An initial classification of supply networks

Richard Lamming, Thomas Johnsen, Jurong Zheng and Christine Harland
University of Bath, UK

Keywords *Networks, Product innovation, Supply-chain management, Classification*

Abstract *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. A review of classifications of supply networks reveals that none of the existing approaches appears adequate for managers facing the practical problems of creating and operating them on a day-to-day basis. This research 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 categorisation of supply chains as its starting point, the research first develops the conceptual basis, using strategy literature, and then tests the resultant initial model in 16 case studies. Finally, a new categorisation for supply networks is presented, using the type of product as a differentiator.*

Supply networks

Two distinct streams of research have been influential in the development of the concept of supply networks:

(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 embeddedness of these in "industrial networks", modelled as inter-connected actors, activities, and resources (Håkansson, 1982, 1987; Ford, 1990; Håkansson and Snehota, 1995). The term "supply chain management" was used originally in the early 1980s (Oliver and

The work reported here forms part of the Inter-Organisation Networking (ION) Project. This three-year research project was funded between 1996 and 1999 by the UK's Engineering and Physical Sciences Research Council (EPSRC), British Telecommunications, plc, and a club of some 20 further companies with operating bases throughout Europe. This support is gratefully acknowledged, as is the work of our research partners: Nick Oliver, Una McCormack and John Anderson at Cambridge, and John Bessant and George Tsekouras at Brighton.

International Journal of Operations & Production Management, Vol. 20 No. 6, 2000, pp. 675-691.

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.

Much of the research on supply networks in an operational context has been based upon descriptive case examples of firms that appear to have managed their networks and achieved some form of competitive advantage; Benetton, Toyota and Nissan are examples of firms covered by such accounts (Jarillo and Stevenson, 1991; Womack *et al.*, 1990; Nishiguchi, 1994). 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 underpinning 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, as recognised in Japan by Western observers during the 1980s. Lean production, entailing the removal of anomalous 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 deemed 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 open book negotiation are eschewed in lean supply as wasteful tactics that engender transaction costs through encouraging guile and cheating; they would similarly detract 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.

It is in the context of the recent developments within supply chain management and lean supply that our research into the creation and operation of supply networks, should be seen. We seek 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 research.

We argue that as 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 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. Table I shows some of the most influential contributions.

The large variety of classifications shown in Table I shows 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.

Authors	Types of network	Classifying variables
Grandori and Soda (1995)	Social Bureaucratic Proprietary	Mix of co-ordination mechanisms: degree of formalisation and centralisation
Rosenfeld (1996)	Hard Soft	Object of exchange
Hinterhuber and Levin (1994)	Internal Vertical Horizontal Diagonal	Network orientation/direction
Campbell and Wilson (1996)	Social Value-creating	Structural autonomy and strategic alignment
Snow and Miles (1992)	Internal Stable Dynamic	Network dynamic
Robertson and Langlois (1995)	Japanese Kaisha Venture capital	Ownership integration and co-ordination integration
Cravens *et al.* (1996)	Flexible Virtual Hollow Value-added	Type of relationships and environmental fluctuations

Note: All references discussed in text

Table I.
Classifications of networks within the literature

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. From our reading of the literature and from initial observation of supply networks in operation, we propose that 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[1].

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[2].

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[3].

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)[5]. The concepts of idiosyncratic 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[6].

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. Scottish malt whisky, for example, has a strong historical background and is produced using a complex and causally ambiguous combination of rare and valuable resources, and is therefore very difficult to replicate. However, whereas it may be important to recognise that product innovativeness and uniqueness are not the same thing, it may be difficult in practice to differentiate between the two.

An initial classification of supply networks

We suggest 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.

Table II shows our initial classification. 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.

The following section discusses our study of 16 supply networks in a variety of industries, supplying different types of product. The examination of such a broad range of supply networks provides an opportunity to further explore and develop our initial classification framework.

The study

The survey was carried out during 1997, exploring strategic, structural and operational features of a wide range of supply networks. The unit of analysis was the physical flow of a particular product within the total supply network i.e. the upstream and downstream network. All the products in the survey were defined from the perspective of the focal firm; the aim was to identify how different focal firms, including component suppliers, had created and operated their supply networks. By focusing on the network as a whole, the survey differed from most other studies of industrial networks, which normally adopt the dyad as the unit of analysis.

