry, toy business -- (an industry that manufactures and sells toys for children)
=> trucking industry -- (an industry that provides transportation for commercial products)

Second set of branches under the second meaning area:

Sense 2

Industry, manufacture -- (the organized action of making of goods and services for sale; "American industry is making increased use of computers to control production")

=> Cottage industry -- (small-scale industry that can be carried on at home by family members using their own equipment)
=> Production -- ((economics) manufacturing or mining or growing something (usually in large quantities) for sale; "he introduced more efficient methods of production")
=> Mass production -- (the production of large quantities of a standardized article (often using assembly line techniques))
=> Overproduction, overrun -- (too much production or more than expected)
=> Underproduction -- (inadequate production or less than expected)
=> Output, yield -- (production of a certain amount)
=> Crop, harvest -- (the yield from plants in a single growing season)
=> Fruitage -- (the yield of fruit; "a tree highly recommended for its fruitage")
=> Capacity -- (the maximum production possible; "the plant is working at 80 per cent capacity")
=> Breeding -- (the production of animals or plants by inbreeding or hybridization)
=> Autosexing -- ((especially of domestic fowl) breeding to reveal differential sex characteristics at hatching)
=> Cattle breeding -- (breeding cattle)
=> Dog breeding -- (breeding dogs)
=> Horse breeding -- (breeding horses)
=> brewing -- (the production of malt beverages (as beer or ale) from malt and hops by grinding and boiling them and fermenting the result with yeast)
=> Cultivation -- ((agriculture) production of food by preparing the land to grow crops)
=> Aquaculture -- (rearing aquatic animals or cultivating aquatic plants for food)
=> Beekeeping, apiculture -- (the cultivation of bees on a commercial scale for the production of honey)
=> Farming, agriculture, husbandry -- (the practice of cultivating the land or raising stock)
=> Animal husbandry -- (breeding and caring for farm animals)
=> Arboriculture, tree farming -- (the cultivation of tree for the production of timber)
=> Dairying, dairy farming -- (the business of a dairy)
=> Gardening, horticulture -- (the cultivation of plants)
=> Landscaping, landscape gardening -- (working as a landscape gardener)
=> Market gardening -- (the growing of vegetables or flowers for market)
=> Flower gardening, floriculture -- (the cultivation of flowering plants)

=> Hydroponics, aquiculture, tank farming -- (a technique of growing plants (without soil) in water containing dissolved nutrients)

=> Drip culture -- (a hydroponic method of growing plants by allowing nutrient solutions to drip slowly onto an inert medium in which the plants are growing)

=> Mixed farming -- (growing crops and feed and livestock all on the same farm)

The criteria for classification

Now we want to examine to find how we can reach a certain challenge area applicable for a certain industry. Also it is preferred to find a set all general challenge areas probable for industries regarding SCM.

These challenges could be defined based on these global variables:

1. Complexity of interactions among business processes that make aggregation and optimisation difficult and uncertain.
2. Complexity of flows inside the firm and inside the SC including: [This complexity can cover such an aspects like legal, physical, safety, security, transportation and shipment items.]
    a. Information flow
    b. Materials flow

Now again it is necessary to examine and explain the criteria mentioned above in some relevant areas of consideration.

Supply chain is a web or network between supply and demand, between need and product development. In cases like book publishing in which we have authors in one side and readers on the other side, in most of the cases there is no possibility for pull and it is fully on the push side. But in some other cases, it is fully the pulling effect governing the chain!

Supply chain practices for surviving:

- the rapid changes in markets
- product innovation
- other developments that challenge senior supply chain managers today

Strategic make-buy analysis

If you do outsource, how will you develop a supply chain strategy that will:

- Position your company for future growth?
- Ensure timely supply of components?
- Allow you to survive the fierce competition, the shorter product life cycles and the heightened customer expectations in today's global markets?

These are a set of criteria, based on which there will be possible to differentiate industries. But the case is to find a set of mutually exclusive and exhaustive criteria covering all aspects and not conflicting.

