“Definition Problems and A General Systems Theory Perspective in Supply Chain Management”

AUTHORS	Mammy M. Helou Ian N. Caddy

ARTICLE INFO	Mammy M. Helou and Ian N. Caddy (2006). Definition Problems and A General Systems Theory Perspective in Supply Chain Management. *Problems and Perspectives in Management*, *4*(4)
RELEASED ON	Monday, 25 December 2006
JOURNAL	"Problems and Perspectives in Management"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
0	0	0

Definition Problems and a General Systems Theory Perspective in Supply Chain Management

Mammy M. Helou[*], Ian N. Caddy[**]

Abstract

The current study aims at increasing the understanding by both academics and practitioners of how to best design, implement and manage supply chain systems. To this end, this study evaluates the application of general systems theory, as developed by von Bertalanffy (1969), Weinberg (1975), Miller (1978) and Yourdon (1989) to supply chains and their management. In particular, Yourdon's (1989) four general systems principles are examined within the context of supply chains and their management. The findings of the current study suggest that undertaking a theory perspective could make significant contributions towards defining the scope of supply chains and developing a greater understanding of their design, implementation and management.

Key words: Supply chain management; supply chains; general systems theory.
JEL classification: M11.

Introduction

'Supply chain management' is a term that has been used to reflect a variety of different meanings. It has been used in different contexts related to management processes, as well as business structures (Harland, 1996). Various scholars nowadays are exploring different approaches to provide for the integration of the different aspects of process, structure, and decision making mechanisms in supply chain modelling (Chopra and Meindl, 2004; Christopher, 2005; Li, Kumar and Lim, 2002). As a notion, 'supply chain management' is not a new concept. The term seems to have originated in the 1980s (Harland, 1996), and it has gained popularity since then, at both the academic and practitioner levels. Nowadays, the term is widely used in textbooks, professional magazines, academic journals, courses of study and individual subject offerings. The wide usage of the term 'supply chain management' in different contexts has led to the lack of clarity of its meaning (Harland, 1995).

As supply chains are considered to be systems, the current research study aims at casting light on the managerial contributions gained from the application of the general systems theory to supply chains and their management. The application of general systems theory, as developed by Boulding (1956), Forrester (1958, 1961, 1975); von Bertalanffy (1969), generally recognised as the founding father of general systems theory; Klir (1969, 1972); Weinberg (1975); Miller (1978), and Yourdon (1989) are discussed. In addition, the contributions of flexible system thinking, physical system theory, and the tools of systems thinking, as outlined by Senge (1990, 1992), Fowler (1999), Lin (1999), Skyttner (2001), Sushil (2002), and Liu (2003) are considered. Sushil (2002) emphasised the need for a 'flexible system theory', relating to several systems based approaches and techniques as a means of effectively catering to problem situations. Furthermore, Yourdon (1989) shows that new insights are gained by abstracting the view of the information systems field. In a similar vein, new and crucial insights may emerge out of the application of general systems theory to supply chains and supply chain management.

Supply Chains and Their Management: Definition and Scope Problems

As previously mentioned, several definitions exist in relation to the terms 'supply chain' and 'supply chain management', depending on the nature, content and context of operations and processes considered. In addition, different interpretations of the terms are reflected in both definitions and

[*] University of Western Sydney, Australia.
[**] University of Western Sydney, Australia.

frameworks of supply chain management. Furthermore, the literature often reveals diversity in application and emphasis on particular attributes of the supply chain with the concomitant implication that these attributes are the critical ones for defining either the supply chain or its management. So far, it seems that these terms do not have a commonly accepted usage.

For instance, Mourits and Evers (1995) discuss the several stages or echelons relating to the flow of goods between a supplier and a customer in current distribution networks. Each stage may be comprised of many facilities, and perform different activities, thus, necessitating intensive communication for their mutual co-ordination. That is, the defining characteristic of the supply chain is the human interaction that necessarily occurs. Stevenson (1999) on the other hand, defines a 'supply chain' as a sequence of suppliers, warehouses, operations, and retail outlets. In this case, the physical attributes are the defining characteristics. Stevenson (1999) differentiates between two basic types of supply chains relating to manufacturing and service operations, presumably because their physical characteristics are different. Gattorna and Walters (1996) explain that in a short period of time, 'physical distribution management' became 'logistics management', and is developing into what is currently referred to as 'supply chain management'. For Gattorna and Walters (1996), this means that as a concept, 'supply chain management' suggests that the firm would extend its emphasis beyond its own performance to a more holistic inter-organizational focus, i.e., the supply chain is defined in terms of the organisation strategic intent.