The survey included 16 major firms from a variety of industries in Europe and their suppliers and customers/distributors. The focal firms in the study represented five industry groups: automotive, fast moving consumer goods (FMCGs), electronics, pharmaceuticals and service, including communications technology (see Table III). The firms were positioned at various points in the supply process, i.e. on a path between raw material to end customer, including manufacturers, distributors and components suppliers.

Semi-structured interviews were conducted with senior personnel of the focal companies between January and April 1997. Respondents were asked to map their supply networks for the specific product chosen for the survey and explain how they networks had been created, operated, and evaluated. Qualitative data analysis was carried out to attempt to identify any patterns of network features (reported in Zheng *et al.*, 1997).

Characteristics	Supply networks of innovative-unique products	Supply networks of functional products
Competitive priority	Speed and flexibility Innovation Quality supremacy	Cost reduction Quality sustainability
Sharing of resources	Potentially problematic	Generally unproblematic

Table II.
Initial classification of supply networks

Sector	Product supplied by focal firm	Position of focal firm
FMCG (5)	Canned soft drinks	Manufacturer
	Beer cans	Manufacturer
	Chocolate bars	Manufacturer
	Aerosol cans	Manufacturer
	Supermarket own label baked beans	Retailer
Automotive, including aftermarket (4)	Off road vehicle	Manufacturer
	Interior trim (component)	Manufacturer
	Wheel cylinders	Distributor
	Window wipers	Distributor
Electronic (2)	LED semi-conductors (component)	Component manufacturer
	Personal copiers	Manufacturer
Pharmaceutical (2)	Drugs	Manufacturer
	Drugs	Manufacturer
Services (3)	Communications technology (component)	Service provider
	ATM services	Service provider
	Client property services	Service provider

Table III. Sample supply network characteristics

Findings: structural, strategic and process variations

The research revealed some clear indications of fundamental differences between types of supply network, which may be significant for managers seeking to create and operate them. These differences could not be explained by differences in industrial context since it is a natural feature of supply networks that they 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.

The following section 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. Four of the cases were especially interesting in this respect: the two drugs, one telecommunications product and one of the electronic products. One of the drugs was more mature than the other, the patent running out in the USA in the near future, and hence less innovative and unique than the other. The telecommunications product was invented almost a decade ago and was as such not new to the market any more. The electronic product, which was a particular type of LED semi-conductor, was both innovative in the sense

of being new and unique in the sense that it was being described as "core". Each of these networks spread across industry sector boundaries. All were technology intensive products, involving key intellectual property rights (IPR). The uniqueness of the products involved was a clearly recognised source of competitive advantage which meant that there was a high level of secrecy inhibiting the exchange of information and knowledge, such as cost and proprietary technology information. It was evident, however, that the company supplying the more mature drug had very close relationships with its many "preferred" suppliers, with whom it shared both know-how and even production technology. Even more information and knowledge (including IPR) was being shared with its "strategic suppliers" (defined as suppliers who could be "completely trusted").

The implications of innovativeness on supply network management was particularly apparent in the LED semi-conductor which had experienced 50 per cent growth in one year and resulted in a high degree of uncertainty. The company was subsequently struggling with its unstable ordering process and had been forced to abandon its just-in-time supply:

> When we have certain constraints people tend to overreact and order much too much and twist the suppliers' arms to increase their capacity. Then they may buy a new factory and then later they are told that it was just a nervous reaction.

Strategic decisions about the structure of the networks had been taken in the four innovative-unique product networks. These were all fairly narrow, i.e. the companies pursued strategies of single or at most dual sourcing. The pharmaceutical cases were both more vertically integrated than companies supplying more functional products although the one supplying the more mature and less innovative product was in the process of outsourcing activities to the "strategic suppliers" (50 per cent now being outsourced as opposed to 25-30 per cent only a few years ago). The automotive cases in particular were involved in the sharing of sensitive information and knowledge, including cost information and discussion of mutual strategies. There were even some examples of very limited (but genuinely two-way) "cost transparency" (see Lamming, 1993; 1995; 1996; Hines *et al.*, 2000) for an explanation of cost transparency and other lean supply principles). One company explained that the profit margin was so low anyway that they would share this information with anyone. More substantial examples of exchange, e.g. sharing of staff, were observed as a frequent activity in networks supplying functional products.

