Simplicity vs. complexity in the logistics discipline - a paradigmatic discourse

Nilsson, Fredrik

Published in:
[Host publication title missing]

2004

Simplicity vs. complexity in the logistics discipline – a paradigmatic discourse

Fredrik Nilsson

Division of Packaging Logistics, Department of Design Sciences, Lund University. Sölvegatan 26, P.O. Box 118, 221 00 Lund, Sweden
E-mail: fredrik.nilsson@plog.lth.se, Tel: +46 (0)46 222 91 55; Fax: +46 (0)46 222 80 60

ABSTRACT

Today one could argue that most of the logistics research available has a strong connection to the positivistic paradigm where there is a great emphasis on simplicity in both the research conducted and in the solutions produced. The overall ability to design, plan and control is promoted by the researchers to a great extent. Consequently, firms invest money, time and resources in solutions, based on linear cause and effect relationships, to control and predict logistics activities. As a result, firms' efforts to manage logistics systems and processes often result in frustration and anxiety, not least for the people who are supposed to be in charge.

The purpose of this paper is to provide a paradigmatic discourse in order to move the logistics discipline on the ontological axis towards a less positivistic view i.e. towards considering more complexity in the problematic situations being studied and the solutions provided. A new perspective, the complexity perspective is provided which indicates changes in our epistemological considerations resulting in another, more complex, paradigmatic view, where emphasis on simplicity is set aside and other more complex phenomena such as emergence, non-linearity, heterogeneity and self-organisation are brought into focus.

Key Words: *Paradigm, complexity, logistics, emergence, self-organisation.*

1. Another Research Agenda

The quest for developing the logistics discipline, with a more theoretical foundation, is something several authors have emphasised and called for (Arlbjørn & Halldorsson 2002;Dunn & Seaker 1994 ;Garver & Mentzer 1999;Mentzer & Flint 1997;Mentzer & Kahn 1995). Garver and Mentzer (1999 p.33) state, for example, that *"researchers are calling for future logistics research to have a stronger theoretical foundation",* while Kent Jr. and Flint (1997 p.6) argue in their discussion concerning the future development of logistics that *"another future focus is likely to be theory building."* However, the aim of this theoretical development of the logistics discipline, nevertheless, differs from author to author. There are indications of a striving towards a theory based on positivistic or post-positivistic-oriented epistemology, which Mentzer & Kahn (1995), Mentzer and Flint (1997) and Garver and Mentzer (1999) represent first and foremost. At the same time, authors such as Mears-Young and Jackson (1997) as well as Arlbjørn and Halldorsson (2002) are asking for challenging paradigms for research conducted in the logistics discipline. The positivistic approach means that we will continue to place an emphasis on simplicity in forms of rationality, stability, equilibrium and linearity while the other approach i.e. with challenging paradigms, opens up the logistics field for more complexity to be considered. In other words, as stated by Robertson (2003 p.61); "*if the business world is viewed as being complex, it is inappropriate to consider models developed under paradigms of equilibrium, stability, and linearity to produce an analysis of a turbulent environment."*

Furthermore, the logistics discipline may be regarded as functionalistic[1] (Mears-Young & Jackson 1997). Consequently, since the logistics discipline is first and foremost an applied research area, and most of the research conducted concerns problem-solving methods related to industry, the paradigmatic foundation in logistics has not been challenged to any great extent. Instead, the debate tends to centre around logistics management activities which aim to achieve a predetermined optimum, based on rationally derived set of objectives, often focusing predominantly on cost minimisation. However, as Guba and Lincoln (1998 p.195) state: *"questions of methods are secondary to questions of paradigm."* Morgan (1983 p.14) adds that if the problem contexts are viewed from different paradigms we can *"see and understand how we can research organizations (and any other aspects of social life) in ways that tell us something new about the phenomenon in which we are interested."* In other words the logistics discipline might benefit from a paradigmatic discourse, in order to further develop logistics research approaches and the knowledge that is produced within the discipline.

This paper deals with how we logisticians perceive the world; simple or complex? More specifically, the focus is on how our assumptions and perceptions of logistics operations affect the choices of methods used and solutions produced. The aim of this paper is to contribute to the debate on challenging paradigms in logistics research and practice. Consequently, this paper represents a proposal aimed at moving the logistics discipline on the ontological axis toward a more nominalistic view or less positivistic view (Burrel and

[1] The term functionalistic is derived from Burrel and Morgan (1979) and is one of the paradigms they use in the analysis of social theory. They (ibid. p.25) state that the functionalist paradigm *"represents a perspective which is firmly rooted in the sociology of regulation and approaches its subject matter from an objectivist point of view."*

Morgan 1979) i.e. towards considering more complexity in the problem situations under study. The reasons for this are several.

- Firstly, firms have put lot of money, time and resources into methods, models and techniques that are based on assumptions of linear causality and certainty. However, the reality researchers and managers confront is mostly non-linear, uncertain and unstable. One example of a positivistic approach in the logistics practice is the business process re-engineering movement where radical changes of firms, and even supply chains, are seen as designable from a top-management point of view (Davenport 1995;Van Ackere, Larsen, & Morecroft 1993). However, the results of these efforts are not very impressive. Cao, Clarke, & Lehaney (2001) report that 70 per cent of re-engineering efforts result in failure. Another applied method, activity-based costing (ABC) is based on the assumption of *"linking individual products and services to their individual cost drivers"* (Palmer & Parker 2001 p.993) which reflects Taylorist assumptions which are based on Newtonian beliefs of certainty and reductionism principles i.e. perfect rationality and determinism.