Handfield and Nichols (1999) explain that a whole 'Logistics Renaissance' era has arrived. Characterised by time-reducing information technologies and logistics networks, it aims at meeting the challenges of globalisation of markets, stabilisation of political economies, and rapid growth in the domestic and international competitive environment. They offer the following definitions of supply chain and supply chain management. A 'supply chain … encompasses all activities associated with the flow and transformation of goods from the raw materials stage (extraction), through to the end user, as well as the associated information flows. Materials and information flow both up and down the supply chain' (Handfield and Nichols, 1999: 29).

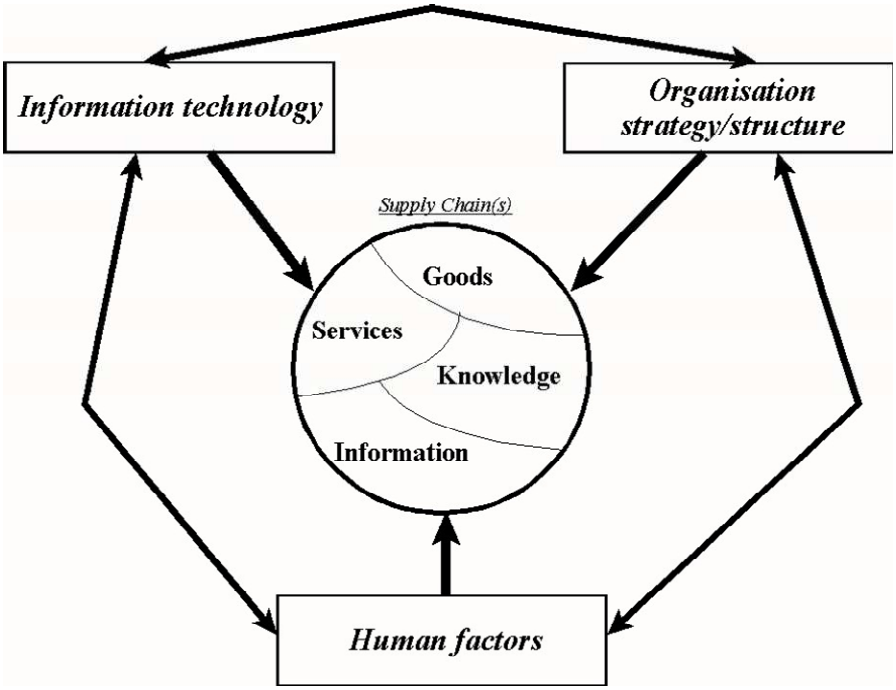
'Supply chain management' on the other hand, is defined as 'the integration of these activities through improved supply chain relationships, to achieve a sustainable competitive advantage' (Handfield and Nichols, 1999: 19). Handfield and Nichols (1999) further explain that, within the context of these definitions, the supply chain includes the management of information systems, sourcing and procurement, production, scheduling, order processing, inventory management, warehousing, customer service, and disposition of packaging and materials. On the other hand, the supplier network consists of 'all organisations that provide inputs, either directly or indirectly, to the focal firm' (Handfield and Nichols, 1999: 21). It is interesting to note that this definition implies that rather than a chain (in which the links can be considered as peer companies), the 'supply chain' is really a 'supply wheel' in which a number of subservient companies supply a dominant master (Avery, 1999). There are many cases where this model would be applicable, e.g. General Motors (Keen, 1991). Nevertheless, there are also just as many cases where it would not.

Generic Supply Chain Model

The purpose of developing a Generic Supply Chain Model (GSCM) (Caddy and Helou, 1999) is to provide a deeper understanding of supply chains, in terms of both their development, operation and management. A representative literature review of supply chain and supply chain management frameworks and models reveal that there is not an already developed and generally accepted comprehensive model of supply chain (Caddy and Helou, 1999). Models of supply chain seem to concentrate on only one particular aspect or dimension of the supply chain, viz. 1) organisation structure/strategy (Moon, 2004), 2) information technology (Kim, Cavusgil and Calantone, 2005), and 3) human factors (Harland, 1995; 1996). While each of these dimensions is considered crucial in its own right, each factor by itself does not provide a complete and comprehensive view of supply chains and their management. Combining the above mentioned three dimensions result in the

development of a generic supply chain model, in which each of the dimensions provides a separate as well as a related conjoint contribution.