It was evident that companies sought a balance along several dimensions, with regard to competitive priorities (supporting Slack's concept of competitive priorities as non-trade-offs). However, it also seemed that companies supplying innovative-unique products tended to emphasise quality and innovation, viewing cost as a given. Companies supplying functional products, however, tended to emphasise cost. Whereas this would have been expected, it was

notable that service, delivery speed and reliability, and flexibility all seemed 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 findings show that the supply networks of relatively complex products (i.e. products consisting of many technology-intensive and interrelated components, such as automobiles) were much broader upstream than supply networks of less complex products – generally as a result of the large number of components[7]. These focal companies also typically relied on relatively few sources for each component, i.e. single or dual sourcing. The size of the downstream network, however, varied. The upstream networks in these cases included a range of powerful suppliers, several of which were 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, tended to be dominated by fewer companies, sometimes by only one strong focal company controlling large parts of the whole network. Where such a company existed in FMCG, however, there was still a challenge from other strong players in the network. Pharmaceutical product supply networks appeared to be fairly small due to the relatively small number of components/ingredients. However, technical product and material standards, regulations in their business environment, coupled with very high levels of process technology, made supply important but complex to control.

As might be expected, the large size of the supply networks of complex products appeared 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 contained about 750 suppliers, around 350 to 400 of these being so-called "first-tier"[8] In comparison, the supply networks of less complex products, including some FMCG or pharmaceutical supply networks, contained fewer than 100 suppliers in total. In such small networks, the use of information technology such as EDI to manage invoices and orders, was 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[9].

Revised classification of supply networks

Based on findings from the survey, a matrix of four distinct types of supply network was 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 appears to be supported by our survey and is shown to be transferable to supply networks. Especially the case of the LED semi-conductor showed the implications of an innovative product on dynamics and uncertainty in the

supply network. The effect on competitive priorities was less clear as most respondents emphasised the importance of delivery speed and reliability and flexibility. This could, however, be due to the methodological difficulties of differentiating order-winning criteria from qualifiers and less important criteria (Spring and Boaden, 1997; Hill, 1985). The survey also confirmed our expectation that 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 was 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 appeared to be affected. Uniqueness thus appeared to be a very important dimension.

The survey also showed that, just 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.

Table IV shows examples of products that fall into the four general categories, drawn from the survey cases[10]. As our survey did not include any product which was both innovative-unique and complex, the data in this part of the framework are synthesised from literature and interpolation of our results.

The supply networks of drugs, communications technology, and electronics appeared to fit the category of unique-innovative product supply networks. In those cases the focal firm exhibited 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. It also exhibited examples of basic cost transparency.

The cases of canned soft drinks, beer cans, brake cylinders, and window wipers all resembled 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.

We do not suggest that the positions of networks within the cells in the classification should be viewed as static – companies might move between

Characteristics	Supply networks of innovative and unique products	Supply networks of functional products
Higher complexity	*Competitive priority*: speed and flexibility, innovation, quality supremacy *Sharing of resources and information*: large amounts of non-strategic information enabled by IT – problematic when involving sensitive information and knowledge *Not included in survey*	*Competitive priority*: cost reduction, quality sustainability, service *Sharing of resources and information*: large amounts of non-strategic information enabled by IT – generally unproblematic: may include cost breakdowns and strategic knowledge *Example from survey*: off-road car
Lower complexity	*Competitive priority*: speed and flexibility, innovation, quality supremacy *Sharing of resources and information*: problematic exchange of sensitive information and knowledge – IT less critical *Examples from survey*: drugs, LED semi-conductor, communications technology	*Competitive priority*: cost (by high volume production), service *Sharing of resources and information*: generally unproblematic – may include cost and strategic knowledge – IT less critical *Examples from survey*: canned soft drinks, beer cans, wheel cylinders, window wipers

Table IV.
Revised classification of supply networks

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 was also identified in the survey as 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

In this article we have put forward the argument that supply networks differ substantially according to the type of product being supplied. We suggest that this may be more useful than sectoral distinctions as supply networks frequently transcend the bounds of one industry. Building on theoretical

arguments and our survey findings we have suggested a framework for classifying supply networks, which distinguishes 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. The survey indicated that firms within supply networks of unique products generally exchanged less information and knowledge of a sensitive and strategic nature and with fewer but close partners. We also conclude that 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. The suggested framework will be used as a platform for a set of in-depth case studies, leading to the development of a taxonomy for creating and operating different types of supply network.