So you need a specialized framework for each branch of industry for strategically managing supply chains in today's rapidly changing markets. And each branch of industry has its own level

of market changing speed. And in this way they need some customized marketing strategy to support their SCM on the demand side as mentioned in the diagram above.

The classification scheme

Now we can reach an initial classification for supply chains. Here we introduce a new concept called supply network which simplifies the complex process of supply chain as a multidimensional fluid concept. The articulation of supply networks, as an extension of supply chains, seeks to accommodate and explain the commercial complexity associated with the creation and delivery of goods and services from the source of raw materials to their destination in end-customer markets. In place of the simplistic, linear and unidirectional model sometimes presented for supply chains, the supply network concept describes lateral links, reverse loops, two-way exchanges and so on, encompassing the upstream and downstream activity, with a focal firm as the point of reference. This classification scheme identifies differing emphases that may be required for managing within supply networks, according to the nature of the products for which they are created. Taking an established categorization of supply chains as its starting point, here we develop the conceptual basis.

Supply networks

Two distinct streams of research have been influential in the development of the concept of supply networks, covering two sides of the process as shown in our diagrams above:

(1) the largely descriptive research on industrial networks conducted by researchers within the Industrial Marketing and Purchasing group (IMP); and

(2) The more prescriptive research on supply chain management, based in the fields of strategic management, operations management and logistics.

Researchers within the IMP group have developed conceptual models to provide a better understanding of business markets in terms of the nature of buyer-supplier relationships and the embedded ness of these in "industrial networks", modelled as inter-connected actors, activities, and resources (Hakansson, 1982, 1987; Ford, 1990; Hakansson and Snehota, 1995). The term "supply chain management" was used originally in the early 1980s (Oliver and Webber, 1992; Houlihan, 1984) to refer to the management of materials across functional boundaries within an organisation but was soon extended beyond the boundary of the firm to include "upstream" production chains and "downstream" distribution channels (Womack et al., 1990; Womack and Jones, 1996; Harland and Clark, 1990; Christopher, 1992).

Supply networks can be defined as sets of supply chains, describing the flow of goods and services from original sources to end customers (Harland, 1996). The relatively recent incorporation of the term "network" into supply chain management research represents an attempt to make the concept wider and more strategic by harnessing the resource potential of the network in a more effective manner. The proposition is that networks compete with networks, rather than simply firms with firms (Cunningham, 1990). It follows that supply networks encompass not only the "upstream" network of suppliers but also the "downstream" network of distributors and customers. Our interpretation of the concept of supply networks is initially inspired by the work of the IMP group on industrial networks and much of the same language is used to describe the building blocks and nature of supply networks. However, unlike much of the

IMP work, our objective is a practicable outcome and we thus limit our focus to a set of manageable, operational tasks that meet the order-winning criteria of customer segments.
The problem for managers who have to cope with supply networks is that these accounts have typically explored particular industries, most notably the automotive industry; managers in other industries, who may be dealing with some different business problems, thus lack theoretical supporting structure for managing their particular kinds of supply network.

During the 1990s, the concepts of lean and agile production and mass customisation have been explored, taking as their starting point the inappropriate application of mass production principles in modern markets for products and services. While exploration of these concepts is still at an early stage, the principles appear straightforward, building upon the concept of just-in-time working. Lean production, entailing the removal of irregular and wasteful practices from processes, and agility, as the ability of a system to adapt quickly to changes in market requirements, clearly have much in common. While it may be inferred that for a system to be agile it must be lean (i.e. not carrying waste), it may not always be necessary for the system to be agile (i.e. some market requirements may not change very quickly). Furthermore, the requirements for agility may call for extra resources to be made available, above what might be termed "lean"; thus a system which is considered to be lean for continuous production of a standard product may need other attributes to remain lean in fast changing markets (i.e. to be agile). When the production ideas are applied to supply, however, the logic is rather different. The waste that is removed from the supply interface in lean supply is not something which, if replaced, could render the system agile. Concepts such as long-term vendor assessment and one-way negotiation are avoided in lean supply as wasteful tactics that engender transaction costs through encouraging cheating; they would similarly take away from agility at the interface. Nevertheless, using the logic discussed above, it may be that the supply interface and network required for a stable supply product may be characterised along different lines from those needed for a short-product life, high volatility product.