The generic model shown below allows for the diversity of real world situations by incorporating into the model the interactions among the three dimensions. Different outcomes are generated given the nature of the type and level of interaction. In addition, the type and level of interactions it would be contingent upon organisational culture, the environment in which the organisation operates, and the characteristics of the supply chains utilised in the exchanges that occur among organisations.



Source: I. Caddy and M. Helou, 1999. Supply chain and supply chain management: towards a theoretical foundation. Presentation at the Second International Conference on Managing Enterprises, 18 November.

Fig. 1. Generic Supply Chain Model

A General Systems Theory Perspective

An evaluation of a considerable number of current and representative frameworks and models of supply chain management indicates that a mature stage of development of a comprehensive supply chain model has not as yet been attained. Furthermore, any real convergence to a generally accepted normative model of supply chains and their management does not appear to exist (Caddy and Helou, 1999). As such, the current study examines the application of the theories and principles of general systems theory to ascertain whether a more general and fundamental supply chain framework can be developed. Furthermore, the current study aims to address the question as to whether the application of general systems theory to this field would provide additional insight in terms of the effective management of supply chains.

Ludwig von Bertalanffy (1969), a biologist who through his work on general systems, came to the conclusion that given the interaction between a system's components, a system was often more than just the mere sum of its components. Furthermore, systems with equivalent components could still be different due to a different 'arrangement' of their components – often leading to different interactions between the components. In most cases, real world systems are open systems, which interacted with, and are often influenced by, their external environment; thus, acquiring new quali-

tative properties which allows them to evolve. Another important general systems concept that emerged from von Bertalanffy's (1969) work, is the idea of a definable boundary that separates a system from its environment and allows inputs to the system and outputs from it.

From a biological perspective, Miller (1978), explains that in order for a system to be considered a living system, it should contain the following sub-systems: reproducer, boundary, ingestor, distributor, converter, producer, matter-energy storage sub-system, extruder, motor, supporter, input transducer, internal transducer, channel or net, decoder, associator, decider, encoder, and output translator.

Yourdon (1989) applied Miller's (1978) findings to the field of information systems. In the process, Yourdon (1989) enriched this field in terms of developing a higher order of understanding of what the 'information system' concept meant. Within this context, the following questions come to mind: what processes could organisations use to re-new supply chains? and, what are the indicators that can be used to point to supply chain obsolescence? The Generic Supply Chain Model (Caddy and Helou, 1999) (Figure 1 above), indicates that supply chains change with time. With the current state of information technology, nowadays, supply chains are operated differently to the way they were operated some time ago. In addition, the nature of the relationship(s) among organisations within the supply chain would also be expected to develop over time.

Futhermore, Yourdon (1989) discussed the application of the following four general systems theory principles to the field of information systems: Principle 1: The more specialised or complex a system is the less adaptable it is to changing environments; principle 2: The larger the system, the more resources are required to support that system – with the increase being non-linear; principle 3: Systems often contain other systems, and are in themselves components of larger systems; and principle 4: Systems grow, with obvious implications for 'Principle 2'. In a similar vein, these principles are applied herewith to the field of supply chain and supply chain management as follows:

The Application of the General systems Theory to Supply Chains: A Managerial Approach

With respect to principle 1, two crucial issues that organisations need to consider in terms of their supply chains prevail. First, the issue of supply chain topology is pertinent. This principle would indicate that the longer the supply chain, in terms of its links, that is, if a third or more party logistics providers are involved (Copacino, 1997; Foster, 1999; Parker, 1999), the less adaptable the supply chain will be to possible changes needed for it to survive. As discussed by various scholars (Forrester, 1961; Senge, 1990; Fowler, 1999), the "physics" of a system limits its achievements, and the possible emergence of stability and control problems may lead to the system's malperformance. Furthermore, once a downstream disturbance initiates, it ripples back through the system with increasing amplitude (Forrester, 1958; Fowler, 1999). This again would apply to supply chains, where, for example, the consequences of marketing managers' decisions or sales representatives' actions, being in direct contact with the target market, may have an increased amplitude echo for upstream supply chain members (Fowler, 1999).