- Secondly, control and predictive assumptions are paramount in the usual literature on management (Lissack 1999) where objective reality is taken for granted and linear cause-and-effect relationships are promoted (Macbeth 2002). Consequently, firms' efforts to manage logistics systems and processes have often resulted in frustration and anxiety (Choi, Dooley & Rungtusanathan 2001), not least for the managers who are supposed to be in charge (Stacey, Griffin, & Shaw 2000). Added to this is the fact that when the underlying explanations for firms becoming successful are examined, it is a fact that the reasons are often what we in retro-perspective call by accident or coincidence. Collin and Porras (1997, p.141 in McCarthy 2004) in their study of successful firms conclude; *"In examining the history of visionary companies, we were struck by how often they made some of their best moves not by detailed strategic planning, but rather by experimentation, trial and error, opportunism and quite literally accident. What looks in hindsight like a brilliant strategy was often the residual result of opportunistic experimentation and purposeful accidents."*

- Thirdly, the knowledge produced within the logistics discipline relies heavily on an objective reality i.e. the positivistic paradigm (as discussed above), and as Kuhn (1967) argues, researchers entering a discipline, and thereby a research paradigm, often concur with the common terminology, norms and beliefs provided by people already within the discipline. Consequently, researchers either, consciously or unconsciously, begin accepting these common beliefs and norms, or they change discipline. This means that researchers who do not believe in the assumptions associated with a positivistic view find it difficult to concur with these, while others researchers accept the assumptions which dominate the discipline, sometimes without even critically reflecting on them. This is the case for logistics managers as well. Consequently, in order to produce new methods, models and techniques to industry and practice other assumptions need to be considered for research conducted and solutions implemented.

- Fourthly, Palmer and Parker (2001 p.997) conclude that *"given the epistemological path taken through the development of alternate management models, there is now, more than ever, a need to re-align the older models with knowledge of uncertainty."* In the logistics discipline there is and has been a reluctant attitude

towards uncertainty. A number of articles have described how to reduce uncertainty (e.g. Childerhouse & Towill 2003) and, of course, this should be done to some extent. However, the pursuit of reducing uncertainty needs to be balanced against epistemological considerations of how to handle uncertainty. This is especially important since efforts focusing solely on reducing uncertainty often produce more uncertainty. As Palmer and Parker (2001 p.992) describe it *"if the current work environment is changing faster than the time taken to develop measurements, then trying to bring about stability through* [e.g.] *documentation is pointless."*

- Fifthly, increased competition and changing demand are making the marketplace increasingly turbulent i.e. the landscape on which firms operate is not fixed or static and cannot be treated using positivistic principles. Instead, in the words of McCarthy (2004 p.139) *"the size and shape of the landscape, along with the defining environment, is continuously changing."* Consequently, disregarding the dynamics perceived in the world of business by too many simplifications may lead to solutions produced that are too far from reality in order to provide any useful explanations or changes in logistics as well as other business operations.
- Finally, in order to meet increased competition and changing demand companies strive for e.g. agile logistics processes. However, as Prater, Biehl, & Smith (2001 p.827) state *"the introduction of factors that increase supply chain agility may increase supply chain uncertainty and complexity."*

Hence, in this paper it is argued that by considering more complexity, and thereby more uncertainty, in the models constructed and theories developed by researchers as well as managers, our ontological views may change and therefore also the way we communicate our reflections and thoughts i.e. our epistemological considerations. The reminder of this paper is organised as follows. The next section provides a discussion concerning the assumptions found and made in both logistics research and practice. This is in order to draw attention to the underlying assumptions that the logistics discipline relies on at a metatheoretical level. The section following that examines how to transform the logistics discipline from an unchallenged approach of simplification to a more balanced view of complexity and simplicity. It is concluded that the paradigmatic question is the key in order to change the frame of reference of the logistics discipline, which means that another set of assumptions needs to be considered. This set of assumptions is discussed in the subsequent section where assumptions influenced by and derived from the science of complexity are introduced. Finally, the last section provides a concluding discussion and a proposed perspective i.e. the complexity perspective, based on a different set of assumptions which are more connected to real-life events than those generally used today.

2. Assumptions in Logistics Research and Practice

Today one could argue that most of the research on logistics has a strong connection to the positivistic paradigm (Mentzer & Kahn 1995). In this section positivistic assumptions which in the logistics discipline are given great emphasis on are discussed. These are: command and control, rationality, objective reality, determinism, linear causality, and reductionism. What these assumptions represent are "effective" ways of breaking down descriptions of phenomena of interest which have been the natural way to advance theories for a long time. However as Kauffman (1995 p.) states *"the reduced description does not capture all the features of the phenomenon"* and as we shall discuss in coming sections

there are several aspects that cannot be found based on these assumptions, which are highly apparent in all complex systems, not at least logistics.

2.1. Command and Control

The overall abilities to design, plan and control are promoted to a great extent in the logistics discipline. For example, in the often-cited definition of logistics management provided by CLM (www.clm1.org[2]), it is stressed that logistics management is about the planning, implementation and control of logistics activities. It seems quite reasonable to interpret the definition in such a way that it implies a positivistic approach to the logistics discipline. Consequently, the definition could be interpreted as one in which an underlying belief of command and control is uppermost, as is the ability of management to plan, implement and control the flow of goods and products, i.e. someone is in the position to control other people and set goals for whole logistics systems and processes. Van Ackere, Larsen & Morecroft (1993 p.413) exemplify the positivistic approach by stating; *"We are all used to the idea that automobiles, ships, aircrafts, office buildings and bridges need careful design to achieve their purpose. But there is much less awareness that business organizations too are 'designable'."*

This observation, that researchers and managers believe they can design and control organisations, is supported by other authors such as Stacey, Griffin and Shaw (2000, p.18), who have observed that *"most managers continue to believe that their role is essentially one of designing an organization and controlling its activities."* However, they (ibid. p.4) also put forward another observation that could be regarded as paradoxical to the belief that managers can design and be in control, because several managers agreed that in their day-to-day operations they were *"the ones in charge but repeatedly finding that they where not in control."* Nonetheless, the common belief of being able to control organisations and, for that matter logistics processes, may not be surprising since management according to a positivistic view brings assumptions and values that are of a mechanical and deterministic character. Axelrod and Cohen (2000 p.29) provide a good explanation for this mechanical approach when they state: *"No doubt, machines and hierarchies provide easier metaphors to use than markets and gene pools. So it is no wonder that most people are still more comfortable thinking about organizations in fixed, mechanical terms rather than in adaptive, decentralized terms."*

