

Complexity Approaches on Logistics: Moving Beyond Systems Approach

ABSTRACT

Logistics is being given increased attention in companies and in research, and is gaining strategic importance as supply chains or supply networks are the realm of today. For both researchers and practitioners in the field of logistics one of the fundamental concepts is the systems approach. As many researchers proclaim, to understand logistics you need to understand the concept of systems; this in order to see holistically, to value total cost and not to suboptimize. However, the majority of research produced is nevertheless positivistically influenced. The aim of this paper is to provide a reflection on one of the dominant approaches to logistics research, namely systems approach, and its connection to two approaches identified; complex adaptive systems and complexity thinking. The result of the paper is an extended view of research approaches in order to address and solve new types of questions and old questions with new approaches.

Key Words: complexity theory, assumptions, paradigm, logistics, innovation.

Introduction

Logistics is being given increased attention in companies and in research, and is gaining strategic importance as supply chains or, more aptly named, supply networks are the realm of today. For both researchers and practitioners in the field of logistics the systems approach is fundamental. As many researchers proclaim, to understand logistics you need to understand the concept of systems; this in order to see holistically, to value total cost and not to suboptimize. The majority of logistics research carried out is positivistically influenced (Mentzer and Kahn 1995) and positivistic assumptions are predominant for the systems approach being used in logistics. Consequently, what are mostly taught to logistics managers on educational programs and used by logisticians in practice are simplified, normative models based on mechanistic principles.

Nevertheless, Arlbjørn and Halldorsson (2002: 22) question this single paradigm of positivism by stating: *“if we take this view for granted, we may produce a unilateral view of logistics knowledge that only focuses on objective and observable phenomena”* and Lewis and Suchan (2003 p.312) elaborates on this even further by stating that *“logistics research may need a growth-inducing language about logistics managerial behavior, a new set of theoretical constructs that will help researchers reframe and thus “resee” their thinking and research designs in ways that help them break from variance theories and the larger positivist paradigm.”*

However, while there are researchers who suggest new paradigms to be explored and used in the logistics discipline, others claim that such efforts are less valuable and, on the contrary, troublesome especially for the practitioners and managers of logistics. Nonetheless, by merely approaching logistics with a positivistically influenced systems approach implies that logistics research and practice will continue to place a predominant emphasis on simplifying assumptions

such as rationality, stability, rationality, linearity, determinism. Hence, as Gammelgaard (2004: 484) declares *“the use of alternatives to positivism should at least be investigated in logistics research.”* Consequently, there might be a potential for logistics research and practice to investigate other approaches from challenging paradigms, this not at least since the complex logistics context of today requires updated and upgraded business logic based on assumptions reflecting the challenges of today and of tomorrow.

The need for assumptions appropriate for the business world of today in logistics is something also Nilsson (2006) calls for. Based on a study of logistics managers’ work in practice and the challenges they are facing it is argued that theories of complex logistics are needed (ibid.). However, for these to be developed paradigmatic changes are required. Trim and Lee (2004: 473) state that *“management researchers need to have the confidence to challenge basic assumptions relating to interpreting research outcomes, and what constitutes appropriate research.”* Challenging basic assumptions is something also Rigby et al. (2000) advocate for especially the need to include human factors and the complexity these bring. He states that *“the usual focus for improvement in the supply chain has been the optimization of a particular company's inventory or scheduling protocols. [...] These systems analysis and redesign methods are excellent at describing and modeling the physical flow of materials, inventory data and demand patterns. However, the human-to-human interaction in network forms of organization has a much higher degree of complexity”* (ibid.: 181). Consequently, this paper takes the standpoint that logistics processes, involving human beings, are not simply a sequence of mechanical devices which can be assumed to work along positivistic beliefs, but instead a complex network of living, innovative, and evolving creatures which react and adapt dynamically to their perceived environment, and try to proactively create what they themselves, or collectively with others, find

to be beneficial for their interests. It is in the interaction between people that coherent patterns of meaning and identity are perpetually created and made sense of. The question is then what approaches are appropriate to use when trying to understand and handle logistics processes based on such a standpoint?

The aim of this paper is to provide a reflection on one of the dominant approaches to logistics research, namely systems approach, and its connection to two approaches identified in the science of complexity; complex adaptive systems and complexity thinking. The purpose of such a discussion is: 1) contribute to the paradigmatic discourse in logistics research and practice, and 2) to provide the logistics research society with an extended view of research approaches in order to address and solve new types of questions and old questions with new approaches, and thereby strengthen the logistics discipline.

The remaining paper is organized as follows. Section 2 will present and discuss the use of systems approach in logistics. Thereafter, in Section 3 two approaches from the science of complexity will be introduced namely complex adaptive systems and complexity thinking. In Section 4 a comparative analysis of the underlying assumptions related to the three approaches is provided starting of with a framework of assumptions. Finally, a concluding discussion is provided with implications for research and practice.