Here we try to identify how supply networks of different types can be created and operated and to develop terminology and ideas from network theory and strategic management theory to conceptualise and operationalise the findings.

Supply networks differ not only between industries but, more importantly, along a range of other dimensions, the starting point for adopting an operational perspective of supply networks should be to distinguish a set of typical or classic examples as we call them archetypes.

Classification of supply networks

Literature on inter-organisational networks lacks a truly comprehensive classification framework. Authors focus on different management issues or structural features, such as Araujo and Easton's (1996) "network approaches" or Nassimbeni's (1998) "network structures and co-ordination mechanisms". The different types of network that have been conceptualised may be viewed as a whole, providing a roughly structured classification.
The large variety of classifications show it is possible to identify many dimensions of networks. Grandori and Soda (1995), for example, distinguish network forms according to their characteristic mix of co-ordination mechanisms. They identify three types of network, which may be more or less symmetric or parity-based, or asymmetric or centralised (existence of a central co-ordinating firm). These are:

(1) social networks, such as parity-based personal networks, certain forms of industrial districts and centralised arrangements such as sub-contracting;
(2) bureaucratic networks such as trade associations and consortia, which are formalised in exchange or associational contractual agreements; and
(3) Proprietary networks such as joint ventures and capital ventures, which include inter-firm cross-holding of equities and property rights.

Rosenfeld (1996) focuses on the object of exchange as the basis for classification and distinguishes between "hard" networks in which three or more firms join forces to co-produce, co-market, co-purchase, or co-operate in product or market development, and "soft" networks in which groups of firms form in order to solve common problems, share information, or acquire new skills. The direction or orientation of networks may also provide the basis for classification. Hinterhuber and Levin (1994) distinguish between horizontal, vertical, and diagonal networks while also recognising that networks may be internal or external. Some networks may be particularly value-creating or strategic. In line with Jarillo's notion of "strategic networks" (1988), Campbell and Wilson (1996) conceptualise a "value-creating network" by focusing on the level of joint creation and strategic alignment of the actors. Networks may also be more or less dynamic (Snow and Miles, 1992) and differ in terms of degree of integration (Robertson and Langlois, 1995). Cravens et al. (1996) identify four types of network - "flexible", "hollow", virtual", and "value-added" - according to the dimensions of volatility of environmental change and the type of inter-organisational relationship involved (collaborative or transactional). Furthermore, they identify the likely variations in market structure, technological complexity, core competency of the co-ordinating organisation, and the network members' core competency, in each of the four types of network.

The majority of the existing categorisations point to some important dimensions and features of networks and thereby help to increase the understanding of different types of network. However, with the exception of the work by Grandori and Soda (1995) and Campbell and Wilson (1996) they offer limited operational assistance for focal companies trying to manage their networks effectively, and even their work does not deal with the special problem of managing supply networks. There is little guidance for firms addressing specific supply-related problems such as choosing the type of supply network appropriate for particular circumstances or how best to employ network technologies to enable the effective flow of supplies from raw material to end customers. The starting point for such a perspective has to take into account the differences in the task of managing supply.

Considering all, three aspects of the product being supplied may have impacts upon the way in which supply networks should be managed. The three aspects are the degree of product innovation, product uniqueness, and product complexity.