2.2. Rationality and Objective Reality

In order to be successful in the planning and control of logistics activities the assumption of rational behaviour is compelling. Rationality implies that each and every constituent part of a system being planned operates rationally i.e. they all have perfect information, the same background, similar beliefs and assumptions, and work towards the same goal (known and designed by someone outside the system). Furthermore, as Allen (2000b) declares, the environment in which the company or department works is stable both before and after the decision has been taken. Additionally, the effects that we do not know can be ignored since they have no effect on the situation in questions. The rationality assumption relies on another element in the positivistic view, namely objectivity. This implies that every phenomenon is perceived in the same way regardless of whoever observes it and that it is value-free, time-free and context independent.

[2] March 2003

2.3. Determinism and Linear causality

Causality relies on sufficient knowledge of prior conditions in order to show future events or impacts, and is the principle behind determinism (Bar-Yam 1997). Since Descartes and Newton, science has been heavily influenced by beliefs of deterministic assumptions. However, as Nobel prize winner Ilia Prigogine (1997 p.52) states,*"Popper and many other philosophers have pointed out that we are faced with an unsolvable problem as long as nature is described solely by a deterministic science."* In natural science there are at least two major improvements that have destroyed the dream of solely deterministic relationships. These are in quantum physics, where it has been proven that there is fundamental indeterminism at the sub-atomic level (Kauffman 1995), and in mathematics with the field of deterministic chaos, which Baranger (2000 p.8) explains by stating: *"chaos destroys our reductionist dream, the dream that we have absolute power if we only know enough about the details."*

The use of linear programming, which is widely used in the practice of logistics to e.g. optimise resource allocations in supply chains, is a good example of an applied method based on deterministic and linear causality assumptions. According to Shapiro (2001 p.85), there are five fundamental properties accepted in linear programming. These are: 1) linearity 2) separability and additivity 3) indivisibility and continuity 4) single objective function, and 5) data known with certainty. The great advantage of linear programming is of course the simplicity of using it. However, it might not represent many of the problems and situations we are affected by in the logistics discipline, especially not at present, since there are several non-linear tools on the market.

2.4. Reductionism

Some of the prominent assumptions in the logistics discipline are those concerning the possibility of reducing complexity and quantifying it by separating parts or problems into simple elements and sub-problems (McCarthy 2004), which lay as the foundation for the positivistic paradigm (Goodwin 2000). Kauffman (1995 p.VII) states that *"the past three centuries of science have been predominantly reductionist, attempting to break complex systems into simple parts, and those parts, in turn, into simpler parts."* This implies an approach where an identified phenomenon (e.g. a logistics process) is broken down into solvable parts (e.g. inventory, transports, manufacturing and sub-processes of these) and where the parts, after being scrutinised and handled separately, are placed together into a solution in a summative manner. *"Such a deterministic view parallels the physical laws advanced by Isaac Newton, which assume that if the complexity of any system is understood then eventually every known interaction in it can be accurately predicted."* (Zohar, 1990 in Palmer & Parker 2001 p.981) With such an epistemological assumption in mind, *"better management is often seen as simply running the "machine" faster or more efficiently"* (Allen 2000a p.1). In management jargon this epistemological assumption could be regarded as top-down-oriented and, as I have interpreted it, the rule in the logistics discipline. However, while this reductive top-down-oriented process suits various problems where reductionism can be assumed quite confidently (Dent 1999), it may not always benefit the result if the phenomenon under study consists of interdependent parts that are difficult or impossible to unravel, i.e. problem situations where context and phenomenon are complex.

Making these assumptions i.e. determinism, reductionism etc. means that stability and equilibrium represent an optimal state to strive towards and that this is possible, since reduction of uncertainty balances the demand and supply of products. This type of

reasoning i.e. a striving towards states of equilibrium and stability, together with reductions of uncertainty, is apparent in the logistics discipline, which Lambert, Stock and Ellram (1998 p. 453) emphasise by declaring that *"an effective organization must exhibit stability and continuity,"* and Lambert and Cooper (2000 p.72) state: *"controlling uncertainty in customer demand, manufacturing processes, and supplier performance are critical to effective supply chain management."* To summarise then; these assumptions and beliefs represent a paradigm that relies on known environments and a predictable future, where someone i.e. managers, has the ability to deliberate design and amend a logistics system towards a chosen goal and this can be done without any thoughts about the history related to the problem. Consequently, we will obtain simple models that are quite easy to understand, however they will certainly not represent many of the problems that are apparent in the logistics discipline, neither for researchers, nor for managers.

3. Towards more Complexity

In order to challenge the common positivistic assumptions in logistics and develop the logistics discipline, the process of knowledge creation i.e. the epistemological considerations, are central. Arlbjørn & Halldorsson (2002 p.31) address the process of knowledge creation on three different levels (see figure 1.1), the practice level, the discipline level, and the meta level.

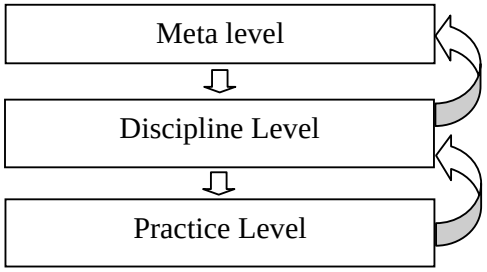

Figure 1. The interplay between the levels of practice, discipline and philosophy of science. Modified from Arlbjørn & Halldorsson (2002 p.31).

