New paradigms in supply chain management

Fast supply chains

JOSÉ CRESPO DE CARVALHO E JOSÉ CRUZ FILIPE

ABSTRACT: This paper has a conceptual nature and explores an approach between Transaction Cost Analysis Theory and Network Theory when applied to supply chains. This approach needs to be followed by empirical work in order to evaluate some hypotheses and a final research question and to draw some conclusions related to the proposed fast supply-demand chains and the correspondent Network of Transactions Theory. Systems Theory is used to carry out this conceptual exercise.

Key words: Networks of Supply Chains, Fast Supply-Demand Chains, Supply Chains

TÍTULO: Novos paradigmas na gestão das cadeias logísticas: cadeias logísticas efémeras

RESUMO: Este artigo explora uma aproximação entre a Teoria dos Custos de Transacção e a Teoria das Redes quando aplicadas às cadeias de abastecimento. Este trabalho, por ora conceptual, necessita de ser completado, em termos futuros, por uma aplicação prática por forma a avaliar as hipóteses e a questão final de investigação que se levanta. No decurso do trabalho conceptual que se apresenta foi tomada como base a Teoria dos Sistemas.

Palavras-chave: Networks of Supply Chains, Fast-Supply Demand Chains, Supply Chains

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INTRODUCTION

Jay W. Forrester (1959) made the first approach to a management problem that explicitly claimed to rely upon systems theory in the late fifties. The inventory "ups and downs" suffered by the General Electric household appliances plants in Kentucky were then explained using a computer model developed in accordance with the principles of systems control theory (Forrester, 1958). The methodology was initially called industrial dynamics (Forrester, 1961), before its general character made it known as system dynamics.

One of the major impacts of Forrester's work was the recognition that only system approaches could provide a deep insight into complex dynamic behaviours, such as the bullwhip effect (Lee *et al.*, 1997). The network configuration of today's supply chains with an ever-increasing number of partners - each one following its own strategy and taking actions that do not always fit with the common objectives -, the fuzzy nature of many of their inter-relationships, and the dynamic character of all the variables, impose a system approach, if one looks for an effective supply chain management (SCM) (Simchi-Levi *et al.*, 2000; Sterman, 2000).

Thus, if network constraints and potentials may open enormous opportunities to explore some type of supply-demand organizations and its arrangements and, also, to discover new flexible and adaptable businesses in order to survive, systems theory may be very helpful in structuring the theoretical background for networks and in conducting the whole approach. In fact, the network approach should be structured bearing in mind the contributions of Doz and Hamel (1998), Gadde and Håkansson (2001) and the enormous contributions of the IMP group (http://www.impgroup.org/) (Network Theory), among others, or systems theory should be followed when considering the dynamic character of all variables in a supply-demand chain or even in a network of supply-demand chains.

If no single company can succeed by itself, thus being required to work in partnership, it may be argued that stable alliances are not the unique answers to this modern wave of win-win collaboration, meaning positive shared achievements. As a result, if networks are becoming the rule, a way to govern complexity and to organise companies, then some conceptual development has to be made in them in order to explain fast engagements and rapid dissociations or the quicker occurrence of collaborations.

The purpose is, then, to develop and present a fast supply-demand chain configuration bearing in mind systems theory and logistics principles. Thus, the paper will

focus on five main issues in order to explore fast supply-demand arrangements: (1) main aspects of systems theory and relations with SCM; (2) fast supply-demand chains created in the broad network context; (3) central (or relevant companies) and peripheral companies in a fast supply-demand chain; (4) leverage mobiles, time for creation and time for destruction in fast supply-demand chains; (5) finally, some conclusions.

SYSTEMS THEORY AND SUPPLY CHAIN MANAGEMENT

Scientific methods based on cartesianism and reductionism, so successful in the physical sciences, first came across their limitations and drawbacks in biology. The modern concept of system, formulated around 1930 by von Bertalanffy (1968) - following previous works by Leduc and Bogdanov - extended to all fields of knowledge and became the current scientific paradigm.