Product innovation

Fisher (1997) focuses on supply chains, concluding that they must be managed according to the nature of the product being supplied. He distinguishes two types of product on the basis of demand patterns, distinguishing the terms: "innovative" and "functional" products. Fisher argues that managing the supply of these two types of product requires two completely different types of supply chain. He observes that functional products, such as stationery items or tinned soup, have

long product life cycles and stable easy-to-forecast demand. Margins for such products are typically low (5-20 per cent) so minimisation of cost through, for example, achieving low inventories and high production runs, is the primary target. Fisher's "innovative products" meanwhile are characterised by unpredictable demand and shorter product life cycles. Margins are higher (usually 20-60 per cent) so, rather than minimisation of cost, the focus is on short lead times and flexibility to profit from the high, but short-lived margins. Fisher provides a few examples of functional and innovative products but does not specifically define or measure his categories or provide theoretical underpinning. However, as innovation is essentially concerned with the degree of change or newness, it is logical to describe these as "significantly new" products. This development of Fisher's categories allows us to link our emerging classification with classical innovation literature, to employ such concepts as "novel", and "radically" new or "revolutionary" (Von Hippel, 1986; Freeman, 1994). An alternative classification would be that proposed by Chesbrough and Teece (1996), who see autonomous and systemic innovations as mandating networked (or virtual) and vertically integrated organisations respectively.

Fisher argues that supply chains for functional products must be physically efficient whereas those for innovative products should be market responsive. The demand for innovative products is, by definition, difficult to predict, and thus may contain more profit potential but also more risk.

Since supply networks consist of sets of interconnected supply chains, it may be argued that Fisher's conclusions can be transferred to networks and that the competitive priorities of the two distinct types of supply network - for innovative products and functional products - are also different. Innovative product supply networks have speed and flexibility, or agility, as their primary concern, whereas supply networks of functional products may not need to be agile since volatility of specification and demand is low; they should focus simply on cost and are concerned with being lean. It therefore becomes possible to distinguish between responsive, high speed networks and efficient low cost networks. Other researchers have recognised this. Slack (1991), for example, emphasises that competitive priorities, such as quality, cost, flexibility, delivery speed and reliability, should not be regarded as "either-or" trade-offs but rather as dimensions between which a balance should be achieved, determined by the specific segment at which the manufacturing operation aims i.e. the specific supply chain. Slack refers to this as the "plant within the plant" concept. In common with Slack, Christopher (1992) argues that operations should not merely seek to be cost efficient, or fast, or flexible but achieve all of these at the same time although not to the same extent. Hayes and Pisano (1994) have put forward a similar argument. Whereas Slack and Christopher both emphasise that it is differences in end customer segments which determine the balance of competitive priorities, and Chesborough and Teece focus on the nature of the innovation itself, Fisher's argument is that it depends on the nature of the product.

Product Uniqueness

We suggest that the degree of product differentiation may also be expected to influence how supply networks are managed. While little research in supply chain management has investigated this, research on strategy has given considerable attention to the nature of products and resources and what makes them "unique". Whereas strategy has traditionally focused on product differentiation, recent developments have shifted the attention towards the nature of the resources

and technologies of the firms that produce the products (Barney, 1991)[4], and the conditions under which resources can be a source of sustained competitive advantage (Wernerfeldt, 1984; Lippman and Rumelt, 1982; Rumelt, 1984). The concepts of idiosyncratic [or unusual] resources and core competencies (Williamson, 1979; Prahalad and Hamel, 1990) are at the heart of resource-based strategy, a school that has become increasingly influential over the last ten years.

According to the resource-based view, firms should seek to gain ownership of or access to valuable, rare, non-imitable, and non-substitutable resources (Barney, 1991). Resources are "valuable" when they enable a firm to conceive and implement strategies that improve its efficiency and effectiveness, and "rare" when in short supply. "Imperfect imitability" arises as a result of unique historical reasons (Arthur, 1989), causal ambiguity (in the link between the resources and success) (Lippman and Rumelt, 1982) or social complexity (beyond the ability of the firm to manage and influence systematically, for example, its reputation among its suppliers and/or customers) (Klein and Leffler, 1981; Fiol, 1991).