Systems approach to logistics

For both researchers and practitioners in the field of logistics one of the fundamental concepts is the systems approach. *“The systems approach is a critical concept in logistics. Logistics is, in itself, a system; it is a network of related activities with the purpose of managing the orderly flow of material and personnel within the logistics channel”* (Lambert et al. 1998a). Hence, the

systems approach is critical when approaching and analyzing logistical issues. Bowersox and Closs (1996: 459) share this view when arguing that *“a basic understanding of the systems concept is desirable for a full appreciation of integrated logistics.”* In addition, Stock et al. (1999: 45) declare that the *“systems approach within the firm has been the underlying premise of much of current logistics management, thought, and practice.”*

Nevertheless, before continuing the discussion of moving beyond the Systems Approach (SA) it might be beneficial for the reader to know what is meant and taken into consideration when the SA is addressed in some of the logistics writings. Based on literature reviews on Nordic dissertations as well as international books and articles that explicitly discusses and uses systems approaches (see for example Andersson 1997; Ballou 2004; Coyle et al. 2003; Holmberg 2000; Lambet et al. 1998; Mears-Young and Jackson 1997; Saghir 2004; Vafidis 2007; Waidringer 2001) it was found that the definitions and underlying system thoughts are most often referred to the early works in systems theory. Most publications refer to general systems theory (Von Bertalanffy 1969), cybernetics (Ashby 1956; Beer 1959) and system dynamics (Forrester 1968) i.e. what often is referred to as hard systems approach. Several publications also refer to Checkland (1993), to Senge (1990) and to the works by Arbnor and Bjerke (1997) i.e. what often is referred to as soft systems approach. While the assumptions ontologically, epistemologically as well as teleologically (i.e. how the future interpreted) differ among the systems approaches (i.e. between the soft and the hard, and in the branches in both the soft and the hard) there are several assumptions that unifies them as well. Hence, the notion that the whole is more than the sum of its parts, and that feed-back processes and relationships between the parts are central features of systems. Furthermore, the SAs rely on an objective reality (ibid.) and in accepting the notion of system comes the issue of boundaries which is another feature of SA. In this context the manager

or researcher has the opportunity to choose what will be the system and what will be the environment. Furthermore, following on from this logic comes the ability to create and/or design subsystems for the researcher or manager. Cause-and-effect relationships are often searched for but not always established within the system but instead *indicator-effect* (Arbnor and Bjerke 1997). The indicator-effect relationships mean that both equifinality (Von Bertalanffy 1969) and multifinality exist in the system. Hence, despite the assumptive differences among the SAs, when applied to logistics the treatment of SA often falls back to positivistically influenced assumptions (Vafidis 2007) e.g. simplicity, objectivity, rationality, prescription, designability, determinism. A reason for this might be in accordance to what Kuhn (1996: 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 as well, where for example Gubi et al. (2003) in their review of doctoral dissertations 1990 to 2001 concluded that as much as 45 per cent have not explicitly incorporated methods or theories originating from the philosophy or theory of science.

However, despite the overwhelming amount of logistics research which uses some kind of SA, there are some aspects which may be reconsidered when research within the logistics discipline is conducted. This is especially the case if the research object includes or is influenced by people. Such aspects would, for example, concern collaboration, power, conflicts, creativity, novelty, innovation, and paradoxes. Nilsson (2006) concludes that based on the challenges logisticians are facing in their daily work models and theories that can handle complex situations and contexts are needed. He states; “*These challenges are characterized by novelty (the type of problems are contemporary), and paradoxes which are of an “unsolvable character” and can only be handled*

by balancing efforts each and every day” (ibid.: 51). Furthermore, Gammelgaard (1997: 17) declares that “an objective world view will not be able to bring forward the subjective pictures of the world as those e.g. caused by difference in power between the actors in the system. Consequently the perception of reality becomes insufficient if systems theory is the only approach in logistics.” However, before any deeper analysis of SA in comparison with the complexity approaches, a description of complex adaptive systems and complexity thinking might be beneficial.

Complexity approaches

The emergence of the science of complexity is, as explained by most researchers in the field, first and foremost an attempt to move science away from the strong emphasis of reductionism and positivism in the majority of scientific disciplines today. The argument is that reductionistic and positivistic assumptions restrain further progress and cannot explain empirical phenomena easily found in nature and social life. Nonetheless, within the science of complexity there are branches that diverge into different directions as a result of the assumptions which are presumed. There are branches that can be regarded as direct extensions or further developments of SA, since they have similar terminology and share some assumptions i.e. the notion of systems, boundaries, formative teleology etc. However, as Phelan (1999: 237) states *“a common terminology suggests a high degree of commensurability between [systems theory and complexity theory]. However, on closer examination, although they share a common worldview, the two theories differ markedly in their research agenda and methodologies.”* Other branches of the science of complexity clearly set out to present other perspectives, i.e. do not share the assumptions of the first type. Richardson and Cilliers (2001) indicate that there are different types of complexity theories and Stacey et al.