Systems theory focus the problems raised by complex entities that are perceived as a whole - i.e., that are more than just the sum of their components - and exhibit properties that cannot be derived from their parts. Among the main features that most systems share it is important to emphasise (Le Moigne, 1977): (1) every system has a structure, which is the set of its components plus the set of rules defining their interrelationships; (2) every system has a teleological character, i.e., is driven towards a set of goals, what is equivalent to saying that every system has a purpose; (3) every system interacts with its environment, performing activities that change the system's state in order to approach the established goals. In the course of this evolution and due to the presence of feedback loops, the system's structure, the set of goals and the environment change continuously. A system that interacts with its environment, influencing it, is said to be an open system.

Two types of complexity are usually present in a system: (1) detail complexity and (2) dynamic complexity. Detail complexity occurs when the system has a large number of components and is related to the difficulty the human brain has in dealing with many variables at the same time. Dynamic complexity has a different character and is a consequence of the system's structure. It is related to the ability that systems have to exhibit emergent behaviours, i.e., dynamic changes in their states that cannot be derived from the parts, but are a property of the whole. They can only be understood if one looks at the system's structure, namely at (1) the causal loops originated by feedback, (2) the time delays that occur between an action and its effect, and (3) the non-linear character of most relationships.

These properties are the main causes for dynamic complexity: in a linear process, inputs are transformed in outputs and, whenever time effects are present, outputs are separated from inputs by a time interval; past influences the present (Richardson, 1999). In more complex processes, however, the result of an action, usually after a time delay, causes modifications in the pre-existing conditions that determined that action. Information about the output is fed back to the system as a new input, leading to a corrective action that changes the output (once again after some delay). A simple cause-effect relationship is then replaced by a causal feedback loop - which introduces a non-linearity.

Time delays, feedback loops, fuzzy variables and dynamic environments are easily recognised features in today's businesses. They are the root causes for the bullwhip effect and many other counterintuitive behaviours presented by social systems (Forrester, 1971). It is thus not surprising that system approaches are now commonly recommended and used in many situations (Checkland *et al.*, 1999; Gharajedaghi, 1999; Sterman, 2000).

The model is another concept that is important to highlight, when one starts to look for ways of developing a system approach. The concept of model is so strongly linked to the concept of system that Le Moigne (1977) considers the theory of the general system as the theory of modelling.

A model is a simplified representation of a system that is useful for solving a problem. Or "the purpose of a simulation model is to mimic the real system so that its behavior can be studied" (Sterman, 1991). And, as many authors refer, the model's development is driven by the search of a solution to the problem to be solved (Forrester, 1961; Sterman, 2000).

The general availability of computers and their ability to easily store and process large amounts of information, and solve thousands of interrelated equations - particularly relevant when someone is dealing with social systems -, offer a cheap and powerful way to develop system models and simulate the system's behaviour in a wide range of different scenarios.

The outcome of a consistent set of simulations can be a forecast, as in the case of econometric models, the evaluation of the impact on the system of different environment conditions or internal decision policies, or the outcome of different strategies. Furthermore, through simulation, some unexpected behaviour can be identified and understood, and new policies can be designed to prevent them (Forrester, 1971; Simon, 1981).

This background provides the reasons why systems thinking, computer models and simulation are increasingly used as an aid in solving management problems.

It was in the management of large modern engineering projects - starting with the military projects launched in the first years of the Cold War - that the high levels of complexity first made a system approach unavoidable. The trend widened soon to other fields, following the systems thinking movement launched by Ackoff and pursued by many others (Jackson, 1999) until the recent attempts to "manage at the edge of chaos" (Stacey, 1995; Beinhocker, 1997; Brown *et al.*, 1998; and many others).

Genetic algorithms, cellular automata, evolutionary game theory, fuzzy-logic, agent-based models, real options, soft systems methodologies and system dynamics are some of the methodologies and tools developed in the last years to deal with complexity and that have application in economics and management.

Applications range from executive training, design of robust decision policies, evaluation of strategic options, support to change management processes, and the development of the "learning organisation" (Senge, 1990).

The acceleration suffered by the economy and the business activity during the last years only reinforced the need for system thinking and for system approaches to many of the managers' problems.

Today, using different technologies anyone can communicate directly to anyone, anywhere, and people and goods can move from one continent to another in a matter of a few hours. Every branch of specialised knowledge is freely available to anyone who has access to the Internet.