Barney's framework (1991) may be used to define unique products as "valuable", "rare", "non-imitable" and "non-substitutable". The implication of this for classifying supply networks is that we would expect companies which supply unique products to nurture them and perhaps also protect them from other parties in the network, fearing that their products, and the resources and competencies which provide their competitive advantage, may be replicated by imitators. Therefore, as firms rely on and protect their unique resources in order to generate sustained competitive advantage, they may be expected to exercise caution in sharing them with other parties. Little research to date, however, has examined this particular problem.

Using Barney's framework as the basis for identifying uniqueness means that the requirements for products to fit this category are very strict. For example, many firms believe that their products are unique; while such products may be differentiated from the competition in marketing terms, however, unique products are rare exceptions to a common offer, according to our definition.

Whereas many innovative products are likely to be unique the reverse may not always be true.

It is suggested that there are two distinct types of supply network:- those for "innovative-unique" products and those for "functional" products. We derive this from a synthesis of Fisher's largely descriptive approach and strategic management theory. We propose that not only do innovative products require a certain type of supply network but also that unique products may constitute an important element of the same category, hence the term "innovative-unique". The management implications of uniqueness are not yet clear, but can be expected to have an impact on the sharing of resources between actors within the network.

Supply networks of innovative-unique products are proposed as focusing primarily on the speed and flexibility to bring the products to market as quickly as possible to benefit from the high initial demand and may also be expected to focus on quality and innovation. Meanwhile, supply networks for functional products are likely to focus primarily on cost and quality.

Structural, strategic and process variations

Fundamental differences between types of supply network, which may be significant for managers seeking to create and operate them, could not be explained by differences in industrial context since it is a natural feature of supply networks that cut across industry boundaries. For

example, automotive and electronics companies are often part of the same network although the two are traditionally viewed as belonging to two different sectors.

Here we will discuss the differences in terms of structure, and the strategies and processes used in creating and operating the networks.

Supply networks of innovative-unique and functional products

Companies who supplied what could be characterised as innovative-unique products, and who possessed unique knowledge and technologies, appeared to differ significantly from others in the ways they managed their networks in terms of strategy and process priorities.

The most evident difference between supply networks of innovative-unique products and those of functional products was the nature of information and knowledge sharing.

The automotive branches in particular are involved in the sharing of sensitive information and knowledge, including cost information and discussion of mutual strategies.

Companies seek a balance along several dimensions, with regard to competitive priorities (supporting Slack's concept of competitive priorities as non-trade-offs). However, it seems that companies supplying innovative-unique products tend to emphasise quality and innovation, viewing cost as a given. Companies supplying functional products, however, tend to emphasise cost. It is notable that service, delivery speed and reliability, and flexibility all seem to be important in all the networks; service seemed to be especially important in supply networks of functional products.

Supply networks of products with varying degrees of complexity

The supply networks of relatively complex products (i.e. products consisting of many technology-intensive and interrelated components, such as automobiles) are much broader upstream than supply networks of less complex products - generally as a result of the large number of components. These focal companies also typically rely on relatively few sources for each component, i.e. single or dual sourcing. The size of the downstream network, however, varies. The upstream networks include a range of powerful suppliers, several of which are trying to gain control of their part of the network. In contrast, supply networks of less complex products, such as baked beans or chocolate bars, tend to be dominated by fewer companies, sometimes by only one strong focal company controlling large parts of the whole network. For example pharmaceutical product supply networks appear to be fairly small due to the relatively small number of components/ingredients. Technical product and material standards, regulations in business environment, coupled with very high levels of process technology, made supply important but complex to control for pharmaceuticals.

The large sizes of the supply networks of complex products appear to make management of information difficult. Investments in information technology for co-ordinating material and information flows were particularly evident in such cases. For example the supply network for a car may contain up to about 800 suppliers, around half of these being so-called "first-tier"[8] In comparison, the supply networks of less complex products, like pharmaceutical supply networks, contains fewer than about 100 suppliers in total. In such small networks, the use of information technology such as EDI to manage invoices and orders, is viewed as less critical, with such matters being handled manually e.g. by fax.