(2000) question whether the complexity movement is a fad or a radical challenge to the SA and the different use of complexity theory in literature and practice.

For the purpose of this paper, two branches of the science of complexity will be described and discussed in the context of logistics. These are complex adaptive systems (CAS) and complexity thinking (CT). Examples of logistics related publications reporting on the usage of CAS are Choi et al. (2001: 352) who state that “*not enough to recognize a supply network as simply a system – a supply network is a complex adaptive system*”, Nilsson (2003) who provides a CAS perspective on logistics, Surana et al. (2005) who conclude that “*in order to effectively understand a supply-network, it should be treated as a CAS*” (ibid.: 4262) and finally Nilsson and Darley (2006) who provides a discussion and empirical examples on CAS in production and logistics contexts. Even fewer examples exist on logistics research that relies on CT. The works of Johannessen and Solem (2003; 2002) are though examples. Johannessen, in his dissertation, provides a definition of logistics from a complex responsive process perspective: “*Logistics is complex processes of relations between humans, nature, technology and resources that interact and unpredictably self-organize into emerging paradoxical patterns with value creating potential*” (2003: 87).

The distinction between CAS and CT will be important for the reader, especially for those for whom the science of complexity is rather new, as the comparison with different paradigmatic approaches may help the reader orient him/herself. It is important to mention at this stage that this is not a discussion aiming at finding the true or best approach for logistics research and practice. Such a discussion would be fruitless and, frankly speaking, foolish. Instead, the proposed value lies in gaining knowledge and understanding of what perspective and approach provides appropriate understanding, and guidance, for the situation or phenomenon to be studied or handled. This since many of the issues, especially raised in logistics practice, concerning

innovation, creativity, service and other directly human-related aspects will not be addressed and handled without appropriate assumptions for such contexts. As it will be further elaborated, it is the author's belief that a multi-paradigmatic approach will be far more beneficial to any research problem than solely using one; the dilemma is to know when, and under what circumstances to use what. The following analysis is aimed at providing the reader with some insights for dealing with this dilemma.

Complex adaptive systems

A complex adaptive system (CAS) can be described as *“a special kind of complex systems since they have the property of adaptation. [...], adaptation means that the agents or elements in the system are responsive, flexible, reactive and often proactive regarding inputs from other agents or elements that affect them”* (Nilsson 2003). CAS consists of several parts, which are commonly referred to as agents, and which act in correlation and interdependence to each other (Kauffman 1995). In the context of logistics these agents could be processes and activities, but on a lower level they could also be the machine operators, the truck drivers i.e. the people within organizations and even artefacts like machines and packages. This means that some agents might have greater influence on the system, and some less, but the interesting part is that no one controls the system. Compared to the brain, there is no master neuron controlling what we think. The complexity arises in the adaptive, self-organising processes among the agents from which perpetual novelty emerges. Attempts to reduce organizational complexity in order to control (i.e. as managers are taught to act) are often counterproductive (Colbert 2004). CAS acts most creatively in states far from equilibrium, often referred as to the edge of chaos, for at the other extreme *“equilibrium is a precursor to death”* (Pascale 1999: 85). In complex adaptive systems assumptions of determinism can still be revealed since there is an underlying belief that

identifiable rules of cause-and-effect can be found in the system, i.e. a few simple rules that can be decided and elaborated on in order to realize predetermined outcomes for a whole system. This notion of designable and controllable systems through the use of simple rules has led to several normative management writings suggesting implicitly that the science of complexity opens new doors for control and prediction (see for example Beinhocker 1999; Kupers 2001).

Complexity thinking

Complexity thinking (CT) differs ontologically, epistemologically and teleologically from both SA and CAS. Ontologically, the underlying belief is that of unordered and subjectivity; epistemologically, of heuristics or anti-positivism; and teleologically, of a transformative nature. CT is in the author's point of view the collection of the works by Stacey et al's (2000; 2001) work on complex responsive processes, Snowden et al's (2002; 2004) Cynefin framework, and the works by Richardson, Lissack and Cilliers (2001; 2001).

