

Supply chain management: notes on the capability and the limitations of a modern logistic paradigm

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Abstract The paper analyses the drawbacks and the potential diseconomies of the attempt to optimize a supply chain in a holistic manner. The conclusion derived by the author is that this is neither a viable nor a beneficial idea. As a consequence he advocates a paradigm shift. The concept of totally integrated supply chains should be replaced by the idea of loosely coupled processes and planning systems run by companies who preserve their autonomy and use competition as an incentive system and a source of energy and flexibility. These companies should interconnect on a bilateral level in order to exchange information about updated demand forecasts and the availability of capacities. But they should not develop strongly integrated networks who start competing with other supply chains on the level of this new identity.

1 Introduction

“Despite 20 years of ongoing research...there is no consensus on what SCM really is” [1, p. 70]. It is not an easy exercise to review and criticize a concept which is so iridescent. In order to focus our line of thought we refer to a definition from the early nineties provided by Cooper and Elram [2, p. 1], cited by Bechtel and Jayaram [3, p. 37]: “supply chain management is an approach whereby the entire network from the supplier to the ultimate customer is analysed and managed in order to achieve the ‘best’ outcome for the whole system”. Within subsequent publications the pretension was further increased by claiming a

“movement away from functional department suboptimization to a holistic optimization of the entire supply chain” [3, p. 21].

Obviously this definition leads to a dramatically extended scope of the resources and activities that managers are expected not only to control but to “optimize”: “supply chain management spans the entire enterprise and beyond, encompassing suppliers on one end and customers on the other” [4, p. 221]. In order to surpass the boundaries of individual rationality companies obviously have to establish something not seen or thought of before: a management beyond the limits of ownership. “This means treating stages in the supply chain that a company does not own as belonging to the company” [5, p. 41]. Before taking a critical look at the potential benefits and shortcomings of this concept we obviously have to ask ourselves how this can be arranged.

Under the headline “supply chain management” we are confronted with two different kinds of scientific work. At the bottom there is a kind of toolbox comprising models like vendor managed inventory (VMI), available/capable to promise (ATP) or collaborative planning, forecasting and replenishment (CPFR). These process models are based on an extension of the kind of information that companies should exchange while doing business with each other. Beyond transactional data like orders, delivery advices or invoices companies are expected to inform each other about updated demand forecasts, inventory days of reach, available production capacities and the current status of all activities affecting the adherence to delivery dates. Based on this new visibility companies are provided with an early view of potential bottlenecks in the supply chain, which in turn enables them to generate robust plans. As a consequence the amount of surprise, emergency and costly ad hoc adjustments can be reduced.

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Processes get more synchronized (that is the famous bullwhip effect will become less harmful) and more oriented to the end customer's demand. It is a common character of these models that they can be (and usually are) implemented within a two-sided relationship. Due to the stronger integration within these partnerships as an additional benefit one can expect a considerable reduction of transaction costs. What these models cannot provide is any kind of a "holistic optimization" across several companies on different stages of a value chain, because without further construction work their implementation does not lead to a system of a higher order which can be submitted to such an operation.

On top of these process models many protagonists of supply chain management therefore propagate the idea that companies which are part of a supply chain should subject their individual planning activities to a coordinating authority which creates an additional value by taking into account all kind of interdependencies between individual resources, restrictions, plans and activities that have formerly been neglected. This creates a larger solution space and opens the door to superior plans which were out of reach as long as the single companies on their respective stages were only following their narrow self-interest. Furthermore companies who are ready to share a common destiny cannot only separate out more contingency of their plans and orders but may develop a higher readiness to execute specific investments because the membership in the supply chain seemingly lowers the financial risks. For the same reason one can argue that transaction costs can be further reduced.

As a seemingly logical consequence the postulate arises "that the whole supply chain should be managed as one single entity" [6, p. 289]. Within the context of transaction cost economics this implies that the market which was used as coordination mechanism *ex ante* is entirely replaced by a hierarchy. The situation strived for is called a "win-win-situation" because it creates an additional value which (if necessary after a redistribution between the participants) puts all members into a better position. From this fundament it is only a small step to postulate a fundamental change in the field of competition. Competition will/should shift from the level of single companies on their respective stage in the value chain to the level of supply chains as whole entities and new players in the market: "the real competition is not company against company but rather supply chain against supply chain" [7, p. 18]. Some authors like Chopra and Meindl [5, p. 41] argue that this shift has already been carried out (It is a common weakness of many articles and books written about supply chain management that the authors do not clearly differentiate between observations, hypotheses, recommendations and predictions).

The following comments result in the statement that this holistic approach is neither viable nor desirable and therefore not likely to be turned into practice. In order to substantiate this converse proposition we will have to take a closer look at the implications and consequences of the idea of integrating companies across all stages of a value chain "from sheep to shop" in a rigid manner. The first and most basic issue highlights the question of the formation of supply chains. This issue is less trivial than many authors in this field suggest.

In a common work titled "defining supply chain management" seven renowned US-scientists start their analysis with the finding, "that there remains considerable confusion as to its meaning" (see [8]). Nevertheless they feel sure that supply chains "exist, whether they are managed or not". It is irritating to see someone claiming the existence of something which is not clearly defined, because within empirical sciences a clear distinction usually is regarded as an indispensable prerequisite of any observation. Furthermore it remains unclear how an innovation like supply chain management can come into existence without being managed.