The practical level, starting from the bottom, concerns the actual logistical work being accomplished in day-to-day operations. The discipline level is where the majority of the logistics-related research is focused. It is on this level that new logistics methods are developed; either from research with an empirical focus, where best-practice solutions are reported and "glory stories" (New 1996) presented, or as theoretical borrowing from other theories (Stock 1997). The final level, the meta level, is where the ontological and epistemological debates are centred and thereby lie as the foundation for the paradigm the logistics researcher belongs to. Ontological assumptions are assumptions about reality, and, as Guba and Lincoln (1998) argue, the ontological questions concerning our view of reality are the first to be asked when a paradigm is discussed. The next question, suggested by Guba and Lincoln (ibid.) concerns knowledge and, as Burrel and Morgan (1979 p.1) state, is thereby *"about how one might begin to understand the world and communicate this as knowledge to fellow human beings."* According to Burell and Morgan (ibid.) a paradigm consists of meta-theoretical assumptions and these assumptions have direct implications for the methodology and methods used and thereby constrain the basic beliefs taken for granted during the research process. This means that the paradigmatic question is the key, in order to change the frame of reference of the logistics discipline.

A paradigmatic discourse may benefit the logistics discipline by increasing our consciousness of *why* we as researchers do the things we do and *how* we do them. When we enter a research field the common assumptions and beliefs which exist in the community are transferred, in explicit as well as implicit modes, and eventually taken for granted (Kuhn 1996). Kuhn (1996, p. 46) states: *"Scientists work from models acquired through education and through subsequent exposure to the literature often without quite knowing or needing to know what characteristics have given these models the status of community paradigm."* This seems to be the case in the logistics discipline, where in a recent review of doctorial dissertations in Scandinavia between 1990 to 2001 by Gubi, Arlbjørn, & Johansen (2003), it was concluded that as much as 45 per cent have not explicitly incorporated methods or theories originating from the philosophy or theory of science.

Mears-Young and Jackson (1997) claim that it might be useful for and beneficial to logistics for researchers to be more self-reflective about what foundations the methods they use and the solutions they provide stand on. Powell (2003, p.286), with relevance to the suggested paradigmatic discourse, states, *"for any empirical discipline, epistemological beliefs have theoretical and methodological consequences, and habitual beliefs can lead to dogmatism, illusion, or despair."* And, as Arlbjørn & Halldorsson (2002 p.22) state: *"if we take this* [the positivistic] *view for granted, we may produce a unilateral view of logistics knowledge that only focuses on objective and observable phenomena."* Furthermore, ontological as well as epistemological considerations i.e. changes of paradigmatic views might reveal new approaches and novel results or as Dent (1999 p.12) describes it *"how we see things determines much of what we see."* Moreover, as Lissack (1999) emphasises, the language being used in a discipline or a firm reflects how reality is conceived, and this limits the possibilities available for the members to improve their mutual understanding as well as to improve solutions to various problems both within the discipline and within firms.

4. The Complexity Perspective

The perception of supply chains and logistics systems as being complex is emphasised by several authors (Bowersox & Closs 1996; Christopher 2000; Cox 1999; Lambert, Cooper, & Pagh 1998; Lumsdén, Hultén, & Waidringer 1998; Tan 2001). However, the complexity is often derived from an interpretation of logistics systems as being difficult to understand since these systems consist of a great number of parts, relationships and flows, i.e. they should be heavily reduced and simplified in order to be dealt with.

As discussed above, in order to move towards less positivistic research and managerial views, there are implications that need consideration when research is being conducted. For example, the concepts of self-organisation and co-evolution are not explicitly dealt with in logistics research and methods and techniques such as systems dynamics, linear programming and other quantitatively oriented approaches cannot comply with these approaches. However, in the emerging science of complexity these concepts and other related ones, such as emergence and adaptability, are of central importance and interest. Complexity theory and its paradigmatic foundations will be introduced here and used as a theoretical foundation towards a paradigm representing assumptions other than those today present in the logistics domain i.e. a complexity perspective.

The ideas and concepts that have appeared in the science of complexity have various applications and points of origin, and these ideas are continually being developed in

several areas within natural sciences, as well as in areas related to social sciences. The science of complexity designates an approach in trying to find universal properties among several disciplines and thereby unifies knowledge and perspectives on reality between different theoretical areas. *"The study of complex systems focuses on understanding the relationship between simplicity and complexity."* (Bar-Yam 1997 p.293) In that sense, it may be regarded as a truly interdisciplinary science.

While the characteristics of complexity theory might seem closely connected to the general systems theory (Von Bertalanffy 1969), cybernetics (Ashby 1956; Beer 1959), system dynamics (Forrester 1995) and the systems approach (Checkland 1993), several differences are identified when we examine how the complexity theory has an impact on research approaches and assumptions. One apparent difference is that *"one of the basic premises of complexity theory is that much of the apparently complex aggregate behavior in any system arises from the relatively simple and localized activities of its agents. Systems theory, on the other hand, defines complexity as arising from a high number of parts (agents) and interactions."* (Phelan 1999 p.239) Another, difference is the emphasis on time and change in complexity theory which differs from the systems theory (Choi, Dooley, & Rungtusanatham 2001). Furthermore, in systems theory the focus is on structure, and on how essential the structure is in order for the dynamics in a system to be understood. This point is especially stressed by Sterman (2000) and Senge (1990), who argue that *'structure drives behavior'*. From a complexity perspective one would agree with this statement, however, as paradoxical it may be, the complexity researcher would also argue that "behaviour creates structure" and would perhaps emphasise this more. The structure is an emergent outcome of self-organising behaviours. The difference, again, is the question of time. The quotation above i.e. *'structure drives behaviour'*, works well in a static context, however, as proven by Prigogine (1997), since time has a direction structures will change. The reason is that we change structures in our daily operations in whatever we do as well as in what we choose not to do.