All this evolution took place at an increasingly quick pace. A century ago, sailing ships made most of the sea trade; forty years ago propeller airplanes offered travel possibilities at an almost unbearable price; twenty years ago the telex was the standard technology available for rapid transfer of information between two companies.

Any manager who envisages staying in business has to be flexible and adapt his company to all these changes, and has to do it very fast, in spite of the volatility of exchange rates and oil prices, and the crushing pressure of the financial markets.

The days when a company like Ford could transform, in a single plant, coal and iron into cars are over, as *The Economist* (anonymous, 2002) remarked. Focus on the core business and outsource everything that someone else can do better and cheaper became the dominant trend and a rule of the game.

In our times of globalisation of economies, markets and knowledge, the boundaries of the firm are fuzzy, the extended enterprise appears as the new industrial paradigm, and supply chain management is recognised - if not yet logistics network management (Carvalho, 2001) - as an important piece of corporate strategy (Gattorna *et al.*, 1996).

Making the fundamental strategic "make-or-buy" decision is increasingly tough when economies and businesses compete in a global economy, with competition running parallel with cooperation: two fierce competitors in one market must cooperate with another one, if they want to succeed. Buyers and sellers look for alliances and become business partners. Selling and buying on a point basis is replaced by outsourcing, and the management of the value system replaces the management of the value chain (beginning, somehow, with Hines, 1993). As stated in a recent paper, "the ultimate core competency of an organization is 'supply chain design', which I define as choosing what capabilities along the value chain to invest in and develop internally and which to allocate for development by suppliers" (Fine, 2000). Thus, managing a business becomes indissociable from the management of the partners' network.

A network is a complex system of entities and relationships, processes and flows, and therefore cannot or, at least, is difficult to be managed without relying upon a system approach - either at a strategic or at an operational level.

The reason for this arises, in part, from the large number of partners and other stakeholders - each with its own set of objectives -, the huge amounts of data, the multidisciplinary expertise needed, and the frequent novelty of the situations that are present in SCM.

However, internal dynamic complexity is usually more relevant: linear processes and simple one-to-one relationships are not the rule anymore. Multiple choices, bifurcating paths, conflicting goals, information feedback, variable time delays, and other elements that originate non-linearities are part of the daily life of today's supply chain manager. And, since the effects of all these are amplified by the dynamics of the external environment, the complexity of each problem in SCM always tends to rise. In such a situation only a consistent model and simulation can efficiently help to find a solution.

The portfolio of problems that can be solved with simulation is almost unlimited and only a very brief outline can be presented here.

At an operational level, resource allocation, co-ordination of inventory decisions and transportation decisions, and matching supply and demand are some

of the problems in SCM usually covered by textbooks (Christopher, 1992; Gattorna *et al.*, 1996; Simchi-Levi *et al.*, 2000) that are easily perceived as requiring a system approach. Models can provide the basis for answering "what-if" questions through simulation, and for finding robust decision policies and optimal decisions.

Distribution strategies, network configuration, organisation design, supply chain integration, strategic alliances and information systems design are some of the strategic decision making processes where a powerful set of methodologies and techniques using scenario planning and simulation can offer a valuable contribution.

Many other approaches are reported in literature, covering matters like the supply chain dynamics (Swaminathan *et al.*, 1998; Fukunaga *et al.*, 2000; Groothedde, 2000; Anderson *et al.*, 2000), partners' management (Sobrero *et al.*, 2002), performance analysis (Cakravastia *et al.*, 1999), decision policies (Strohhecker, 2000), and integration of product management with order strategies (Barlas *et al.*, 1996).

In this turbulence one should try to explain fast supply-demand chains created over broad network contexts. Systems theory may help in reasoning because the focus is concentrated upon systems dynamics instead of systems stability or long term collaboration, ideal conditions to compel directional and somehow crystallized (and undesired) supply chains.

FAST SUPPLY-DEMAND CHAINS

One can find, on a large scale, several companies developing multiple actions in various activity sectors and, also, with diverse business typologies. Therefore, there is a company universe that can be considered statistically endless. If each of the company in the entire universe decides to collaborate with the others, the potential number of relations would also tend to be endless. Thus, it is better - and more realistic - to consider the existence of a global business system including the companies' universe and multiple business sub-systems whose companies may establish more or less stable relationships between each other.