Probably the idea that supply chains already exist before any attempt to submit them to a "holistic optimization" seems so self-evident because one always has the technologically predefined linear sequence of value adding activities in mind that one has to run through in order to bake bread, build mountain bikes or produce a yoghurt. In this trivial sense the existence of supply chains of course cannot be doubted. What can be doubted is the (unmanaged) existence of networks which are ready to be managed or even optimized in a holistic manner. To call any network of suppliers and customers surrounding a company a "supply chain" would disentitle the notion of any innovative meaning and render the word redundant. It would then be sufficient to use the word "logistics" and discuss the issues of an intensified supplier and/or customer relationship management.

2 Network identity: where can "supply chains" be found?

In order to prevent misunderstandings we point out that we will not discuss about the following three issues:

1. No business is an island. It is trivial to state that every company is connected with numerous customers and suppliers and that the quality of these relations has an impact on the company's ability to survive and create value.
2. It is equally unquestioned that in a global economy companies face the challenge to manage complex

process chains involving an increasing number of players.

- Everybody appreciates the opportunities offered by modern IT systems to improve the coordination of demand forecasts, production schedules and capacities (including inventories) across the boundaries of single companies.

All these issues have been and can be further discussed at length under the headline “logistics”. Interconnectedness was not a foreign word in this context. But as already mentioned interconnectedness by itself does not lead to institutional innovations or systems of a higher order which can be managed in a holistic manner—even if by means of a single sourcing strategy the relations to suppliers get tighter and more companies seek a relief of complexity and a reduction of transaction costs by accepting a longer duration of supply contracts.

When defining his concept of “strategical networks”, Sydow [9, p. 82] describes what is needed to constitute such a new organizational entity: “explicitly formulated goals,... a formal structure with the allocation of formal roles... and an own identity”. We have to add: without the enabling limits of closed boundaries separating the organization unambiguously from its environment a common optimum is impossible for simple logical reasons. Open opportunities (sourcing from or selling to third parties) would fragment the network and destroy the possibility to derive a common optimum, because there would be no common agenda and no common, closed solution space. Even the more basic goal of surviving in an uncertain environment could not be controlled because it remains unclear who precisely should be kept living. Conversely this means: the price companies must pay for a holistic optimum is a limitation of its freedom of action and a subordination. This characteristic cannot be graduated. (Within every day speech the notion of “optimization” is used in an inflationary manner denoting any kind of improvement. We use it in the strict sense in which it is used within the field of Operations Research, denoting solutions which, given a set of data and assumptions, cannot be further improved.)

If companies are ready to abandon their autonomy and subsume their narrow self interest for the benefit of the supply chain as a whole they establish the prerequisites for relocating competition. They compete as an integrated supply chain against other supply chains. Christopher [7, p. 5] illustrates this “new competitive paradigm” with a simple drawing showing a company surrounded by its customers and its suppliers and their customers and suppliers. Together they form the “confederation of mutually complementary competencies and capabilities” [7, p. 286] that seems ready to be subjected to a holistic optimization.

If this formation is interpreted as an advice to all companies regardless of their industry and their position in a value chain, there would be as many networks (“extended enterprises”) as there are companies, which means there would be none (Fig. 1).

Already before any attempt to analyze this paradox in a systematic manner, some doubts take possession of our mind. Should Airbus really take care about possible bottlenecks in the capacities of brazilian companies occupied with the extraction of the ore, because after several conversion steps transforming ore into steel in China the material is build into turbojet engines by Rolls and Royce in Great Britain (who also supply other companies in the aircraft industry)? Furthermore it is unclear who decides whether this is the supply chain of Airbus or the network of Rolls and Royce.

Coming back to the question whether supply chains exist out of themselves or have to be shaped before they can be further managed we base our arguments on the following perception of the current state of most german industries: if we take a closer look at the mutual interdependencies that connect companies operating on different stages of their respective value chain, we do not observe isolated chains, but instead we see overlapping open polycentric networks. Many companies appear as crossroads passed by different material and semi-finished goods which subsequently become part of totally different end products. Glas yarn is needed to produce laminate, which in turn is a material required by the manufacturers of circuit boards that go into cars, mobile phones and industrial robots. Another output of the capacities used to produce glas yarn is fiber glass which, among other products, goes into paperhangings. Consequently a car manufacturer or a producer of mobile phones—without knowing from each other—my be hit by a bottleneck in the capacity of the supplier of glas yarn, and while depending on the same raw material the automotive industry is connected with companies selling hangings. These overlapping, open and polycentric networks cannot be subjected to a holistic optimization, because they are far too complex. They have

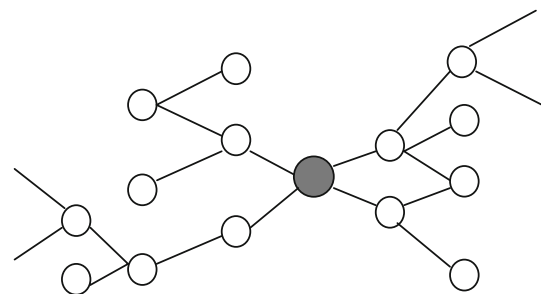


Fig. 1 The supply chain network

neither a distinct boundary nor (as a consequence) an own identity. This finding has three major implications:

1. The requirement that all supply chains should totally focus on the needs of the ultimate customer is misleading. On the pre-stages of production it is often unclear, who the final customer will be and, if there are several, if their requirements concerning the performance of “the” supply chain are identical. (For a manufacturer of hard disk drives like Western Digital the end customer can be a child using his paddle as well as a large company using mainframe computers).
2. The idea of constantly feeding actual customer demand forward to all players in the supply chain can not be applied without a distinctive preliminary reduction of complexity (even than it will turn out to be extremely difficult to find the way to the 5th or 7th tier suppliers through a number of complex bills of material on all levels of the chain and to calculate the related lead times per item, supplier and stage which must be known in order to allocate the adapted times of delivery that have to be achieved by all suppliers on all stages).
3. Supply chains can not be found in reality as existing objects for managers or researchers (like fruit flies can be found by a genetic researcher). Instead they must be created by carving a limited number of companies on different stages of production out of an unmanageable network of networks.

For several reasons the latter is not a trivial act. One reason points to an organizational problem. Until today the organizational pattern of many companies still follow the idea of a functional specialization. This means: in order to become a member of a single supply chain, people from the purchasing and the sales department have to be convinced that their way to see the world is not as relevant as the world outlook of logisticians. Purchasers e.g. tend to like competition in the buying market which would have to be abandoned in order to make a holistic optimization of “their” supply chain possible. Multiple sourcing could create “economies of substitution”, but it would fragment the chain in the same way in which multiple distribution channels would do (in the latter case there is no predefined reference object for the “optimal” allocation of scarce capacities).

This problem cannot just be solved by broadening the concept of SCM, e.g. by defining SCM “as being more than just logistics” and extending it to “the management of all business processes” [10, p. 5]. Companies would have to reorganize themselves via a fundamental shift of interfaces and a related redistribution of power and influence. But even if logistics and purchasing are organized as subsections of a newly established superior supply chain

management the addressed goal conflict would not simply disappear. Building tightly coupled supply chains on the basis of a single sourcing strategy is not a logical implication of systems thinking, but just one of several possible ways to structure a system. The objective evidence that this arrangement creates more benefits than opportunity costs has to be provided in every single case.

Another problem is the generation of a strategy that can be undersigned by all the members of the supply chain. Intrinsically this strategy is needed before the formation, because it is the basis for deriving the selection criteria and defining the business case. On the other hand a legitimization of the strategy ideally should be based on the approval of all members. The only way out of this circle is a company which has enough power to define the boundaries of a network which can than be subjected to a holistic optimization. In this case the formation of the chain will be biased by the individual interests of the focal enterprise. An ongoing conflict within the german consumer goods industry exhibits the implications of this approach.

Within this sector it has been a long and unquestioned tradition that the supply of retail outlets is the genuine task of the manufacturers. Accordingly they have established their distribution systems, which show the pattern of uprooted trees and whose efficiency strongly depends on the annual transportation volume a single supplier controls (economies of scale and density). Since the end of the last century not only in Germany more and more retail chains have discovered the opportunity to get control over their inbound goods flows in order to exploit the benefits of bundling for themselves. Because this change of system leadership requires a change in the delivery terms this model is also called “factory gate pricing” (Germans use the word “Selbstabholung” which means selfcollection). Figure 2 illustrates the conflict behind these competing claims to define “the” supply chain. The two models cannot tolerate each other because both create economies of scale which can only be generated and exploited once.

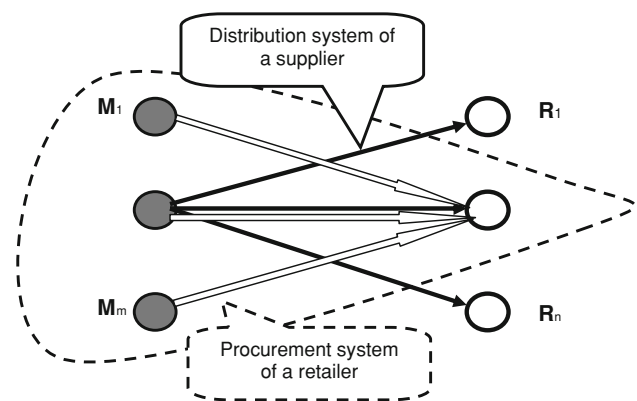


Fig. 2 Competing supply chain definitions

In order to fully understand the picture, imagine that the supplier in the middle is Proctor and Gamble delivering pampers to the retailer in the middle named METRO. The dark arrows represent the distribution system of Proctor and Gamble which is bundling orders from different retail organizations and perhaps some healthcare organizations on the way to the outlets, regional warehouses or clinics where they are needed (the real architecture of such a network of course is more complex, what matters here is the fact that the commodity flows are entirely controlled by the manufacturer). If METRO is successful in claiming that all their inbound flows from different manufacturers (comprising among others pampers, CD-players, mountain bikes, power saws and food of all kind) have to be regarded and treated as their supply chain, the dark arrows are replaced by the bright arrows and a totally different, formerly unknown network with a different architecture arises. The boundaries of this alternative “supply chain” are marked by the dotted line. (By the way: METRO was very successful in following this path).