A major differentiator of CT in comparison to SA and CAS is that CT is developed for human- and human organizational phenomena, i.e. there are no extrapolations from physical, chemical or biological sciences. This is in line with the consideration Boulding (1956) makes in his hierarchy of complexity on nine levels for theoretical discourse, where on the seventh and eight levels human and human organizations and societies are placed. The complex responsive process perspective sets out to explain transformational change as emerging from self-organizing processes which are born out of human interaction which cannot be observed objectively (Stacey 2001). Based on transformational teleology the future in CT is regarded as mainly unknown, or, as Prigogine (1997) states, under "*perpetual construction*". It follows from this that epistemological assumptions are in line with the limitations of handling or even understanding of the perceived reality to a greater extent. Focus is on exploratory analysis of the phenomena being

studied and these complex phenomena are incompressible from in CT (Richardson et al. 2001). As Kurtz and Snowden (2003:480) point out: “*Conceivability is not the point: preparation for the unexpected is.*” Paradoxes are seen as natural in CT and follow Hegel’s logic in that they possess different characteristics and explanations at the same time i.e. phenomena being predictably unpredictable (Stacey 2002), or knowledge characterized as both a substance and a flow, simultaneously (Snowden 2002). By the acceptance of paradoxes in organizational contexts the CT approach involves considerations of central aspects in human life such as conflicts, power, creativity, novelty, joy, and love where these aspects are central to the way human beings relate to each other and these qualities help create meaning in most situations.

A comparative analysis of assumptions

The ontological, epistemological and teleological assumptions are prerequisites for the methodological assumptions and choices which are being made in any discipline (Burrell and Morgan 1979; Morgan 1983; Snowden 2002) e.g. Guba and Lincoln (1998: 195) state: “*questions of methods are secondary to questions of paradigm.*” Consequently, starting out from a paradigmatic discussion about assumptions has direct implications for the approaches, methods and tools to be used when dealing with logistics phenomena. Examples of assumptions associated to positivism (i.e. most systems approaches) are; simplicity, order, objective reality, reductionism, deliberate design, rationality, optimality, determinism and to complexity perspectives (i.e. CAS and CT); complexity, unordered, intersubjective/subjective reality, emergence, self-organisation, co-evolution, bounded rationality and indeterminism (Nilsson 2003).

It is important to point out that a complexity perspective considers all assumptions i.e. also the positivistic, and it is not a question of duality where for example simplicity and complexity are

extremes on an axis, but instead based on an underlying assumption that both states can exist simultaneously i.e. a underlying dialectic nature of the complexity perspective. In this regard, Richardson and Cilliers (2001: 11) state *“insights from the human sciences on the one hand, and natural science on the other, should not be set against each other, nor should they be assimilated too easily. They should be used to challenge each other.”*

To provide a fruitful analysis of assumptions and their treatment in SA, CAS and CT, a categorization of assumptions will be provided as a starting point. The categories are; 1) structural, 2) behavioural, and 3) time-related. The structural assumptions are **simplicity/ complexity, order/unorder, reductionism/emergence** and **objectivity/ subjectivity**, based on the reason that these assumptions relate to beliefs in how structural aspects of logistics phenomena and processes are connected and how they are formed. Assumptions categorized as behavioural are **deliberate design/self-organization, coevolution**, and **rationality/ bounded rationality**, since these all relate to the creatures involved, both individually and collectively, and to how they interact. Finally, assumptions regarding **determinism/indeterminism** and **optimization** will be seen as time-related assumptions since they relate to future states or conditions. It is important to point out that this categorization is not a claim to be complete or inclusive since some of the assumptions are related to both time, behaviour and structure e.g. coevolution. Instead the purpose is, from a logistics point of view, to bundle them together in such a way that could benefit further development of the logistics discipline. In other words, the reader may and is encouraged to, from his/her subjective view, regard this characterization differently. Thus, the important message is for the logistician to rethink the assumptions he/she makes and is guided by. For that process this categorization could be beneficial, at least as a starting point.

Structural assumptions

When it comes to the structural assumptions one apparent similarity between SA and CAS concerns the fact that both approaches agree on the assumptions of objectivity or at least of an objectively accessible reality, and from that, a chosen system can be separated from its environment (see Table 4.2). However, how this is done differs between the two theories. In SA systems are observable from the outside where both researchers and managers can position themselves (SA). In CAS systems can be assessed objectively but are very limited due to the assumption of its dynamic nature and it is especially problematic if the objectivity is to be used for intervention. The situation is different in CT. In CT the assumption is of a more interpretive character, where meaning and value are created in the interactions among people in their daily activities. Thus, some common view of some characteristics of life is contextually created, and formally or informally agreed on by those involved, crating some kind of intersubjectivity. However, due to people's multiple identities, paradoxical and time-related aspects might change such agreements, as contexts perpetually change. This is due to the inherent complexity perceived in making long-term commitments to several characteristics and situations simultaneously. In this regard Stacey et al. (2000:61) state that "*systems work, to the extent that they do, because of the informal, freely chosen, ordinary, day-to-day cooperative interactions of an organization's members, and this cannot be controlled*" and not objectively observed. As reported in Nilsson (2006) the challenges logistics managers are concerned about are related to the sense-making of situations in their organisations which calls for intersubjective perspectives and not objective realities.