It is known that companies collaborate to reach alternative markets, to complete product lines or services, to achieve synergetic effects in operations and marketing, to win critical mass in purchasing, to centre themselves on the core business or to transform fixed costs into variable costs, among others.

For the same markets and for various products/services typologies, arrangements that emerge from simple partnerships have become more like networks of opportunities, in a global world, than time stable networks.

The truth is that instruments and contact tools and possibilities between companies and suppliers only came to 'aggravate' that tendency. E-Procurement tools and all the automation of the suppliers' qualification processes are an example of that. The easiness of procurement is, nowadays, greatly amplified; hence, a stable relation upstream can easily be questioned by a straightforward discovery of more interesting alternative suppliers (substitutes), being geographically distant but very close in informational terms.

The downstream CRM practices should lead, additionally, to bigger customer loyalty. Although, nowadays it is known that market share can come precisely through the share of wallet - or client share accumulation. Even so, the client has become less oriented to fidelity, in a global world, because experiences add more value - both personal and professional - than products or services. Experiences are, therefore, obtained through several products, services and events combinations.

These facts raise serious problems for supply chains that, when not being configured as stable - for determined market demands -, become more and more dynamic, with fast establishment and rapid end. These situations occur when trying to offer a new experience facing the perception of a new or differentiated exigency.

In these circumstances, even upstream or downstream, bigger relation volatility can be found than that defended by network theory without necessarily leading to TCA - Transaction Cost Analysis Theory -, *tout court.* TCA assumes that economic relations between two parties follow predictable patterns, resulting in attempts to optimise the economic benefits for each party in the relationship, i.e., each party involved in a relation seeks to optimise their own benefit from the relationship because the costs of building deep relationships are usually higher than a win-loose (ad-hoc) liaison.

Even so, one cannot say that nowadays network principles are not driving business models and raising collaboration as an organizational principle. However, an increase in empirical aspects that show hybrid behaviours should not be excluded: (1) agent's limited rationality; (2) agents' opportunistic action (TCA); (3) necessity of risk neutralization (TCA); (4) tendency to collaborate and create networks of supply chains (Network Theory).

The coexistence of the Network Theory, as a business paradigm, along with the Transaction Cost Analysis Theory, allowed the evolution of this reasoning in the logistic area, i.e., focused on fast supply-demand chains (Network Transaction Theory): (1) collaboration is opportunistic itself; (2) agents are always keen on earning from several different experiences, usually possible due to the accumulated partnership knowledge, namely when a new/diverse market demand happens; (3) the hierarchical control (vertical integration) used in the Transaction Cost Analysis Theory, in order to minimize risk of opportunistic behaviour, was transformed in the network information control (rapid informational integration capacity), that should allow the accumulation of a set of experiences and to normally accept the change as a management component; (4) Systems Theory, however, provides the best explanation - in practice - when a company is close to integrate a fast supply-demand chain.

Within this scenario, one can easily understand why companies are asking to participate in supply chains that will provide them with knowledge and various experiences: (1) visibility; (2) contacts with diverse suppliers and clients; (3) entry in geographically disperse markets; (4) informational interface standardization; (5) creation of new capabilities; (6) cost rationalization; (7) business virtualisation; and (8) accumulated relational capacity; among others.

In this sense, companies will have to be familiar with, and looking for, integration in fast supply-demand chains.

TYPES OF COMPANIES INTERESTED IN FAST SUPPLY-DEMAND CHAINS

Central companies to fast supply-demand chains are those fighting to accumulate knowledge and relational capabilities. Relational capability is achieved through contact increasing and, also, through experience development. For this reason companies will tend to be classified as being central or peripheral according to the level of accumulated knowledge. They will be more central when more experiences and knowledge accumulation can be demonstrated and more peripheral when the opposite happens. Therefore, the centre or the peripheral character of a company today cannot be measured only through the origin or location in terms of geographic area, but also, through the bridges they are or are not able to build with other companies and agents throughout the world, namely benefiting from information and communication systems and technologies.

When using Shannon and Weaver's (1954) work (Information Theory) to define entropy, a transposition to more central or peripheral companies can be made when using its own entropy coefficient. In this context, entropy means the higher or lower probability with which certain relationships can occur between the company and its potential suppliers and clients.