Although this is an interesting question, this is not the place to discuss which side has the stronger arguments or whether this is a zero sum game. What matters in the given context is the finding that

- The confining of a supply chain is a foregoing act which cannot be “optimized” in itself.
- The thesis that “collaboration” in supply chains always and by necessity unlocks win-win-situations cannot be kept up.
- Starting the reflection about supply chains based on the assumptions that there is (or should be?) “a common agreed agenda driving the achievement of the supply chain goals” [7, p. 293] and a “joint ownership of decisions” is audacious.

3 Governance structures: how can supply chains be managed?

The idea of a management beyond the limits of ownership is not as trivial as may look like. Keeping in mind that the concept of an “extended enterprise” is an institutional innovation and that institutions are defined by roles and rules, it is amazing to see that most articles on SCM focus on process models and on the potential outcomes and benefits of supply chain management while losing sight of the problems connected with the organization of leadership. Before discussing this issue we list up some of the problems that have to be addressed and solved in order to make a supply chain work:

- Who is/should be in charge of deciding which companies should be accepted or excluded as member of the supply chain?
- If the coherence of the chain and the channelizing of behaviour is not only guaranteed by incentives and mutual trust (which seems to be favoured by the advocates of “collaboration”) but by negotiated explicit reciprocal obligations written down in long term contracts (which might be regarded as necessary in order to foster and protect specific investments): who can/should play the role of the contractual partner?
- If a member steps out of line by exploiting the opportunity to source some material from outside (because the products are cheaper or better) or by allocating part of his capacities to a third party because they are ready to pay higher prices: who has the authority to inhibit this or force the disloyal to compensate the victims? (Would a prevention of this opportunism be compatible with the idea of “optimization”? And: are the related opportunity costs included in the calculation of the “win-win-situation”?)
- Who takes on the costs for observing compliance with commitments or enforcing contracts?
- Who measures/controls the benefits or losses which collaboration initially (that is before any redistribution) generates within the four walls of each member? (This presupposes the absence of opportunistic behaviour of all partners while exhibiting their data and it raises some delicate measurement problems: for instance the question to what extent the number of unplanned ad hoc changes of short term production schedules formerly provoked by unforeseen bottlenecks in the capacities of suppliers can be reduced and what the exact bottom line effects of this stabilisation are).
- Who decides about the reallocation of the benefits/losses if (which has to be expected) these outcomes initially are spread among the members in an asymmetric manner?
- If the results of the before mentioned activities (incentives, subsidies and/or guaranties) must be known in advance in order to facilitate the decision of a company to join a supply chain: who can claim the legitimation to do this work before the supply chain has assumed a concrete shape and how could anyone get access to the sensitive data base needed to simulate the outcomes for different constellations?
- If, as Lambert et al. (2008) correctly point out, a process-oriented organization overcoming the internal functional silos (procurement, production, marketing/sales) within the individual firm is a prerequisite for any supply chain-wide process integration: who can stimulate the necessary transformation in order to create

supply chain readiness within companies which are still organized around business functions?

- If a coordinated production planning across the whole supply chain requires modern IT-tools like so-called Advanced Planning Systems installed in all companies plus the associated adjustment of master data (like bills of material): can all suppliers be forced to accept the considerable expenditures actuated by these measures?

Basically there are two solutions offered to shape the governance structure of a supply chain, namely (a) the subordination to a company endowed with enough power to orchestrate the coordination across all other participants, and (b) a heterarchical coordination based on a mutual partnership among companies with equal rights called “collaboration” (in the latter case the organizational arrangement would be some kind of a steering committee). The question whether the idea of self-organizing, poly centric actors forming a supply chain presupposes a symmetric distribution of power (a situation which can hardly be found in reality) or can be combined with a distinct power-based leadership remains unanalyzed because it is barely raised. This is not a big drawback because both approaches do not solve the problem.

If the orchestration is done by a strong leading company it remains unclear

- why a powerful company should give up its individual optimum for the benefit of a superordinate “supply chain profitability” [5, p. 6], and
- what could make the powerless members of the supply chain believe that after long years of a fierce competition on the shares of the value added the supply chain leader while orchestrating the chain will always respect their interests and not capture the surplus? (If in the face of market power suspicion established by previous experience cannot be replaced by trust the functioning of information sharing cannot be expected. Instead opportunism will spread and generate the kind of problems which have been elaborated in detail within the agency theory [see e.g. 11], in particular there will be hidden information and hidden action).

Power comes along with legitimation problems, reduces loyalty, provokes resistance and the striving for independence (and/or the building of countervailing power), and in most cases it loses strength when it is extended “upstream” to the supplier’s supplier. Probably these are the main reasons why most exponents of supply chain management prefer the second option for the design of a governance structure which ideally presupposes the absence of power: Collaboration.

Unfortunately while solving one problem the absence of power creates some others. Collaboration is/should be

based on the mutual trust between equal partners. Like power trust is a means to reduce complexity. It averts the risk of opportunistic behaviour, reduces uncertainty, allows for decreased controlling efforts and thus can reduce transaction costs. But if trust is a prerequisite of collaboration it must be in place before the supply chain can be constructed. The problem whether a leap of faith pays off has been discussed at length within game theory (see for instance the insights delivered by Axelrod [12] regarding human behaviour in a situation called “prisoner’s dilemma”). But unlike people playing games real companies have a long history in their role as customers and/or suppliers which strongly affect their expectations concerning the behaviour of their “partners”, and an equal distribution of power is uncommon in most markets. This leads Christopher [7, p. 286] to the insight that “perhaps the one of the biggest challenges to the successful establishment of marketing networks is the need to break free from the often adversarial nature of buyer/supplier relationships that existed in the past”.