A central emphasis in SA is the focus on structure, and on how essential the structure is in controlling and directing the dynamics in a system. This point is especially stressed by Sterman

(2000) and Senge (1990), who argue that “*structure drives behaviour.*” In this regard Lee et al. (1997: 548) conclude that companies which aim to get control of the bullwhip effect should attack “*the institutional and inter-organizational infrastructure and related processes.*” Another example is provided by Disney et al. (1997) in their discussion of causes of the bullwhip effect. They declare that poorly designed order handling systems may cause amplifying behaviour through the supply chain and thus, “*it is essential to select the appropriate structure for the production ordering system, and then to set the system parameters at their ‘best’ value*” (ibid. 1997: 176). It could be interpreted that some hidden order or structure exists, which can be selected, design and controlled by someone in a holistic, outside position such as top management, for instance, to control and direct behaviour in lower hierarchies. Furthermore, as Johannessen (2003: 15) states; “*it is assumed that the system is stable for such a time period that analysis can be made ... a system should be able to display predictable and stable behavior.*” In both CAS and CT one would agree with the SA assumption that ‘structure drives behaviour’ (CAS) or at least influences it (CT), however, as paradoxical this agreement may be, the complexity researcher would also argue that “behaviour creates structure” or at least, “behaviour creates the perception of structure” and emphasizes this even more. The “structure” or order in CAS and CT is an emergent outcome of self-organizing behaviours of the constituent elements, where the elements are heterogeneous in both substance and action resulting in a natural variety in all phenomena. This variety is the true source for both novelty (Stacey 2002) and innovativeness (Allen 2000) as well as survival (Kauffman 1995). Kauffman (ibid.) calls this self-organizing outcome ‘order for free’ as temporal stability emerges as a natural result of the non-linear interactions among the elements. Hence, from a CAS and CT perspective structure cannot be deliberately created, only more or less stimulated to reach stable conditions,

temporally. Furthermore, what CT shares with CAS is the notion of unordered i.e. paradoxical situations involving both order and disorder, simultaneously, and with the soft SA, the uniqueness of human phenomena and organizations (Snowden and Stanbridge 2004).

The perception of supply networks and logistics as being complex is emphasized by several authors (Bowersox et al. 2002; Christopher 1998; Lambert et al. 1998b). However, based on paradigmatic standpoint there is a difference in how complexity is understood and how it can be simplified. In SA the complexity appears in systems as a cause of how many parts and interactions are present. For example, Milgate (2001: 107) observes that “*complexity should be viewed as a deterministic component more related to the numerousness and variety in the system.*” Furthermore, using a system dynamics approach Childerhouse and Towill (2003: 18) declare that the concept of seamless supply chain is “simple in nature and based on a control engineering approach.” In several writings it is argued for twelve simplifying rules where these are based on reducing, simplifying, unifying, eliminating assumptions such as rule seven; “elimination of all uncertainties in all processes”, and rule twelve; “*all players should think and act as one*” (Towill 1999: 11). In contrast to SA, the overall belief in CAS is that the complexity is the result of interacting and self-organising agents which follow simple rules. On higher levels of description they create complex as well as simple patterns of coherence and chaos. This means that the heterogeneity of the agents and the variety among them are put forward and not regarded or treated as an average in which variety can be reduced or eliminated. CT shares most of the CAS considerations but emphasizes the subjectivity and the paradoxical nature of people. Hence, in CT treating logistics as complex means considering human involvement and the paradoxes created in human interactions. Consequently, it also means considering the concrete, actual work being done and the mental models created by the humans involved.

Table 1

A Comparison of Structural-related Assumptions in SA, CAS and CT.

[Table 1 about here]

Behavioral assumptions

The phenomenon of self-organization can be found in all approaches, however, it differs in its meaning and in how it is defined (see Table 4.2). In SA some elements of a systems behaviour are sometimes referred to as being formed by the feed-back loops which are prevalent in e.g. logistics systems. However, at the same time there is a great belief in the engineering capability of the observer (researcher or manager) as being able to control the behaviour and direct it toward some predetermined goal. A holistic picture of the situation provides the observer with the chance to see “all” feedback loops and from that he/she rejects those which are deemed less efficient or effective for the overall goal. Van Ackere et al. (1993: 413) exemplifies this 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'.”* Stacey et al. (2000: 120) state that *“in systems thinking, causality is primarily of the formative type taking a linear form in which the feedback process of the system causes its patterns of behavior, usually in a predictable way.”* In CAS the discussion about self-organization is less determinable since there is a belief is that it is far more spontaneous i.e. less engineerable. Kauffman (1995: 185) states that *“self-organization may be the precondition of evolvability itself. Only those systems that are able to organize themselves spontaneously may be able to evolve further.”* In addition the notion of system designer in CAS is less prevalent. In CT this notion of designability is limited, unpredictable and paradoxical since the firm belief is that a process or phenomenon *“can self-organize into disintegration just as it can into a rigid, repetitive pattern”* (Stacey et al. 2000: 147). Furthermore, in CT a