Although it appears axiomatic that product complexity affects the size of supply networks, little work has been done to investigate its effect on network management.

Revised classification of supply networks

A matrix of four distinct types of supply network is developed, distinguishing supply networks of innovative-unique products from those of functional products, and using product complexity as a second differentiator. Fisher's dichotomy of innovative and functional supply chains is transferable to supply networks. The role of product uniqueness has to be recognised and indicated that there seem to be two critical implications on supply network management:

(1) the extent of information and knowledge exchange is constrained, and opportunities for cost transparency thereby limited (and thus lean supply, for managers employing traditional supply paradigms) (Lamming, 1993, p. 154); and

(2) The strategic priorities and structure of the networks also appear to be affected. Uniqueness thus appears to be a very important dimension.

As products vary considerably in terms of complexity, so do their supply networks. This has important implications for the management of the supply networks; some of those in our survey were fairly small and easily managed networks while others were very complex, calling for sophisticated information technology to enable the processing of the large flows of information.

For example the supply networks of drugs, communications technology, and electronics appears to fit the category of unique-innovative product supply networks. In these cases the focal firm exhibits difficulties in pursuing open communication and knowledge exchange.

The supply network for off-road cars resembled a functional and fairly complex product although not "systemic and highly customised" as Davies (1997) would describe.

The cases of canned soft drinks, beer cans, brake cylinders, and window wipers all resemble very functional, commodity type product supply networks, pursuing cost minimisation and quality optimisation and some apparently open two-way communication of costs and margin data. Some of these products can be viewed as components and therefore relatively simple and functional from a focal firm perspective, i.e. they may be part of a customer's complex and innovative product supply network. However, from the point of view of those focal firms trying to manage their supply networks, it is useful to perceive such "components" as the "products" of those suppliers.

The positions of networks within the cells in the classification should be viewed as static - companies might move between boxes; for example, from unique-innovative to functional as the product matures over time. Such changes would be intricately linked to a revision of supply strategy.

In practice, of course, a product classification of supply networks must be combined with assessment of other dimensions of supply networks. For example, Grandori and Soda's emphasis on symmetric or parity-based networks versus asymmetric or centralised networks seems to have a strong impact on the way focal companies can manage their supply networks. The issue of power is also an important factor explaining the extent to which focal companies could influence the rest of the network. Firms positioned in supply networks involving many large and evenly balanced other firms seemed to have less control over the rest of the network and seemed to be coping with rather than managing their networks. However, with the product as the basis for classification we conclude that the classification of supply networks is a potential contribution to the operational perspective for managers.

Conclusions

We put forward the argument that supply networks differ substantially according to the type of product being supplied. This may be more useful than sectoral distinctions as supply networks frequently surpass the bounds of one industry. In our proposed framework for classifying supply networks, we distinguish a matrix of four types of supply network. This classification supports and develops Fisher's argument that the supply chain for an innovative product should be different from that of a functional product due to differences in demand patterns.

In addition to moving from chains to networks, however, we have extended the argument beyond Fisher's dichotomy, using strategic management theory and our own research to conclude that it is not only the level of product innovativeness that determines the appropriate type of supply network but also product uniqueness, and that the two may be used together as a feature of the product. Firms within supply networks of unique products generally exchange less information and knowledge of a sensitive and strategic nature and with fewer but close partners. The complexity of the product being supplied is significant: supply networks of complex products are more complex to manage as a consequence of the large number of components and hence actors involved. The need for information technology therefore seems to be greater in these particular networks.

The major implication of adopting a product-specific view of supply networks is that management of the network becomes contingent upon different factors. Management of supply networks of functional products, however complex, must focus on cost and quality issues whereas for unique-innovative products, the emphasis is on speed and flexibility.

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