If one takes a closer look at the way in which original equipment manufacturers in the automotive industry or larger retail chains interact with their suppliers one soon realizes that via severe negotiations on prices these companies still fight for their part of the value creation in their respective supply chain, using all the power they have. Do they need a re-education because they have not yet understood that eliminating the bullwhip-effect and reducing transactions costs by means of collaboration can yield higher benefits than letting suppliers fight for orders and exploiting economies of substitution?

Of course one has to change things if one wants to improve them. The current performance of managers therefore may be the wrong benchmark for the evaluation of an innovation. But the advocates of collaboration have to ask themselves some fundamental questions: can an organization that abstains from any hierarchy be strong enough to create and run something like an “extended enterprise” reaching out from the production of raw material to the end customer consuming the end product? Can an arrangement led by some kind of a steering committee (with the inclination to endless debates about the right strategy, the distribution of benefits, etc.) really compete with more rigid organizations which rely on empowered managers taking over personal responsibility?

If one hesitates to impute ignorance, inertia or irrational behaviour to managers who do not “break free from adversarial relationships” and accept a shared destiny with their partners the conclusion from what we can observe is different. Obviously the concept of collaboration is based on unrealistic assumptions and at the same time too confuse in order to be used as (or instead of) a governance structure which is strong enough to create and manage

whole supply chains as if they were legal entities. This assessment corresponds with a number of recent empirical findings.

Kampstra et al. (2006, p. 315) diagnose that “paradoxically, SCC is immensely popular both in business and academia and at the same time most collaborative initiatives end up in failure”. A joint study of Capgemini, the Georgia (Southern) University and the University of Tennessee states: “supply chain collaboration is needed, but not happening” [13], and a study delivered by Forrester comes to the conclusion that the “much-hyped concept in the late 1980s and 1990s”... “did not live up to the industries expectations” [14]. Vereecke and Muylle [15, p. 2] do not only cast doubt on the dispersion of collaboration, but also on the capability of this model to deliver better results: “Empirical support for the relationship between supply chain collaboration and performance improvement is scarce”, they state and sum up their own investigation with the conclusion “performance improvement is only weakly related to the extent of collaboration with customers or suppliers”.

4 Incentive systems: more competitiveness based on less competition?

Within integrated supply chains market prices have to be substituted by internal transfer prices. This operation comes along with a huge loss of valuable information. Looked at from outside a market price looks like a rather poor information: it consists of only one number. What is making it rich and valuable as an incentive and as the linchpin of a steering mechanism is its mode of formation. Market prices reflect the currently prevailing conditions of the production and distribution of a good, including for instance updated oil prices, increased road charges, the pricing policies of suppliers and competitors, and the shortness of material and capacities.

Market prices work as signals leading managers to adapt even to facts that are out of their sight. By producing and spreading these signals markets permanently create situations in which all decision makers can use much more information than any single one of them has at his disposal. The market mechanism uses a knowledge which does not exist as an entity, and it therefore is a much better instrument for the usage of scattered information than any central planning institution could ever be (for a fundamental analysis see [16]).

The replacement of market prices by an internal pricing system inevitably leads to delayed and biased adjustments. A supplier facing overcapacities in his original market would not feel the need to adjust the internally defined transfer prices he was granted under previous conditions.

Probably his partner and former customer would not even notice the opportunity for a price cut because in order to reduce transaction costs (which is always highlighted as one of the major benefits of integration) he has dismantled his procurement department. Within the so called “new institutional economics” [17] the harmfulness of dissymmetrically distributed information has been elaborated in detail under headlines like “adverse selection” and “moral hazard”. With their captive internal markets supply chains are the ideal nutrient medium to generate such dysfunctional effects. The external competitiveness of supply chains will diminish because inside the network competition has been suspended as a controlling mechanism and as a source of energy.

For the same reason the advocates of rigidly integrated supply chains should be careful with their assertion that this institutional arrangement would lead to a stronger orientation towards the needs of the “ultimate customer”. As long as purchasers and suppliers compete for their part of the value added the market mechanism makes sure that at the end of the day all increases in efficiency will be handed on to the end customer. In contrast to this while reading about the win-win-situations that supply chain management creates and about the necessity to share these effects among the partners in a fair manner one gets the impression that supply chains should take possession of the additional gains as “relational rents” in order to stabilize the arrangement. This is definitely not in the interest of customers and it can turn out to be a competitive disadvantage in relation to those companies who refrain from joining any collective.

A side impact of internal transfer prices is the effect that in a dynamic environment the associated partners after a short time will no longer know whether the allocation rules fixed with these prices comply with the requirements of fairness and justness. This can generate as much dissatisfaction as the impression that one could buy or sell products outside the supply chain at better conditions. Astonishingly neither the question whether such an arrangement fits in the shareholder value concept nor the question whether it is compatible with anti-trust-law has ever been raised and discussed.