Secondly, the nature of the item that is being exchanged within the supply chain is also pertinent. As supply chains may evolve from the movement of only physical goods to the movement of both goods and information or knowledge, they tend to evolve in complexity. That is, it becomes a more difficult task to ensure that the right information or knowledge is passed 'up' or 'down' the supply chain, than it is to ensure that the right goods or services have been exchanged. Accordingly, the higher the degree of maturity of a supply chain, the less adaptable it will be to changing environmental forces.

In terms of principle 2, supply chains offer the opportunity to outsource functions to other organisations (Chase, 1998; Lawrence, 1999; Stundza, 1999), by adopting new techniques such as vendor-managed inventory as a way to streamline their operations (Holmstrom, 1998). Nevertheless,

organisations need to realise that outsourcing does not completely delete the associated management and administrative activities. In fact, as the use of outsourcing grows by the organisation, the more the resources are needed to devote to the management of the outsourced activities. What was initially seen as a benefit may as such become more of a burden. In addition, organisations should determine the level of activity between the supply chains within which they participate. Accordingly, high activity supply chains will need more management resources to ensure that benefits do emerge from them as compared to low activity supply chains.

Principle 3 indicates that supply chains are not monolithic organisation artifacts. For example, Miller (1978) found that living systems can be broken down into a number of smaller sub-systems. Yourdon (1989) also applied this principle in the development of structured systems methodology, which is based primarily on the assumption that complex information system functions can be broken down into smaller and more easily understood information system functions or modules. Indeed, this principle changes the view of the general supply chain model previously discussed. Rather than considering organisation strategy/structure, information technology and human factors as different static and separate dimensions of the Generic Supply chain Model (Caddy and Helou, 1999), the three factors can, in fact, be considered as dynamic sub-systems participating and interacting within the one supply chain system.

With respect to principle 4, Yourdon (1989) stated that even though information systems are artificial constructs, they do in fact grow. Growth of an information system can occur in various ways including the number of users interacting with the information system, the amount of data processed by the information system, and the level of system functionality associated with the information system. The same is true with supply chains, where by the amount of goods, services, products, information and knowledge exchanged through the supply chain may grow. As such, the more are the resources that organisations need to apply to ensure the effective management of the supply chain. Furthermore, organisations need to realise that although information systems and supply chains are artificial constructs, and, therefore, are not living systems, this does not mean that they are static. They are indeed quite dynamic and do evolve and change over time as they interact with changing factors in the internal and external environment.

Summary and Conclusions

This research study addresses the possible application and managerial contributions of general systems theory to supply chains for the development of a greater understanding of their design, implementation and management. Miller's (1978) findings provide an opportunity to distinguish the sub-systems that operate within a supply chain. Identification of supply chain sub-systems leads to a better understanding of the dynamics within supply chains as they evolve over time. In addition, combining the work of Miller (1978) with the concept of a system boundary, as developed by von Bertalanffy (1969), allows for the exploration of interactions that occur between supply chain sub-systems across their system boundaries; thus, leading to a greater understanding of supply chains.

In addition, the four general systems theory principles applied by Yourdon (1989) to the field of information systems were considered with respect to supply chains. Their application indicates that a deeper understanding of supply chains and their management could in fact be gained. Finally, it is worthwhile to note that organisations need to develop a better understanding of the dynamic constructs that will evolve over time, as such require a dynamic evolution of management practice in order to maintain supply chain effectiveness.