transformative teleology is assumed, meaning that changes do appear spontaneous and unpredictably and, as paradoxical it may seem, emergent continuity is kept simultaneously. This is derived from Hegel's dialectical notion i.e. an individual is both constructing and influenced by the society at the same time (Johannessen 2003) and there are no notions of system levels or hierarchies. Transformational processes can be understood by "*paying attention to phenomena like self-organization, emergence, paradox and unpredictability*" (ibid.: 42). Conclusively, as stated by Nilsson (2003:33): "*From a positivistic perspective, self-organization causes uncertainty and since it cannot be effectively controlled, planned or designed it should be reduced, or even eliminated. However, this process of self-organization is in several cases the source for novelty, creativity and innovativeness.*"

Table 2

A Comparison of Behavioural-related Assumptions in SA, CAS and CT.

[Table 2 about here]

Another assumption, that of coevolution, can be defined as "*a process of coupled, deforming landscapes where the adaptive moves of each entity alter the landscapes of its neighbors in the ecology or technological economy*" (Kauffman and Macready 1995: 27). Products and services "live" in niches created by other products and services i.e. there is an interdependence that makes the coevolution occur. Coevolutionary processes could be seen as combinations of traditional evolutionary thinking and self-organization; it is survival of the fittest but in both cooperative and competitive ways. In CT the assumption of coevolution provides meaning to the paradox of simultaneous competition and cooperation causing human freedom and constraint arise in spontaneity and diversity of micro interactions in daily life. It is in these processes that true novelty emerges i.e. the concepts and ideas that no one could predict. In CAS it is explained that through local active and lively behaviour global characteristics emerge which then alter the way

the agent on lower levels interact (Anderson 1999). This in turn leads to changes in objectives, structures, motivations i.e. coevolution of organizational functions, company networks and of the economy as such. In SA, again, there is a wish and strive to design change and that it can be done in some kind of isolation, i.e. by setting the boundaries right, and is achieved by rational decisions and actions. Hence, the assumption of coevolution is problematic since it challenges the belief in designability.

The assumption of rationality is another assumption which differs widely among the approaches. 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, the environment in which the company or department works is stable both before and after the decision has been taken (Allen 2000). While (perfect) rationality is more or less rejected by all the approaches it is treated differently by them. In this regard Rigby et al. (2000: 181) state that *“in practice, open systems theory gives a central role to “management” to maximize bounded rationality. This “gatekeeper” role requires management to predict and design appropriate structures and responses and to manipulate resources and connected actors in what is perceived to be a desirable manner.”* In other words, based on the assumption of objectivity and the notion of a formative and rational teleology, highly empirically observable aspects such as conflict, power, and creativity, are disregarded and cannot be satisfactorily explained when a SA is used. Gammelgaard (1997: 17) concludes, for example, that *“conflicts are simply not on the research agenda in that part of reality which systems theory uncovers.”* This is to a great extent the case in CAS as well, however, instead of the great emphasis on avoidance of and reductions in such uncomfortable aspects (e.g. conflict), these are seen as

natural and essential for advancements, evolution and survival. Since CT is developed for social complexity, bounded rationality is the rule, and considerations of subjective pictures of situations, the narratives and contexts are greatly emphasized. It is in acts of freedom that creativity and innovations are to be best produced i.e. where the rational is not determined by objective functions or rules set by organizations such as normative approaches with major focus on efficiency enhancing efforts e.g. the lean concept. And as Walters (2004: 227) concludes: “*not only is this [focus on cost-led efficiency] constraining, but also it has to be shown not to be in the shareholders' interests: cost reductions typically have a negative impact on customer service and this, in turn, has the same impact on revenues.*”