Notes

1. Note that Chesbrough and Teece also focus on process innovation, describing, for example, the lean production system as "a truly systemic innovation".
2. Although Fisher's arguments are simplistic, there is an appealing logic to the idea of connecting product characteristics and supply chain performance requirements (see also Swink and Hegarthy, 1998).
3. Different customer segments are, of course, also often targeted with different products and types of innovation, so broad consideration is still important.
4. Following Daft (1983), Barney (1991) defines resources as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm . . .".
5. See Wernerfeldt (1984) and Barney (1991). Note that "sustained" implies that it is a competitive advantage not easily duplicated by competitors (Lippman and Rumelt, 1982; Rumelt, 1984).
6. The resource-based view of strategy was originally suggested by Wernerfeldt (1984) and popularised by Prahalad and Hamel (1990).
7. We use the term "complexity" here to denote physical complexity which affects the supply management task. A drug, for example, is less complex in this sense although its pharmaceutical nature may, of course, be extremely complex.

8. For varying interpretations of the term "tier" in the supply context, see Lamming (1993, pp. 186-90), Hines (1994) and Hines *et al.* (2000).
9. Research in innovation has often treated complex products as a special case, e.g. passenger aircraft, helicopters and oil refinement equipment are all highly customised and systemic (Davies, 1996).
10. For confidentiality reasons, the products from the survey cannot be named.

References

Araujo, L. and Easton, G. (1996), "Networks in socio-economic systems", in Iacobucci, D. (Ed.), *Networks in Marketing*, Sage, London.

Arthur, W.B. (1989), "Competing technologies, increasing returns, and lock-in by historical small events", *Economic Journal*, Vol. 99, pp. 116-31.

Barney, J. (1991), "Firm resources and sustained competitive advantage", *Journal of Management*, Vol. 17, pp. 99-117.

Campbell, A.J. and Wilson, D. (1996), "Managed networks: creating strategic advantage", in Iacobucci, D. (Ed.), *Networks in Marketing*, Sage, London.

Chesbrough, H.W. and Teece, D.J. (1996), "When is virtual virtuous? Organizing for innovation", *Harvard Business Review*, January/February, pp. 65-73.

Christopher, M.G. (1992), *Logistics and Supply Chain Management*, Pitman, London.

Cox, A.W. (1997), *Business Success*, Earlsgate Press, Hull.

Cravens, D.W., Piercy, N.F. and. Shipp, S.H. (1996), "New organisational forms for competing in highly dynamic environments: the network paradigm", *British Journal of Management*, Vol. 7, pp. 203-18.

Cunningham, M.T. (1990), "Survival and growth strategies in new technology markets", *Proceedings of the 6th IMP Conference*, Milan, pp. 346-372.

Daft, R. (1983), *Organization Theory and Design*, West, New York, NY.

Davies, A. (1996), "Innovation in large technical systems: the case of telecommunications", *Industrial and Corporate Change*, Vol. 5 No. 4, pp. 1143-80.

Fiol, C.M. (1991), "Managing culture as a competitive resource: an identity-based view of sustainable competitive advantage", *Journal of Management*, Vol. 17, pp. 191-211.

Fisher, M.L. (1997), "What is the right supply chain for your product?", *Harvard Business Review*, March/April, pp. 105-16.

Ford, I.D. (Ed.) (1990), *Understanding Business Markets: Interactions, Relationships and Networks*, Academic Press, San Diego, CA.

Freeman, C. (1994), "Critical survey", *Cambridge Journal of Economics*, Vol. 18, pp. 463-514.

Grandori, A. and Soda, G. (1995), "Inter-firm networks: antecedents, mechanisms and forms", *Organization Studies*, Vol. 16 No. 2, pp. 183-214.

Håkansson, H. (Ed.) (1982), *International Marketing and Purchasing of Industrial Goods: An Interaction Approach*, Wiley, Chichester.

Håkansson, H. (1987), *Industrial Technological Development: A Network Approach*, Croom Helm, London.

Håkansson, H. and Snehota, I. (1995), *Developing Relationships in Business Networks*, International Thomson Business Press, London.

Harland, C.M. (1996), "Supply chain management: relationships, chains and networks", *British Journal of Management*, Vol. 7, pp. S63-S80 (Special Issue).

Harland (Jones), C.M. and Clark, J. (1990), "Effectiveness framework for supply chain management", *Computer Integrated Manufacturing Systems*, Vol. 3 No. 4, November, pp. 196-207.

Hayes, R.H. and Pisano, G.P. (1994), "Beyond world class. the new manufacturing strategy", *Harvard Business Review*, January/February, pp. 77-86.

Hill, T. (1985), *Manufacturing Strategy*, Macmillan, London.

Hines, P. (1994), *Creating World Class Suppliers: Unlocking Mutual Competitive Advantage*, Pitman, London.

