20 Unchaining: Why Supply Chains and Business Networks are Different

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Abstract

What makes a high-performing, sustainable supply chain? Our dear colleague and friend professor Jo van Nunen has been investigating this important question during the last years of his productive and inspirational life (Neto et al., 2010; van Nunen & Zuidwijk, 2004). As a mathematician and highly respected scholar of operations research he was intrigued by the amplifier effect of small changes in market demand within the supply chain (Lee et al., 1997) resulting in excessive inventory, production waste, delivery delays and financial and environmental losses. A sustainable supply chain requires "closed loops", Van Nunen claimed, right from the market to all parties involved in the sequential chain of companies and linking their production processes. Information sharing and control would be essential. However, the abundant use of networking technologies may challenge this view. We argue that companies grouped as business networks can have different ways to handle the amplifier effect and do not need to have full access to market information data, and may not require joint informational control.

20.1 Chains or networks

The scientific works of professor Jo van Nunen are an interesting exposure of the shift of management science attention from the individual firm to relationships between organisations ("interorganisational systems" or IOS), and subsequently the arrangement of companies as relays in a sequential production chain (supply, or logistical chains). Trained as a decision scientist, Jo's initial focus has been on decision support systems to help individual companies make decisions on key operational and logistical processes. This changed as Porter introduced the concept of "value chain" to provide a tool to analyse a firm's individual activities and a method to view the interrelationships of these activities as a "value system" (Porter, 1985). It is one of the contributions of Van Nunen and his research team to extend Porter's single-company view to the IOS: an industry-wide supply chain. He also understood clearly the importance of information to co-ordinate the flow of activities both within and between companies (Fleischmann et al., 2003; van Nunen & Zuidwijk, 2004). As products flow downstream in the supply chain, information needs to flow upstream - presenting the problems of sharing the necessary coordination data and synchronising that data with the physical flows.

Electronic data interchange (EDI) became a recognised tool for doing so and the cost and benefit analysis of EDI has been an important contribution of Van Nunen et al. (Hoogeweegen et al., 1996). This resulted in the development of the management tool "modular business network design" (MND) (Hoogeweegen, 1997): companies become actors in a supply network, products are defined as a set of "service elements" and production capabilities as "production elements". Service elements can be grouped in many different ways while each actor co-ordinates its production capabilities via agreed rules that control the matching of service elements to production elements. MND, according to Hoogeweegen (1997; 1999), enables a dynamic business network defined as "*numerous firms (or units of firms) operating at each of the points at the value chain, ready to be pulled together for a given run and then disassembled to become part of another temporary alignment*" (Miles & Snow, 1992). In this view companies are not seen as part of a value chain - with a limited view to their immediate business partners, i.e. their suppliers and distributors - but a part of a flexible network: the chain is no more and no less than a temporary path set up between various actors linked together via the network (Vervest et al., 2004a; Vervest et al., 2004b).

The constructs “supply chain” and “supply network” are often confused (Vervest et al., 2005). See Fig. 1. A chain is a subgraph of a “supply tree” where each link connects exactly to one other link. A tree is a hierarchical graph that has no cycles and each node has only one parent. A network is a generalised graph consisting of multiple nodes connected by links in many directions. A fully connected network is a graph where each node is connected to all the others and the nodal degree is g-1 for each node (g being the total number of nodes) and the network density is 1 (Iacobucci, 1999).

The graph as seen from the customer’s view will often (but not always) be a tree. For example, the Eaton Corporation supplies automotive subassemblies to GM, and Dana Corporation supplies subassemblies both to GM and to Eaton, making the relevant graph a network and not a tree. If the supplier looks downstream into the graph for a particular product, he will only see his own customer, that customer’s customer, and so on. This structure is a chain. Hence, we see that the term “supply chain” refers to the supplier’s view of where his product or service is taken into the end customer. However, this term is often used when the customer’s view is intended, where the correct term is “supply tree” or “supply network”.