Time related assumptions

The last category deals with the assumptions of determinism and optimization (see Table 4.3). As Phelan (1999) explains, the SA focuses on problem-solving and action to improve some identified or conceptualized system in order to reach an optimal state, i.e. a predetermined objective which represents a stable future situation. Bowersox and Closs (1996: 459), exemplify this determinable ability by arguing that use of the SA in logistics stresses “*total integrated effort toward the accomplishment of predetermined objectives.*” Stacey et al. (2000: 59) provides a reflection on such assumptions. They state that “*systems thinking provide powerful ways of thinking about, and designing means of securing, organizational stability and continuity and, in the case of systems thinking, unfolding potential change already enfolded in the system.*” This means that a formative and rationalist view is taken for granted and the assumption is that systems are deterministic. This notion is less emphasized in CAS, for example, Choi et al. (2001: 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.*” Changes in CAS are

seen as being *non-linear* and toward a *non-random future*, meaning that the future is not totally random; however neither can it be predicted in a deterministic manner. In addition, in CAS the role of path dependency is also emphasized since projections from the past may influence both its present actions, and their anticipations and expectations of the future. In the process of anticipating the future, agents search for patterns in the past and, as Beinhocker (1999: 97) declares, “*our drive to see patterns and trends is so strong that we will even see them in perfectly random data.*” This makes the connection with a more transformative view for the CAS approach explicit. Thus, due to the inherent indeterminism, the possibilities for predictions are heavily reduced. However, in the “rule”-based CAS community the wish for prediction is still apparent, often through computer simulations but it is often on the level of emerging patterns that result from these models. The focus in CT is, in contrast, on exploratory analysis where understanding helps the researcher and practitioner to live with the complexity and the indeterminism it brings in instead of trying to remove it. The emphasis is even more on the living present from which we change both the future and the past in the activities we perform and in how we relate to other people.

Table 3

A Comparison of Time-related Assumptions in SA, CAS and CT.

[Table 3 about here]

When it comes to the assumption of optimality several examples exist in the logistics literature.

For example, Chen and Wang (1997: 606) conclude in the context of large scale steel production that “*cross-functional operations can be optimized and overall optimality can be obtained.*”

Furthermore, Mentzer et al. (2004) make the following proposition: “*Logistics supply-management interface capabilities lead to optimization of the total process of logistics activities, which leads to minimization of system-wide total cost, which leads to competitive advantage.*”

Moreover, Mears-Young and Jackson (1997) argue that from a logistics perspective, people as well as artefacts, can be engineered in order for the objective of optimization to be realized. In SA the risk of sub-optimisation is emphasized however, as the numerous examples from logistics literature show, the assumption of optimisation is central to the logistics discipline and it gets support from the SA as long as the boundaries are set in the “right” way. In both CAS and CT the concept of optimality is heavily limited. In CAS the discussion is more concerning the fitness of a system often involving numerous aspects that cannot be analytically assessed. In CT the reasoning is similar to the words of von Hayek (1989: 5): *“I confess that I prefer true but imperfect knowledge even if it leaves much undetermined and unpredictable, to a pretence of exact knowledge that is likely to be false. ... The credit which the apparent conformity with recognized scientific standards can gain for seemingly simple but false theories may, as the present instance shows, have grave consequences.”* For the CT approach the assumption of optimization does not exist and if it is present is in the narrative dialogue between actors in relational processes.

Concluding discussion

This paper has taken on the paradigmatic discourse initiated before in logistics (e.g. Gammelgaard 2003; Lewis and Suchan 2003; Nilsson 2004; Näslund 2002) and by other researchers in other disciplines. While there are several authors who asks for the introduction of new paradigms and new approaches in logistics research and practice (for example Arlbjørn and Halldorsson 2002; Gammelgaard 2004; Sachan and Datta 2005) few provide such. Examples are Lewis and Suchan (2003) who propose structuration theory and Näslund (2002) who suggests action research. In addition to those, this paper provides two approaches from the science of complexity with the purpose to further develop the discipline by providing a reflective analysis

and discussion of established and new research approaches with potential benefits for the logistics community.

The three approaches presented and discussed in this paper (SA, CAS and CT) all represent different perspectives on reality, based on different assumptions, and are thus applicable to different contexts, situations, and problems. Knowing each approach's limitations and its underlying assumptions is valuable when using these approaches in any research endeavour. In SA there are certain assumptions which are less beneficial in explaining logistics activities on a daily basis and in creating a meaning for the people involved. SA's provide good objective illustrative descriptions of technical parts of logistics "systems", however, they place less emphasis on the subjective perspectives logistics people have in "reality". The problem with CAS theories applied to human phenomena is similar to that of SA, in the sense that these are developed and derived from studies of mathematics, physics, chemistry and biology, and not for human and social phenomena. Hence, the underlying assumptions of the theory applied have to be rethought, otherwise the theoretical approach does not fit into the context to which it been transferred in its intended form. Both CAS and CT provide alternatives in exploring innovation, learning and sense-making in logistics. As a final conclusion, I would argue that for further developments of logistics, approaching logistics phenomena from several perspectives may achieve best results. The unifying efforts of logistics may provide value since in some situations a common defined terminology may ease communication and consensus. However, based on a belief of an ever-changing reality filled of transformations of identities, a multiperspectival approach to logistics may be valuable in making decisions concerning 'the right things to do' i.e. in creating effective logistics. Furthermore, in order for the logistics discipline to develop strategic dimensions and strategic value for firms aspects such as creativity, novelty, innovation

together with human involvement will be in need for approaches that, based on appropriate assumptions, are developed to handle such aspects.