Hines, P.A., Lamming, R.C., Jones, D.T., Cousins, P.D. and Rich, N. (2000), *Value Stream Management*, Financial Times/Prentice Hall, London, Chapter 12.

Hinterhuber, H.H. and Levin, B.M. (1994), "Strategic networks – the organisation of the future", *Long Range Planning*, Vol. 27 No. 3, pp. 43-53.

Houlihan, J.B. (1984), "Supply chain management", *Proceedings of the 19th International Technical Conference*, BPICS, pp. 101-10.

Jarillo, J.C. (1988), "On strategic networks", *Strategic Management Journal*, Vol. 9, pp. 31-41.

Jarillo, J.C. and Stevenson, H.H. (1991), "Co-operative strategies: the payoffs and the pitfalls", *Long Range Planning*, Vol. 24 No. 1, pp. 64-70.

Klein, B. and Leffler, K. (1981), "The role of price in guaranteeing quality", *Journal of Political Economy*, Vol. 89, pp. 515-41.

Lamming, R.C. (1993), *Beyond Partnership: Strategies for Innovation and Lean Supply*, Prentice-Hall, Hemel Hempstead.

Lamming, R.C. (1995), "The future of purchasing: developing lean supply", in Lamming, R.C. and Cox, A.W., *Strategic Procurement Management in the 1990s: Concepts and Cases*, Earlsgate, pp. 35-54.

Lamming, R.C. (1996), "Squaring lean supply with supply chain management", *International Journal of Operations and Production Management*, Vol. 16 No. 2, pp. 183-96.

Lippman, S.A. and Rumelt, R.P. (1982), "Uncertain imitability: an analysis of interfirm differences under competition", *Bell Journal of Economics*, Vol. 13, pp. 418-38.

Nishiguchi, T. (1994), *Strategic Industrial Sourcing*, Oxford University Press, New York, NY.

Nassimbeni, G. (1998), "Network structures and co-ordination mechanisms: a taxonomy", *International Journal of Operations and Production Management*, Vol. 18 No. 6, pp. 538-54.

Oliver, R.K. and Webber, M.D. (1992), "Supply chain management: logistics catches up with strategy", in Christopher, M.G. (Ed.), *Logistics: The Strategic Issues*, Chapman & Hall, London, pp. 63-75.

Prahalad, C.K. and Hamel, G. (1990), "The core competencies of the corporation", *Harvard Business Review*, May/June, pp. 79-91.

Robertson, P.L. and Langlois, R.N. (1995), "Innovation, networks, and vertical integration", *Research Policy*, Vol. 24, pp. 543-62.

Rosenfeld, S.A. (1996), "Does co-operation enhance competitiveness? Assessing the impacts of inter-firm collaboration", *Research Policy*, Vol. 25 No. 2, pp. 247-63.

Rumelt, R. (1984), "Towards a strategic theory of the firm", in Lamb, R. (Ed.), *Competitive Strategic Management*, Prentice-Hall, Englewood Cliffs, NJ, pp. 556-70.

Slack, N. (1991), *The Manufacturing Advantage*, Mercury Business Books, London.

Snow, C.C. and Miles, R.E. (1992), "Managing 21st century network organisations", *Organisational Dynamics*, Winter.

Spring, M. and Boaden, R. (1997), "One more time: how do you win orders? A critical reappraisal of the Hill manufacturing strategy framework", *International Journal of Operations and Production Management*, Vol. 17 No. 8, pp. 757-79.

Swink, M. and Hegarthy, W.H. (1998), "Core manufacturing capabilities and their links to product differentiation", *International Journal of Operations and Production Management*, Vol. 18 No. 4, pp. 374-96.

Von Hippel, E. (1986), "Lead users: a source of novel product concepts", *Management Science*, Vol. 32 No. 7, July, pp. 791-805.

Wernerfeldt, B. (1984), "A resource-based view of the firm", *Strategic Management Journal*, Vol. 5 No. 2, pp. 171-80.

Williamson, O.E. (1979), "Transaction cost economics: the governance of contractual relations", *Journal of Law and Economics*, Vol. 22, pp. 233-61.

Womack, J.P., Jones, D.T. and Roos, D. (1990), "The machine that changed the world", Macmillan, London.

Womack, J.P. and Jones, D.T. (1996), *Lean Thinking: Banish Waste and Create Wealth in your Corporation*, Simon & Schuster, New York, NY.

Zheng, J., Harland, C.M., Johnsen, T. and Lamming, R.C. (1997), "Features of supply networks", paper presented at the British Academy of Management Annual Conference, 8-10 September, London.