If the entropy is very high, the tendency to form or take part of a (or a set of) fast supply-demand chain(s) is maximum; on the contrary, the lower the entropy the lower the probability of participation in fast supply-demand chains.

If the entropy is high, all the events (and the relationships) have the same probability of happening for a company and it should hold an enviable knowledge and position in terms of fast supply-demand chains constitution. In this case, it will be among the more apt to answer those markets looking for diversified experiences. On the contrary, a company with minimum entropy has a low surviving capacity and its relationships are so sporadic that it will hardly survive to change conditions that build or destroy fast supply-demand chains.

If one substitutes the probabilities (of relationship) - p - by relative relationship occurrences (frequencies) - f -, entropy can become a measure of a company's relational ability and aptitude to become a fast supply-demand chain member. The entropy formula based on frequencies will be represented by the following expression:

$$E = \sum_{i=1}^{K} f_i \times \log (f_i)$$

With: E = entropy; k = total number of activity sectors potentially related with the company; n_i = total number of companies/agents that are present suppliers or clients; N = total number of present and potential companies/agents that could be elected as suppliers or clients; and f_i = company's relational frequency, knowing that ($f_i = n_i/N$).

The relative entropy allows one to obtain a simple measure for analysis and possible comparisons between companies, therefore making possible a better way to explain their central or peripheral character. Furthermore, it admits representation in an interval [0,1], with the maximum entropy equal to 1. It is considered that relative entropy (RE) is represented by the following expression: RE = E/log k.

Through this line of reasoning, and regarding the company as an open system with a hybrid behaviour character between TCA and Network Theory, one can go along with the hypothesis that fast supply-demand chains are more frequent in activity sectors with multiple players and high competitive pressures (1st factor); within the

proximity of final markets (consumer oriented markets) (2nd factor); in intensive I&D sectors (3rd factor); and between companies with strong dependence of information and communication systems and technologies (4th factor).

This type of hypothesis, that should lead to future empirical work, has been possible, and raised, after a series of surveys (conducted by IN OUT GLOBAL - ISCTE - University of Lisbon, between 1998 and 2002) involving: (1) fast moving consumer goods industry; (2) automotive industry; (3) transports industry; (4) telecommunications industry; (5) several services industries; finally, (6) third party logistics providers industry. These surveys were all conducted with different purposes but always involving subjects related with collaborative behaviour.

CONCLUSIONS

At this stage, three major conclusions, followed by a question, should be intensively addressed: (1) Transaction Cost Analysis Theory (TCA) assumptions should be used and remembered even if the moment favours Network Theory approaches; a hybrid theory between one and the other should be developed - something like Fast Supply-Demand Chain Theory or Network of Transactions Theory; (2) because of its nature, Systems Theory will certainly represent an ideographic approach to help further developments; (3) formal and empirical studies should be carried out in order to validate hypotheses and to identify the keys, or leverage mobiles, to create fast supply-demand chains; (4) finally, the question that should help future reasoning should be posed in these terms: is knowledge (society) more aligned with fast supply-demand chains (or Network of Transactions Theory) or with traditional and stable supply chains?

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Economia e gestão do conhecimento
Um ensaio introdutório

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RESUMO: O texto é extraído de um livro em preparação sobre o mesmo tema. Divide-se em três partes. Na primeira, discute-se o conceito de conhecimento nas suas várias formas e, em particular, a natureza do conhecimento «científico». Na segunda, descreve-se o processo evolutivo que conduziu o capitalismo de suporte industrial e da época do operário de «colarinho azul» à chamada «economia baseada no conhecimento» e aos trabalhadores do conhecimento. Na terceira e última parte, estabelece-se a relação entre o processo inovador e a gestão do conhecimento.

Palavras-chave: Conhecimento, Inovação, Gestão

TITLE: Knowledge management and knowledge based economy: an introductory essay

ABSTRACT: The article is part of a book the author is presently elaborating. It has three parts. The concept of knowledge is discussed in the first part. The second deals with the process of change from industrial capitalism at the time of the blue collar worker, to the so-called «knowledge based economy» and knowledge workers. In the thrid part of the article, the author analyses the relationship between innovation and knowledge management.

Key words: Knowledge, Innovation, Management

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