Disengaging oneself from the market mechanism as means of coordination obviously generates considerable opportunity costs. The presumably most negative effect of the idea of vertically integrated supply chains in this regard has not yet been mentioned. Competition stimulates and encourages innovation. Eliminating competition and entrepreneurship therefore means eliminating an important source of competitive advantages. Suppliers whose sales seem secured through the membership in a supply chain do no longer have to prove their right to exist by positioning themselves at the top of technological progress. They

would also find it relatively hard to get there because they lack the permanent confrontation with the demand and expectations of different customers. Perhaps they are also discouraged by the expectation that in a tight cooperation it is hard to prevent an unattended leakage of knowledge or even that the potential benefit of an innovation would be socialized within the network they are part of. In the end they are no longer willing to do what they were capable of. In any case it seems most unlikely that integrated supply chains could originate suppliers with the calibre of Intel or Bosch. They are also unable to integrate them *ex post* because such companies derive their strength from their autonomy. In the end this is for the benefit of the whole economy because within open networks innovative products are made accessible to more companies and to more customers. Facing such proud suppliers supply chains will make the distressing experience that they either have to do without the market leaders or to give up their holistic management approach.

Last but not least we have to point out that a single sourcing strategy practiced within a supply chain in order to enable an end to end optimization of the whole network destroys economies of scale and scope that can be exploited by companies which preserve the option of purchasing from different sources and accept vendors supplying their competitors (which is common practice within the German automotive industry). Risk reducing pooling effects on the level of an inventory which is carried by a supplier for several customers can be regarded as part of these economies. For simple logical reasons a holistic optimization requires dedicated resources (if not specific investments that cannot be redeployed for alternative use). This confinement inevitably increases the risks of major investments, raises capital costs and scales down the shareholder value. To advocate this in a world in which the coincidence of globalization and the internet reduces transaction costs and creates sourcing opportunities companies never had before seems to be a peculiar idea.

5 Flexibility: are supply chains better prepared to cope with uncertainty?

“Responsive supply chains are by definition highly integrated”, says Christopher [7, p. 280]. Besides the fact that this is not a matter of definition we argue in the following chapter that the opposite is true. We start our argumentation with a little mental exercise putting ourselves into the position of a mathematician trying to build an integrated planning tool which covers all the interdependencies between the activities and capacities of the companies forming a supply chain. Basically there are two kind of interdependencies that have to be covered: besides

relations between processes on different levels which are sequentially interdependent one also has to look at interdependencies between resources which can have the effect that short capacities of one company affects the capacity utilization of another. With regard to planning processes these two interdependencies are interconnected. If all possible constraints across all members of a supply chain were known to one central planning authority this instance could replace local suboptima (which formerly resulted from taking the output of other local decisions as given restrictions) by a total optimum which makes the best use out of the joint capacities of the whole chain and in addition (by taking out uncertainty) could make plans more stable. This expectation seems to bare an undisputable logic. But there are dysfunctions and a severe spillover that are often ignored.

The attempt to map and represent all interdependencies in one decision model leads to the necessity to cover and represent a huge number of variables, restrictions and parameters that have formerly been hidden behind the interfaces which had separated the companies into smaller legal entities (i.e. they were absorbed by the market). Ideally this is a way to gain control over something that formerly was an annoying source of surprise and emergency. But unfortunately many of the parameters now included in the model are not just there (ready to be collected as fixed data) but have to be forecasted (the relevant environment of a whole supply chain comprises much more potential sources of a disturbance than the environment of one single company). The implication is that with the extension of the model a lot of additional uncertainty is imported (an uncertainty that formerly other people cared about). This makes the outputs of the model more and more unstable and creates the necessity of more and more amendments of plans.

The result looks paradoxical: the attempt to represent the complexity of a whole network in a central decision model does not only produce the need to collect and process a huge amount of data (as multi-level bills of material), but it also foils the intention to gain control over the whole system: instead of increasing the stability of plans the amount of uncertainty rises. In the end the organization will not gain, but loose control and has to handle one exception after the other. Instead of reliability and resilience the result is vulnerability. There are no more local problems which can be solved on a local level. Instead each local problem raises the necessity of readjusting the overall plan (otherwise one would neglect interdependencies and give up “systems thinking”). Because of its inability to incapsulate and absorb local disturbances and resolve them ad hoc, the system creates one domino effect after another. (Experts in macroeconomics will see remarkable analogies to the way socialistic economies were run. They were also

based on a linear, mechanical and unworkable notion of control).

6 A paradigm change: loosely coupled systems cross-linked by modern IT systems

In the beginning of our investigation we have separated the “tool box” which has been developed under the headline of “supply chain management” (comprising concepts like VMI and ATP) from the philosophy propagated on top of these models. This analysis has led to the conclusion that the idea of optimizing networks in a holistic manner (embracing all companies of a value chain from the suppliers of raw material to the ultimate customer) is all utopian. For several reasons it cannot be put into practice, and even if it would be viable it would be unwise to pursue it. A further consequence of this analysis is the prediction that the often propagated shift of competition to the level of entire supply chains in many important industries is unlikely to evolve.