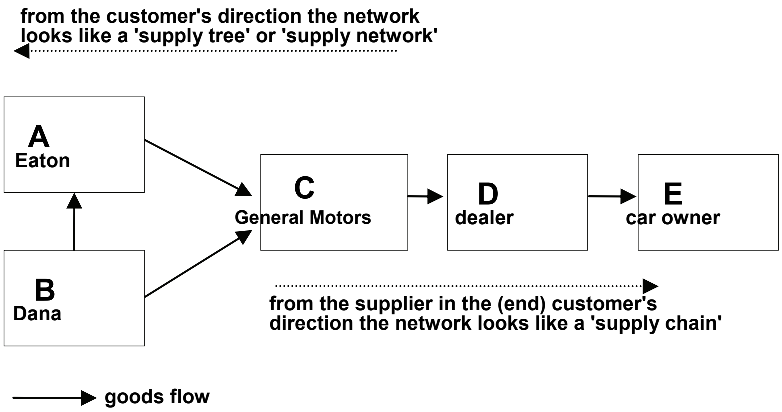

Figure 1. Seeing directional graph networks up or down the business network

20.2 The bullwhip in supply chains

In general companies in a supply chain order from their immediate upstream member. Inbound orders from a downstream member serve as informational input to upstream production and inventory decisions. As goods flow downstream information in the form of orders flows upstream. Lee et al. (1997) examined the *bullwhip effect*, or *whiplash effect*: orders to the supplier tend to have a larger variance than sales to the buyer (“demand distortion”), and this distortion propagates upstream in an amplified form (“variance amplification”) i.e.

$$Var(z_{j,t+1}) \succ Var(D_t) \text{ and } Var_{j+1} \succ Var_j$$

meaning that the quantity Z ordered at time t+1 by supplier j exceeds the demand D at time t (demand distortion) and that the higher j (the more a supplier is distanced from the original demand) the higher the distortion.

Lee et al. (1997) take an idealized situation of a multi-period inventory system that is operated under a periodic review policy, the “order-up-to-S” (S being a constant) policy and prove mathematically that each of the ideal-state conditions give rise to the bullwhip effect. They argue that improvement of information flow design can have significant efficiency gains, in particular by sharing sales data and inventory status data (between retailers and manufactures) for overcoming the bullwhip effect.

Idealized conditions for a multi-period inventory system under periodic review policy	**Bullwhip effect if condition is not met**
1. past demand is not used for forecasting	*demand signal processing*: past demand is used to update forecasts
2. resupply is infinite with a fixed lead time	*rationing*: strategic ordering by buyers when supply shortage is anticipated
3. there is no fixed order cost	*order batching*: fixed order cost is nonzero and ordering in every period is uneconomical
4. purchase cost of the product is stationary over time	*price variations*: non-constant purchase prices of the product

Table. 1. The bullwhip effect in supply chains

Their advice has been well taken into account as companies have started to share information across the chain, for example by direct communication of Point-of-Sale data to their suppliers. Since their seminal paper the technical possibilities for information sharing and access have advanced enormously. But a chain requires that information is processed quickly from customer to supplier (i.e. across the supply tree): A "back-loop" must process demand information quickly to every relevant part of the upstream chain - and this loop must be "closed" i.e. it must be linked to each of the chain participants and be timed, or synchronised with the amplification effects. Information sharing across the chain is a necessary but not sufficient condition. Each part of the chain needs to respond in acceptance with the control information that it receives, or the chain will be broken. This informational control needs an adequate governance structure - if it fails each of the members of the chain will suffer. It begs the question if supply chains will be able to keep up as demand becomes more change-able, erratic, and disturbed.

20.3 Do networks have bullwhips?

Networks are different from chains as they have multiple paths to link from demand to supply. Business is increasingly organising as a collectivity of capabilities that can form temporary alignments to meet specific demand (van Heck & Vervest, 2007). Actors in such business networks have made arrangements such that they can quickly connect their business processes to each other - and quickly disconnect as appropriate. This is very different from being "chained" - where one is commercially and technically bound to neighbouring business partners (supplier or distributor) with few and no short-term possibilities to choose alternatives. In network language, the chain is a frozen pathway and one cannot re-route.

The bullwhip effect in business networks needs research. As a network provides multiple routes, variance in demand may even out across network members in a way different from inventory replenishment schemes.

For instance, divisable load balancing used in computer networks (Robertazzi, 2003) could be used to optimise production capacity scheduling across all network actors instead of using inventory to smooth demand variation.