References

1. Avery, S. Toshiba Program Rewards Suppliers for New Ideas // Purchasing, 1999 – No. 8. – pp. 24-26.

2. Boulding, K.E. General Systems Theory – The Skeleton of Science // Management Science, 1956 – No. 3. – pp. 18-26.
3. Caddy, I., Helou, M. 1999. Supply Chain and Supply Chain Management: Towards a Theoretical Foundation // Presentation at the Second International Conference on Managing Enterprises, 1999 – 18 November.
4. Chase, R. Map Your Route to Outsourcing Success // Transportation & Distribution, 1998 – No. 12. – pp. 69-72.
5. Chopra, S., Meindl, P. Supply Chain Management: Strategy, Planning and Operation. – New Jersey: Pearson Education International, 2004.
6. Christopher, M. Logistics and Supply Chain Management: Creating Value-Adding Networks. – Harlow, England: Prentice Hall Financial Times, Pearson Education, 2005.
7. Copacino, W. C. 'Fourth-Party Logistics': Beyond 3PL // Logistics Management, 1997. – No. 4. – p. 43.
8. Forrester, J.W. Industrial Dynamics: A Major Breakthrough for Decision Makers // Harvard Business Review, 1958. – No. 4. – pp. 37-66.
9. Forrester, J.W. Industrial Dynamics. – Cambridge, MA: MIT Press, 1961.
10. Forrester, J.W. Collected Papers of Jay W. Forrester. – Cambridge, MA: Wright Allen Press, 1975.
11. Foster, T. 4PLs: The Next Generation for Supply Chain Outsourcing? // Logistics Management & Distribution Report, 1999. – No. 4. – p. 35.
12. Fowler, A. Feedback and Feedforward As Systemic Frameworks for Operations Control // International Journal of Operations & Production Management, 1999. – No. 2. – pp. 182-204.
13. Gattorna, J.L., Walters, D.W. Managing The Supply Chain: A Strategic Perspective. – London: Macmillan Press, 1996.
14. Handfield, R.B., Nichols, E.L. Introduction to Supply Chain Management. New Jersey: Prentice Hall, 1999.
15. Harland, C.M. The Dynamics of Customer Dissatisfaction in Supply Chains // Production Planning and Control, 1995. – No. 3. – pp. 209-217.
16. Harland, C.M. Supply Chain Management: Relationships, Chains and Networks // British Journal of Management, 1996. - No. 7. – pp. S63-S80.
17. Holmstrom, J. Implementing Vendor-Managed Inventory the Efficient Way: A Case Study of Partnership in the Supply Chain // Production & Inventory Management Journal, 1998. – No. 3. – pp. 1-5.
18. Keen, P.G.W. Shaping The Future: Business Design Through Information Technology. – Boston, MA: Harvard Business Press, 1991.
19. Kim, D., Cavusgil, S.T., Calantone, R.J. The Role of Information Technology in Supply-Chain Relationships: Does Partner Criticality Matter? // Journal of Business & Industrial Marketing, 2005. – No. 4/5. – pp.169-178.
20. Klir, G.J. An Approach to General Systems Theory. – New York: Van Nostrand Reinhold, 1969.
21. Klir, G.J. Trends in General Systems Theory. – New York: Wiley, 1972.
22. Lawrence, A. Is Third Party Distribution Paying Its Way?// Works Management, 1999. - No. 5. – pp. 51-53.
23. Li, Z., Kumar, A., Lim, Y.G. Supply Chain Modelling – A Coordination Approach // Integrated Manufacturing Systems, 2002. – No. 8. – pp. 551-561.
24. Lin, Y. General Systems Theory: A Mathematical Approach. – New York: Kluwer Academic/Plenum Publishers, 1999.
25. Liu, G. Normal Sum Decomposition of General Systems // Kybernetes, 2003. – No. 5/6. – pp. 640-643.
26. Miller, J.G. Living Systems. – New York: McGraw-Hill, 1978.
27. Moon, S-A. The Relationships Among Manufacturer Product Strategy, Supply Chain Structure and Supply Chain Inventory // Asia Pacific Journal of Marketing and Logistics, 2004. – No. 2. – pp. 20-45.

28. Mouritus, M., Evers, J.M. Distribution Network Design: An Integrated Planning Support Framework // International Journal of Physical Distribution & Logistics Management, 1995. – No. 5. – pp. 43-57.
29. Parker, J.G. The 3PL Plunge // Traffic World, 1999. – No. 4. – pp. 16-17.
30. Senge, P. The fifth Discipline. – New York: Doubleday/Currency, 1990.
31. Senge, P.M., Sterman, J.D. Systems Thinking and Organisational Learning: Acting Locally and Thinking Globally in the Organisation of the Future // European Journal of Operational Research, 1992. – pp. 137-150.
32. Skyttner, L. General Systems Theory: Ideas and Applications. – Singapore: World Scientific, 2001.
33. Stevenson, W.J. Production/Operations Management. – Boston: McGraw-Hill, 1999.
34. Stundza, T. Aerospace Purchasing Gets Overhauled // Purchasing, 1999. – No. 9. – pp. 66-73.
35. Sushil, T. Physical System Theory: Fundamentals, recent developments and relationships with system dynamics // Kybernetes, 2002. – pp. 496-528.
36. von Bertalanffy, L. General System Theory: Foundations, Development, Applications. – New York: G. Braziller, 1969.
37. Weinberg G.M. An Introduction to General Systems Thinking. – New York: Wiley, 1975.
38. Yourdon E. Modern Structured Analysis. New jersey: Yourdon Press, Prentice-Hall International, 1989.