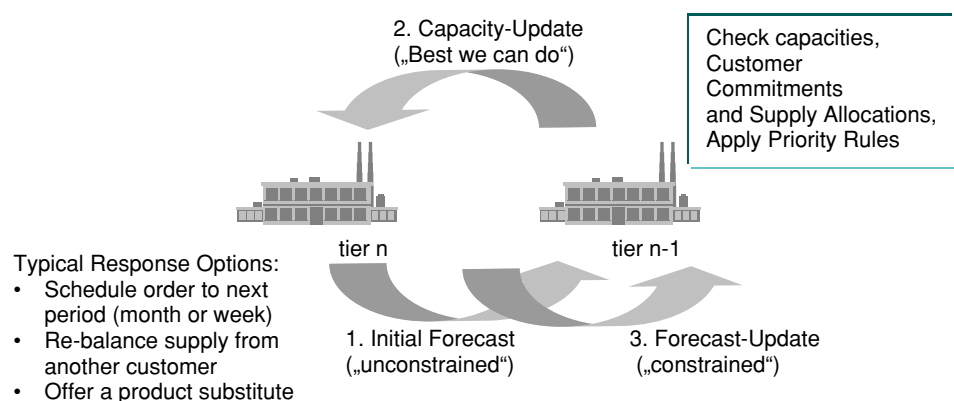
We therefore have to replace the paradigm of optimizing “extended enterprises” by another paradigm which comprises the feasible idea of an improved mutual visibility concerning updated demand forecasts and the availability of resources without generating the detrimental side effects of a rigid vertical integration. We advocate the idea of loosely coupled companies maintaining their autonomy within polycentric overlapping networks because in a complex and dynamic environment loose coupling is not a defect but a precondition of stability and resilience. Within these open networks which do not strive for a new superior identity as “supply chains” efficiency can be considerably increased by implementing the above mentioned models in numerous bilateral arrangements. In some cases this may lead to close relations between purchasers and suppliers, to long term contracts and to the development of mutual trust.

Figure 3 illustrates the functioning of an “available-to-promise”-model (for further details see [18]).

The model shown in Fig. 3 replaces the standard lead times which traditionally structure the coordination within order fulfilment processes. Standard lead times, usually defined by the number of days required to deliver a product, do not consider the availability of resources (inventory or production capacity) at the time orders are accepted. As no supplier can afford to cover infrequent demand peaks with additional capacity it usually is an unexpressed part of the agreement that on time delivery rates do not exceed a level of $95 + x\%$ (depending on the particular industry). The remaining risk comes not by surprise but is intended and expected (and usually defined by dimensioning safety stocks), thus using the customer as a final buffer.

The ATP-model shown in Fig. 3 can be described as an extended feedback loop, which replaces the common sequence “plan–act–check–replan” by the sequence “plan–check (availability)–replan–act”. The original equipment manufacturer (OEM = tier n) propagates his initial production schedule (“unconstrained forecast”) upstream to his first tier suppliers and calls on them to check possible constraints either on the level of inventory or on the level of production capacities (in the latter case one can use the notion “capable-to-promise”). As a feedback he receives a capacity update (“best-we-can-do”-message). Ideally the suppliers have modern software tools called “Advanced Planning Systems” in place which enable them to derive stressable commitments out of a constraint based planning (for further details see [19]). In case of disclosed bottlenecks the OEM either adjusts his plans and propagates them as viable planning basis upstream again (“constrained forecast”) or exploits economies of substitution and sources part of his demand from another supplier. Ideally this results in a situation where the involved suppliers only produce what is really needed whereas the OEM is disburdened from the risk of ad

Fig. 3 “Available-to-promise” as an extended feedback loop



hoc-adjustments and/or the belated completions of unfinished work. Within the cooperation the activation of processes changes from a push- to a pull-mode.

The model delivers an ostensive description of a mechanism capable of exploiting the benefits of an increased visibility between partners in a value chain. It represents that part of knowledge delivered under the headline of “supply chain management” that we regard as useful and viable (although for several reasons the complexity of their implementation by far exceeds the complexity of their logic). These models do not lead into a perfect world (e.g. the uncertainty reduced by an ATP-message will not disappear completely but show up again before the next query, suppliers may hesitate to submit a commitment if the risk of a cancellation is not compensated, and the chain is still exposed to an unknown risk as long as some potentially critical suppliers are excluded from the game). Nevertheless one can proceed in this direction and we therefore base the paradigm advocated here on the idea of companies supplying each other with more information needed for a stable allocation of resources.

But keep in mind: within these models the companies do not completely give up the flexibility of exchanging partners and using the market as a means to provide economies of substitution. They understand that in a dynamic and uncertain environment indeterminateness is a strength. Maintaining the opportunities the market offers is part of their risk management. In contrast supply chains would make the experience that rigid coupling and an overdone connectivity foster structural inertia and narrow the number of options if major changes in the environment require major internal changes in order to survive. Supply chains lack what the cybernetician Ross Ashby [20] once has called “requisite variety”. (Further analogies cannot only be found in the fields of education (see [21] and artificial intelligence (see the current discussion of “swarm intelligence” (Kennedy et al. 2001) and the description of multi-agent systems and the “internet of things” (e.g. with [22]), but also within evolution biology: “it is not the ability to adapt, but the ability to decouple which explains the enormous stability and resilience of life and of all systems build upon it” says the German sociologist Luhman [23, p. 556] referring to the work of leading biologists like the author of the “Principles of Biological Autonomy” [24]).