Put differently the network does not "replenish inventory" but "publishes" production capabilities to the network actors: Actors match demand to their own production capabilities and to those of other actors with whom they are linked. Demand is not seen as a defined quantity for static, integrated product at a given price, but as a negotiable set of requirements that can be fulfilled by way of dynamically composed production modules (Hoogeweegen & Wagenaar, 1996). As an example, take

Amazon[1]: demand is not defined as the potential order for a specific book but as a budget of requirements to be satisfied by combining author, book, delivery, payment, etc. from a network of contributing actors. The same applies to "rent-a-coder"[2].

Business networks need not handle demand distortion via "closed loops" and informational control - but can do so by way of the informational structure of the network resulting in different *network horizons* for each of the network actors.

Network Horizon
The network horizon refers to an actor's amount of information on other actors involved in the network (van Liere et al., 2008): it is an important determinant of the position of an actor in the business network, and therefore its competitive position. Previous studies show that a more extended network horizon is associated with a stronger bridging position - defined as (Burt, 1992) a network position where there are no direct links between the ego's business partners. The bridging position gives strong informational and control benefits.

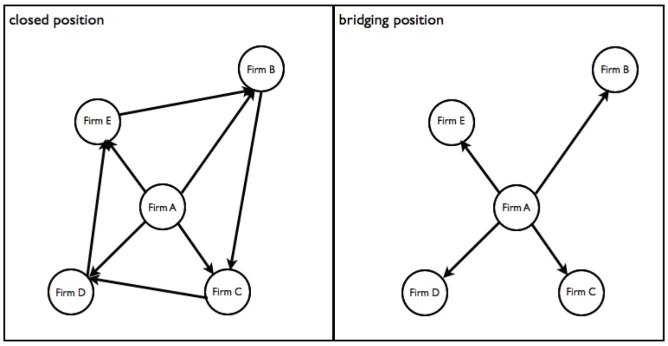

Figure 2. Closed and bridging positions in business networks

Using tools specifically developed to study interfirm networks (the Business Network Engine™ and LINKS™). Van Liere (2007) shows that the size of a firm's network horizon is a critical determinant of a firm's ability to strengthen and keep its bridging position. This does not mean that a firm should always try to expand its network horizon as the study indicates a threshold: Expanding the network horizon beyond this point gives rapidly diminishing returns.

Extensive simulation revealed the distribution of network horizon across network firms (the amount of *network horizon heterogeneity*) as a key factor for the sustainability of network positions. The results were striking. In the traditional supply chain where all firms have a low network horizon (that is, the firms know their upstream and downstream partners but little of the other actors) a competitive advantage can be sustained for some time (van Liere et al., 2008).

However, when the network horizon becomes more heterogeneous, firms change their network positions faster until all firms in the network have a high degree of network horizon and the network becomes homogeneous again: "Any opportunity can be spotted by many firms and any competitive advantage is therefore short-lived".

20.4 Impact on strategy: Unchaining

Van Nunen's work on supply chains has given new insights on customer order coupling and decoupling points. "Made-to-stock" became "made-to-order" and "just-in-time" manufacturing was destined to give high strategic benefits. Strategy shifted to focus on partnerships and complex co-making relationships. Supply partners needed to make strategic decisions according to their role and position in

[1] www.amazon.com
[2] www.rent-a-coder.com

the chain. Treacy and Wiersema (1993) grouped these decisions as opting for operational excellence focusing on the execution of a few key capabilities; product leadership as providing the best in the market; or customer intimacy to be closest to the customer.

Networking strategies, however, aim to get a "best position" in the network - the bridging position being an example of a strategic brokerage position. Each company in the network faces strategic decisions: to invest in network horizon (more links, better relationships); network resources (core or key capabilities); or to do both. This results in the following generic networking strategies (Vervest et al., 2009):

- *Platform providers* are product leaders - they invest in network links as well as resources - and focus on the constant use of and interaction on their platform, continually finding new ways and value to increase their size.
- *Capability hubs* focus on a key capability - deliver operational excellence through a combination of quality, price and ease of purchase that no one else in their market can match.
- *Network orchestrators* need a large network horizon - close to the end customers they understand their needs, access the network and select the nodes or capabilities that are required to fulfil the customer need best at any point in time but always flexible.