Nevertheless, the complexity movement is first and foremost an attempt to move science away from the strong thoughts of reductionism and positivism in the majority of scientific disciplines today. From an ontological view the perceived reality is complex i.e. phenomena, people, artefacts etc. are interwoven and interrelated and the processes perceived are irreversible, all of which denotes the important factors of time and change (Axelrod & Cohen 2000; Bar-Yam 1997; Gell-Mann 1994; Kauffman 1995; Waldrop 1992). The future is mainly viewed as unknown, or, as Prigogine (1997 p.1) states, under *"perpetual construction."* Choi, Dooley, & Rungtusanatham (2001 p.356) declare that *"in a complex system, it is often true that the only way to predict how the system will behave in the future is to wait literally for the future to unfold."* It follows from this that the epistemological assumptions associated with the complexity theory are, to a greater extent, in line with the limitations of handling or even understanding perceived reality. Richardson, Cilliers, and Lissack (2001 p.13) state that *"a principal requirement of a complexity-based epistemology is the exploration of perspectives."*

While the complexity theory consists of several concepts that are treated more or less in each of these disciplines and theories, it is probably best described by some of the central concepts considered in the complexity theory. These are emergence, self-organisation, adaptation and co-evolution, all of which will be briefly described in the next section. These concepts serve as a unifying bridge to the following section where the complexity perspective will be described and other concepts related to a less positivistic view of logistics knowledge and reality.

4.1. Emergence and Self-organisation

Emergence could be addressed as the outcome of collective behaviour i.e. self-organisation of several units, elements or human beings i.e. agents[3], performing something individually, or together, that creates some kind of pattern or behaviour that they themselves cannot produce (Bar-Yam 1997;Goodwin 2000;Lissack 1999). Emergence is commonly referred to as the global behaviours that emerge from the interactions individuals make with each other in a local context. Local context refers to connections in either spatial and/or conceptual space (Bonabeau & Meyer 2001;Gell-Mann 1994;Kauffman 1995). This means that emergent properties are to be found in the collective of constituent agents, since these do not have these properties themselves (Axelrod & Cohen 2000). The concept of the "invisible hand" introduced by Adam Smith in the eighteenth century could be regarded as an emergent phenomenon. Bar-Yam (1997 p.10) provides another example from thermodynamics of two emergent properties, namely pressure and temperature. *"The reason they are emergent is that they do not naturally arise out of the description of an individual particle. We generally describe a particle by specifying its position and velocity. Pressure and temperature become relevant only when we have many particles together."*

It is crucial to consider the phenomena of self-organising and emergent behaviour, which are often observed in every kind of complex system, since these explains several situations where the models or predictions made concerning a certain phenomenon do not provide anything substantial. An understanding of self-organising behaviour is beneficial in order to determine the possibilities to control a particular phenomenon. Stacey, Griffin and Shaw (2000 p.155) state that *"when one succumbs to the powerful drive to reduce complexity to simplicity one loses sight of what is so striking about the possibility of self-organizing interaction producing emergent coherence."*

The concept of emergence and that of self-organisation are what I would argue represent the least-understood features or concepts related to the complexity theory in the logistics context. From a rational perspective, i.e. treating human beings as rational in their behaviour, self-organisation does not exist, since the outcomes of processes and activities are results of design and choices (Stacey, Griffin & Shaw 2000). Nonetheless, global properties as a result of emergence are observable in the logistics area even if their origins and appearance are not addressed to a greater extent. A process is an example of an emergent phenomenon, as it is the result of several parallel and sequential activities or events, i.e. distributed both in space and in time, to produce a coherent outcome. In other words, a process is an emergent phenomenon resulting from the actions of different agents.

By making the assumptions of self-organisation and emergence, we limit the prediction of the system under study to probabilistic patterns of behaviour on different levels of description. The behaviour of individual events is considered, and according to Allen (2000b p.85) this gives *"the system a collective adaptive capacity corresponding to the spontaneous spatial reorganization of its structure."* This means that the agents within the system can and often will change the system structure. The consideration given to the agents in the system distinguishes the self-organising approach from system dynamics. The ability to reconfigure the system from the outside is also probabilistic at this stage, i.e. influences from the outside can affect the system but what outcome it will produce will only be revealed over time. The link to logistics research and practice is hard to make since

[3] the term agent is commonly used in the complexity theory for the constituent parts of a system

tools or methods based on only these assumptions are limited. However, the work carried out by Eurobios[4], using agent-based modelling in the solutions produced, suits this approach (see Nilsson & Darley 2004 for a description). The consideration of emergence and self-organisation is a progression towards a less positivistic approach i.e. more connected to reality, since assumptions of linearity, determinism, rationality and reductionism are disregarded and instead, highly common behaviours found in all type of organisations are considered i.e. emergence, non-linearity, bounded rationality.

4.2. Adaptation and Co-evolution

Adaptation in complex systems can be described as the way agents, as well as collections of these, in competitive and co-operative ways act on and react to changes perceived in their environments. What this means is that agents adapt to adaptations by other agents in their local context i.e. they co-evolve. Holland states (in Waldrop 1992 p.146) that *"one of the fundamental mechanisms of adaptation in any given system is this revision and recombination of the building blocks."* This could have a physical as well as conceptual dimension, whereas the former could be the rearrangement of ants in protecting their nest, and the latter could mean thinking in new ways, gaining new perspectives on reality, and thereby adapting to, for example the information revolution. Andersson (1999) adds to this the importance of adaptation as being something that has evolved and has not been planned, especially in environments considered to be far from equilibrium and stable conditions. Another central feature especially required for populations to adapt is variety within the population (Axelrod & Cohen, 2000). This relies on the argument that variety and heterogeneity represent differences between the capabilities of the elements within the population, which brings new and challenging perspectives to certain issues. Allen (2000b p.88) makes the distinction that *"adaptation and evolution result from the fact that knowledge, skills, and routines are never transmitted perfectly between individuals, and individuals already differ."* In other words, thanks to differences, disagreements and conflicts adaptation and co-evolution can take place. Furthermore, as MacIntosh & MacLean (1999) state *"if one accepts the notion that systems not only complex and adaptive, but that their complexity and adaptiveness can itself change, then one can see different implications for the evolution of organizations."*