Using the market mechanism will equip companies working together in loosely coupled networks with a higher intelligence which is not embodied in a single location, organization or IT system. From an SCM-perspective polycentric networks are the incarnation of redundancy. But for the companies embedded in these networks this is the basis of their adaptiveness. They can use a wealth of information (among them meaningful prices) which can

never be completely transferred from the location where problems first appear to the top of a central planning authority. Hierarchies are built to communicate directives top down but for several reasons they usually show a poor performance if a transfer of data in the opposite direction is required. The consequence is that loosely coupled networks are faster in adapting to changing conditions and that they can develop a superior learning aptitude. Endowed with modern planning tools they can build feedback loops comprising customers and/or suppliers (in general not beyond the first level) which enable them to take constraints into account which were formerly hidden behind the four walls of their partners. But the companies which are embedded in such open networks do not have to anticipate the huge number of changes in the environment which a whole supply chain would have to take into account and which would put their planning system into a state of a permanent great nervousness. (To point this out more clearly: The number of contacts to the outside world per company is smaller but an integrated supply chain as a whole has much less contacts than the open, overlapping, polycentric networks we are talking about. Living in a richer context means receiving more impulses to learn and improve. Conversely supply chains are endowed with less sensitive sensing mechanisms).

The institutional arrangement that is recommended here can derive several competitive advantages from using the market as a coordination mechanism. Some of these have to do with the incentives which have an impact on the behaviour of managers. While the determined membership in a closed network can be interpreted as an invitation to an opportunistic behaviour competition drives suppliers into a continuous improvement process. Innovation is stimulated by the aspiration to be rewarded by relational rents. But this motivation only works if these rents are not granted and remain uncertain, that is to say if competition is not abandoned. The permanent threat to loose a customer may be regarded as a rather negative kind of motivation because it is associated with fear. But this is the price that suppliers have to pay for preserving their autonomy and uniqueness which many of them regard as their most important source of motivation.

The ability to solve local problems locally does not only preserve more diversity in responding to changes in the environment and prevent trouble from spreading (“domino effects”). It also reduces the intensity of communication and thus helps to reduce transactions costs. Nevertheless the total effect on transaction costs can be regarded as ambiguous. On the one hand there is no need to establish a secondary organization on top of the supply chain which can accomplish the holistic optimization. Furthermore there will be fewer goal conflicts to be resolved and there are less frictions arising from different corporate cultures

and less inconsistencies between actions to be discussed. And there is no controlling effort needed in order to prevent members from exploiting the lock-in-situation created by supply chains through opportunistic actions. But of course on the other hand the permanent need to adjust prices forces companies embedded in open networks to establish larger sales and purchasing departments. Thus the balance of different impacts on transaction costs may be classified as unclear. Fortunately this is not the main criterion needed to resolve the cost-benefit-equation we are discussing.

In his famous article on “The Architecture of Complexity” Simon [25] has pointed out that modularity can be a strong means to avoid the drawbacks of interlaced process architectures. This idea leads us to complete the picture by highlighting the role which standardized interfaces can play in the field of collaboration. Standardized interfaces facilitate integration and replaceability concurrently (for a more detailed discussion see 26). Integration must no longer lead to lock-in-situations, and one could combine the benefits of interconnectedness with the benefits of using markets and competition. Transaction cost could then be cut to an absolute minimum. But on the other hand modularity and standardization are not compatible with the individual strive of companies for competitive advantages based on a unique process design. Probably it is not least this ambivalence that has made the implementation of concepts like a demand and capacity management integrated across the interfaces between purchasers and suppliers so delicate in industries like the German automotive sector. However modularity can be regarded as an intelligent doorway to the flexibility which organizations need in order to survive in a dynamic environment. Unfortunately modularity fragments supply chains and are a threat for those companies who seek competitive advantages or relational rents out of closed networks, specific investments and rigidly coupled processes.

7 Summary

In this article a separation was made between two kinds of outcome of the past research on the subject-matter of supply chain management. On top of a number of substantiated process models a widely shared philosophy has been developed that shows all the elements which Kuhn [27] has described as attributes of a “paradigm”: a shared world view (which is rather a perspective predefining our perception of reality than a theory about it), a number of standard problems (like in this case the “bullwhip-effect”), a number of solution statements (like the calling for “systems thinking”, the mantra of total integration or the advice to shift competition to the level of whole supply

chains), and a community of scientist who confirm each other in their way of thinking. The classification of this part of the literature on supply chain management as a paradigm is further confirmed by the observation that many authors who propagate the related ideas do not realize that their concept might produce opportunity costs (compared to alternatives not seen on their radar screen) or some unforeseen spillover.

The analysis of the drawbacks and potential diseconomies of the attempt to optimize supply chains in a holistic manner as if they were legal entities has led to the conclusion that this is neither a viable nor a beneficial idea (see also [28]). The author therefore advocates the shift to a paradigm which favours loosely coupled processes and planning systems and the usage of competition as an incentive system and a source of flexibility. Within this paradigm the above mentioned process models have their place because they can support decentralized planning via feeding the decision making processes with updated demand data and information about the availability of inventory or production capacities sourced from suppliers. In order to exploit the potentiality of an increased visibility the building of supply chains is a sufficient, but not a necessary precondition.

As a logical consequence the prediction/recommendation that competition will be/should be relocated to the level of entire supply chains is disputed. There are some valid arguments favouring IT-based cross-links between companies within open polycentric networks. What we neither observe nor expect is the emergence of strongly integrated networks which develop their own superior identity by defining clear boundaries to their environment and establishing an exclusive “collaboration” inside these borders. Whoever advocates such systems of a higher order should keep in mind that there is a price to pay for the development of the institutional arrangements recommended under the headline of “supply chain management”.

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