Each of these strategies has different implications on how demand information propagates through the network. Firms pursuing a capability hub strategy aggregate demand directly from many other firms: no single company is responsible for a large portion of the total demand, making capability hubs less vulnerable to demand fluctuations. Network orchestrators generally use pull (or build-to-order) inventory models that require less build-up of inventories and reduce demand uncertainty because they have direct contact with customers. Platform providers use digital platforms for co-ordination and grouping of network actors - resulting in a highly programmed way of demand management.

We postulate that demand distortion and variance propagation result from this "chaining" of companies. The inability to "unchain" from immediate business partners is perhaps the biggest weakness of many of today's businesses: Competitors that are not "chained" but have the capability to quickly connect and disconnect in a broad, loosely coupled business network, may move faster, deliver more variety, at better price, lower cost, than traditional value chains that are hooked in complex information sharing arrangements.

This will become a formidable competitive challenge for today's business environment. Like in social networks one needs the ability to "unfriend"[3] in order to find new places to befriend.

20.5 Researching winning strategies for unchaining

Unchaining means to dissolve supply chains into larger business networks, and by doing so decrease bullwhip effects. Research tools are needed that allow for manipulation of the overall network structure as well as individual network positions. Two research methods in particular come to mind: simulation and network experiments.

BNE™ (Hoogeweegen et al., 2006) is a platform for designing and running such simulation and experiments. BNE™ models a specific business network that responds to specified market demand. The network consists of a number of supply chains, each composed of a series of individual firms. The firms cooperate within their own supply chain to meet simulated customer demand. Each firm owns specific capabilities to contribute to customer demand fulfilment.

[3] **unfriend** – verb – To remove someone as a 'friend' on a social networking site such as Facebook, see Oxford University Press: http://blog.oup.com/2009/11/unfriend/

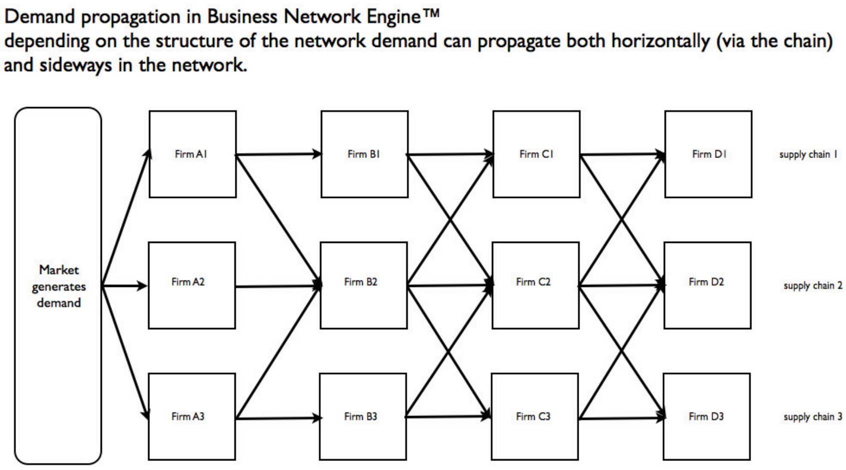

Figure 3. Propagation effects in BNE™

Using BNE™ we can simulate the performance of a business network, its participating supply chains and the individual firms within these supply chains. The BNE™ allows us to change customer demand over time, both in terms of variation and required quantities. This creates bullwhip effects and allows to assess the quantitative effects of unchaining. How firms in this simulated business network develop and execute unchaining strategies will determine the extent to which the business network will decrease bullwhip effects and thus, improve the performance of the total network as well as of its individual firm participants.

BNE™ can make us understand if and why unchaining leads to improved firm performance and how to do so. The amplifier effect in supply chains has convinced us of the dangers of chaining. However,

demand distortions that propagate wildly through highly connected business networks, such as recently in the financial worlds[4] may have a detrimental effect on modern, networked business. This is a major challenge for business research.

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[4] http://www.wired.com/techbiz/it/magazine/17-03/wp_quant?currentPage=all

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