5. Conclusions and Discussion

"For 50 years organization science has focused on "controlling uncertainty." For the past 10 years complexity science has focused on how to understand it so as to better "go with the flow" and perhaps to channel that flow." (Lissack 1999, p.120)

One great challenge for logistics researchers and practitioners to reconsider, in developing the logistics discipline, is what the quotation above emphasises i.e. the need to recognise uncertainty and complexity and "go with the flow" instead of trying to remove and control uncertainty. This reconsideration has to start in a paradigmatic discourse, since, as stated previously, the ontological and epistemological assumptions are prerequisites for the methodological and method-related assumptions and choices that are being made.

In this paper the paradigmatic discourse suggests reflecting on the meta-theoretical level as to how complexity concepts e.g. emergence, self-organisation, adaptability etc. will

[4] www.eurobios.com

provide an alternative paradigmatic view, that is, another research agenda. MacIntosh &MacLean (2001 p.1345) state that *"the development of complexity theory, …, is regarded by some as signalling the arrival of a new scientific paradigm in the Kuhnian sense"* which is in line with the proposed complexity perspective in this paper i.e. a perspective where more complexity is considered in the research process and the solutions provided. The focus is placed on reconsidering assumptions normally accepted in the logistics discipline that are of a positivistic character, and on extending these frames by considering other assumptions and perspectives. The complexity perspective is illustrated in figure 2 (see below) where the commonly used assumptions in the positivistic view i.e. linear causality, reductionism, determinism, objective reality, simplicity, independence, and command and control, are extended by factors derived from the paradigmatic view proposed in this paper.

While the positivistic view covers approaches and assumptions that are appropriate to

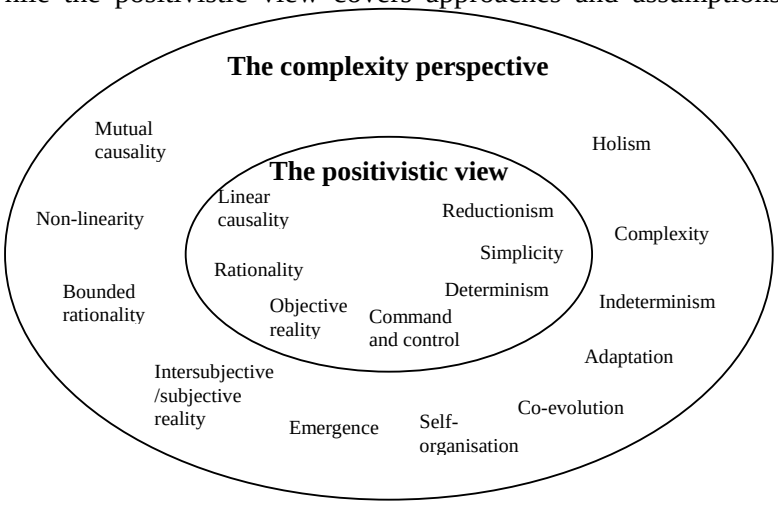

Figure 2. The proposed complexity perspective based on the science of complexity as an extension of the traditional positivistic view, in the logistics discipline. The perspective is here illustrated in a figure derived and modified from Dent (1999 p.9).

some type of problems, the complexity perspective emphasises phenomena and factors highly common and apparent in social contexts i.e. in logistics-related areas. These will be described and compared to the positivistic assumptions underlying the bulk of research in the logistics discipline today.

- ***Mutual causality and non-linearity.*** Instead of linear causality the causes of most problems and issues are of a mutual character since small disturbances can be amplified in non-linear fashions so that there is no interest in finding single factors for complex problems. This Butterfly effect (Palmer & Parker 2001) of small changes in some conditions which sometimes cause huge changes in outcomes and other times no measurable effects makes the Newtonian linearity of cause and effect virtually worthless in the understanding of complex systems which logistics systems typically represent.
- ***Bounded rationality.*** In essence, rational choice and behaviour cannot be found in logistics operations, and even if the people involved could act rationally they are constrained by the impossibility of accurate information and perfect forecasts that rational models impose. Instead, recent research indicates that there are several interesting outcomes when the assumptions of "perfect rationality" are relaxed to

some extent (Darley 1999). This relaxation of rationality makes theories, models and solutions more connected to what can be observed in daily logistics operations.

- ***Intersubjective/subjective reality.*** Adaptation is a central feature covered by the complexity perspective and since the agents' actions are the results of perceptions of the reality they feel exposed to, this adaptability is a result of their subjective views of reality. This ontological view differs from the objectivistic approach emphasised in the positivist view.
- ***Emergence.*** In an objective reality it would not be appropriate to mention the concept of emergence since it involves non-reductive patterns which cannot be derived or determined from the agents' autonomous activities. Emergent patterns are, however, still apparent when the collective behaviour these agents create together are examined.
- ***Self-organisation.*** The concept of self-organisation does not fit into the positivistic paradigm since it does not follow any of the assumptions or factors listed above. From a positivistic perspective, self-organszation causes uncertainty, and since it cannot be effectively controlled, planned or designed it should be reduced, or even eliminated. However, in several cases, this process of self-organisation is the reason for novelty, creativity and innovation.
- ***Adaptation and co-evolution.*** The fact that agents, whether they are seen as people or firms, co-evolve causes a number of problems in the positivistic paradigm. Again, co-evolution does not match up with the deterministic assumptions and the linear causality emphasised in the positivistic view, since it involves non-linear feedback mechanisms from parallel activities, distributed both in time and in space, often by a huge number of agents.
- ***Indeterminism.*** In the positivistic view the emphasis on determinism is the rule rather than the exception. Deterministic assumptions underpin the great emphasis for reducing uncertainty and the focus on actions to improve some identified or conceptualised system in order to reach an optimal state. This differs from the indeterministic approach which is emphasised in the complexity perspective. The focus of the complexity perspective is, in contrast, on exploratory analysis aimed at understanding a certain phenomenon, which helps the people involved to live with uncertainty instead of trying to remove it.
- ***Simplicity and reductionism.*** From an epistemological point of view, disregarding simplicity as a means of communication of knowledge and instead considering it as an emphasis on provision of a complex picture, diverges the complexity perspective from more positivistic assumptions in the act of creation of knowledge described. Complexity could be defined as the amount of information needed to describe or understand something (Bar-Yam 1997). This implies that striving towards simplicity through modelling and explaining certain phenomena in a positivistic manner i.e. by adopting a solely reductive approach, might, in many cases, result in too great a disregard for information and data to provide a picture which is sufficiently complete to facilitate comprehension. One example is that the dynamics might not be included in such simplistic descriptions and, as Gillies and McCarthy (2000) hint, the complexity perspective shows that much of our knowledge is focused on static descriptions i.e. on being, rather than on dynamic processes i.e. on becoming.

To summarise; the complexity perspective proposed in this paper is based on insights gained from the science of complexity. As stated in the introduction, the assumptions made concerning how to approach and transfer knowledge attained from our perceived reality govern the choices of methods used when research is conducted and have, of course, great influence on the results obtained and presented from any research process. Adopting a complexity perspective means taking a step away from the common positivistically influenced view, which dominates the logistics discipline, and approaching the phenomena of interest with a different set of assumptions and prerequisites in the research and management process.

References

Allen, P. M. 2000a, "Harnessing Complexity", *The Complexity Society Working Papers Series*.

Allen, P. M. 2000b, "Knowledge, Ignorance and Learning", *Emergence*, vol. 2, no. 4, pp. 78-103.

Arlbjørn, J. S. & Halldorsson, A. 2002, "Logistics knowledge creation: reflections on content, context and processes", *International Journal of Physical Distribution & Logistics Management*, vol. 32, no. 1, pp. 22-40.

Ashby, W. R. 1956, *An introduction to cybernetics*, First edn, Chapman & Hall LTD, London.

Axelrod, R. & Cohen, M. D. 2000, *Harnessing Complexity - Organizational Implications of a Scientific Frontier*, First edn, Basic Books, Perseus Books Group, New York.

Bar-Yam, Y. 1997, *Dynamics of complex systems*, First edn, Perseus Books, Reading, Massachusetts.

Barrenger, T. 2000, Chaos, Complexity, and Entropy - A physics talk for non-physicists, http://www.necsi.org/projects/baranger/cce.html Visited: 2002

Beer, S. 1959, *Cybernetics and management*, First edn, The English Universities Press LTD, London.

Bonabeau, E. & Meyer, C. 2001, "Swarm Intelligence - A Whole New Way to Think About Business", *Harvard Business Review*, vol. 79, no. 5, pp. 106-115.

Bowersox, D. J. & Closs, D. J. 1996, *Logistical Management, the integrated supply chain process*, International edn, McGraw-Hill, New York.

Burrel, G. & Morgan, G. 1979, *Sociological Paradigms and Organizational Analysis; Elements of the Sociology of Corporate Life*, First edn, Heinemann Educational Books Ltd, London.

Cao, G., Clarke, S., & Lehaney, B. 2001, "A critique of BPR from a holistic perspective", *Business Process Management Journal*, vol. 7, no. 4, pp. 332-339.

Checkland, P. 1993, *Systems Thinking, Systems Practice* John Wiley & Sons Ltd, Chichester.

Childerhouse, P. & Towill, D. R. 2003, "Simplified material flow holds the key to supply chain integration", *Omega*, vol. 31, no. 1, pp. 17-27.

Choi, T. Y., Dooley, K. J., & Rungtusanatham, M. 2001, "Supply networks and complex adaptive systems: control versus emergence", *Journal of Operations Management*, vol. 19, no. 3, pp. 351-366.

Christopher, M. 2000, "The Agile Supply Chain - Competing in Volatile Markets", *Industrial Marketing Management*, vol. 29, no. 1, pp. 37-44.

Cox, A. 1999, "A research agenda for supply chain and business management thinking", *Supply Chain Management: An International Journal*, vol. 4, no. 4, pp. 209-211.

Darley, V. 1999, *Towards a theory of autonomous, optimising agents*, Doctor of philosophy, The Division of Engineering and Applied Science and the Department of Economics, Harvard University.

Davenport, T. 1995, *Business Process Reengineering: Its Past, Present and Future*, Harvard Business School Publishing, Boston, 9-196-082.

Dent, E. B. 1999, "Complexity Science: a Worldview Shift", *Emergence*, vol. 1,no. 4,pp. 5-19.

Dunn, S. C. & Seaker, R. F. 1994, "Latent variables in business logistics research: Scale development and validation", *Journal of Business Logistics*, vol. 15, no. 2, pp. 145-173.

Forrester, J. W. 1995, "The beginning of system dynamics", *The McKinsey Quarterly* no. 4, pp. 4-16.

Garver, M. S. & Mentzer, J. T. 1999, "Logistics research methods: Employing structural equation modeling to test for construct validity", *Journal of Business Logistics*, vol. 20, no. 1, pp. 33-48.

Gell-Mann, M. 1994, *The Quark and the Jaguar: Adventures in the Simple and the Complex* ABACUS, London.

Gillies, J. M. & McCarthy, I. P. 2000, "Complex Systems Thinking: Key insights for the social sciences, and an industrial application", Warwick University, Coventry, UK.

Goodwin, B. 2000, "Out of Control into Participation", *Emergence*, vol. 2, no. 4, pp. 40-49.

Guba, E. G. & Lincoln, Y. S. 1998, "Competing Paradigms in Qualitative Research," in *The Landscape of Qualitative Research*, N. K. Denzin & Y. S. Lincoln, eds., SAGE Publications, Inc., Thousand Oaks, pp. 195-220.

Gubi, E., Arlbjørn, J. S., & Johansen, J. 2003, "Doctoral dissertations in logistics and supply chain management: A review of Scandinavian contributions from 1990 to 2001", *International Journal of Physical Distribution & Logistics Management*, vol. 33, no. 10, pp. 854-885.

Holland, J. H. 1998, *Emergence from Chaos to Order*, First edn, Perseus Books, Cambridge, Massachusetts.

Kauffman, S. 1995, *At Home in the Universe: The Search for Laws of Self-Organization and Complexity* Oxford University Press, New York.

Kent Jr, J. & Flint, D. J. 1997, "Perspectives on the Evolution of Logistics Thought", *Journal of Business Logistics*, vol. 18, no. 2, pp. 15-29.

Kuhn, T. S. 1996, *The Scientific Revolution*, Third edn, The University of Chicago Press, Chicago.

Lambert, D. M., Cooper, M. C., & Pagh, J. D. 1998, "Supply Chain Management: Implementation Issues and Research Opportunities", *The International Journal of Logistics Management*, vol. 9, no. 2, pp. 1-18.

Lissack, M. R. 1999, "Complexity: the Science, its Vocabulary, and its Relation to Organizations", *Emergence*, vol. 1, no. 1, pp. 110-126.

Lumsdén, K., Hultén, L., & Waidringer, J. "Outline for a Conceptual Framework on Complexity in Logistics Systems", A. H. Bask, ed., NOFOMA 98, Finnish Association of Logistics, Helsinki.

Macbeth, D. K. 2002, "Emergent strategy in managing cooperative supply chain change", *International Journal of Operations & Production Management*, vol. 22, no. 7, pp. 728-740.

MacIntosh, R. & MacLean, D. 1999, "Conditioned emergence: a dissipative structures approach to transformation", *Strategic Management Journal*, vol. 20, no. 4, pp. 297-316.

MacIntosh, R. & MacLean, D. 2001, "Conditioned emergence: researching change and changing research", *International Journal of Operations & Production Management*, vol. 21, no. 10, pp. 1343-1357.

McCarthy, I. P. 2004, "Manufacturing strategy: understanding the fitness landscape", *International Journal of Operations & Production Management*, vol. 24, no. 2, pp. 124-150.

Mears-Young, B. & Jackson, M. C. 1997, "Integrated Logistics - Call in the revolutionaries!", *Omega*, vol. 25, no. 6, pp. 605-618.

Mentzer, J. T. & Flint, D. J. 1997, "Validity in Logistics Research", *Journal of Business Logistics*, vol. 18, no. 1, pp. 199-216.

Mentzer, J. T. & Kahn, K. B. 1995, "A framework of logistics research", *Journal of Business Logistics*, vol. 16, no. 1, pp. 231-250.

Morgan, G. 1983, *Beyond Method - Strategies for Social Research*, First edn, SAGE Publications, Inc.

Morgan, G. 1997, *Images of organization*, Second edn, SAGE Publications, Thousand Oaks.

New, S. J. 1996, "A framework for analysing supply chain improvement", *International Journal of Operations & Production Management*, vol. 16, no. 4, pp. 19-34.

Nilsson, F. & Darley, V 2004, Improving decision-making with agent-based modelling - experiences from a packaging company, Working paper.

Palmer, E. & Parker, D. 2001, "Understanding performance measurement systems using physical science uncertainty principles", *International Journal of Operations & Production Management*, vol. 21, no. 7, pp. 981-999.

Phelan, S. E. 1999, "A Note on the Correspondence Between Complexity and Systems Theory", *Systemic Practice and Action Research*, vol. 12, no. 3, pp. 237-246.

Prater, E., Biehl, M., & Smith, M. A. 2001, "International supply chain agility - Tradeoffs between flexibility and uncertainty", *International Journal of Operations & Production Management*, vol. 21, no. 5/6, pp. 823-839.

Prigogine, I. 1997, *The End of Certainty - Time, Chaos, and the New Laws of Nature*, First edn, The Free Press.

Richardson, K. A., Cilliers, P., & Lissack, M. R. 2001, "Complexity Science: A "Gray" Science for the "Stuff in Between"", *Emergence*, vol. 2, no. 3, pp. 6-18.

Robertson, D. A. 2003, "Agent-Based Models of aBanking Network as an Exampleof a Turbulent Environment:The Deliberate vs. EmergentStrategy Debate Revisited", *Emergence*, vol. 5, no. 2, pp. 56-71.

Shapiro, J. F. 2001, *Modeling the Supply Chain*, First edn, Duxbury, Pacific Grove.

Stacey, R. D., Griffin, D., & Shaw, P. 2000, *Complexity and management - Fad or radical challenge to systems thinking?* Routledge, London.

Stock, J. R. 1997, "Applying theories from other disciplines to logistics", *International Journal of Physical Distribution and Logistics Management*, vol. 27, no. 9/10, pp. 515-539.

Tan, K. C. 2001, "A framework of supply chain management literature", *European Journal of Purchasing and Supply Management*, vol. 7, no. 1, pp. 39-48.

Van Ackere, A., Larsen, E. R., & Morecroft, J. d. W. 1993, "Systems Thinking and Business Process Redesign: An Application to the Beer Game", *European Management Journal*, vol. 11, no. 4, pp. 412-423.

Von Bertalanffy, L. 1969, *General Systems Theory - Foundations, Development and Applications*, First revised edn, George Braziller Inc., New York.

Waldrop, M. M. 1992, *Complexity - The emerging science at the edge of order and chaos* Touchstone, New York.