Implications for researchers and practitioners

There are several beneficial aspects of extending the assumptions and approaching logistics with a complexity perspective. These rely on the fact that by focusing on the effectiveness of different processes instead of today's efforts on efficiency, the dominant cost-reducing focus can be complemented with both revenue-enhancing activities and with higher leverage from improvement efforts. The revenue-enhancing activities i.e. logistics effectiveness efforts are restrained in the mechanical beliefs inherent in the systems approach mostly used today since these need a different type of logic. This logic covers human-related aspects such as creativity and innovativeness and from this novel processes and activities can thus be created i.e. different ways of fulfilling customer requirements, and ensuring the satisfaction of other stakeholders involved. Furthermore, by identifying and accepting paradoxes inherent in logistics will provide novel perspectives and from these develop the discipline further. What the avoidance of such paradoxes provides is a self-reinforcing belief of running the machine faster. Ignoring the empirically identifiable paradoxical processes, which take place on a daily basis, and the effect these have in theories which both researchers and practitioners are guided by, results in less valuable guidance and understanding for the logistics community.

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Table 1

A comparison of structural-related assumptions in SA, CAS and CT.

Assumption	SA	CAS	CT
simplicity/ complexity	complexity is a cause of how many parts and interactions are present i.e. it can, and should be simplified in order to be dealt with.	complexity is the result of interacting agents or parts which follow simple rules.	complexity and simplicity coexists, simultaneously and relates to the perceptions of the actors involved. It is in the relating processes that complexity appears as well as disappears.
order/unorder	order is hidden in every situation. Order is achieved by holistic control and deliberate design hence "structure drives behaviour"	order is the natural result of non-linear interactions. Behaviour creates structure and structure is an emergent outcome of self-organizing processes.	paradoxical situations involving both order and disorder, simultaneously i.e. unorder. Behaviour creates the perception of structure, and perceived structure affects the perceptions of both structures and behaviours.
reductionism/ emergence	mostly static descriptions of breakable systems i.e. focus on being, but also system properties that cannot be taken apart.	dynamic processes from the bottom-up focusing on becoming.	through emergent outcomes novelty is created which cannot be broken apart or controlled, only post-rationalised.
objectivity/ subjectivity	systems are observable from the outside where both researchers and managers can position themselves.	things can be assessed objectively but are very limited due to the assumption of its dynamic nature.	subjective experiences and views that are created in the process of human relating causing sometimes intersubjective views.

Table 2

A comparison of behavioural-related assumptions in SA, CAS and CT.

Assumption	SA	CAS	CT
Deliberate design/self- organization	designed and planned change through rational decisions and actions. Self-organization is mostly regarded a source for uncertainty and should be reduced to a controllable state.	self-organisation is regarded as a natural process and often as a source for novelty, creativity and innovativeness.	diverse microinteraction of a paradoxical kind that sustains identity and potentially transforms it.
coevolution	is not explicitly dealt with. It does not fit any deterministic assumptions and the linear causality, and it is difficult to include in defined systems.	due to interdependence coevolution is created through local active and lively behavior global characteristics emerge which then alter the way the agent on lower levels interact and adapt.	provides meaning to the paradox of simultaneous competition and cooperation.
rationality/ bounded rationality	rationality is bounded but desirable to achieve - with increased information and knowledge rationality can be more or less attained. Conflict, power etc. are disregarded and cannot be satisfactorily explained when the SA is used.	bounded and accepted as such. Aspects such as conflict, power etc. are regarded natural and essential for advancements, evolution and survival of any system.	bounded rationality is a prime assumption, the subjectivity and narratives are central.

Table 3

A comparison of time-related assumptions in SA, CAS and CT.

Assumption	SA	CAS	CT
determinism/ indeterminism	deterministic assumptions underlie the great emphasis for reducing complexity and the focus on actions to improve some identified or conceptualized system in order to reach an optimal state.	emerges in the interaction among individuals. Patterns may be predictable since the future is regarded as non-random, if there are underlying rules that can be assessed.	indeterminable since the future is under perpetual construction and is created in the relational processes among the agents. By focusing on exploratory analysis aimed at understanding a certain phenomenon, the individuals involved are helped to live with complexity instead of trying to remove it.
optimization	the risk of sub-optimisation is emphasized However, it is central to the logistics discipline and it gets support from the SA as long as the boundaries are set in the "right" way.	cannot be attained. Instead emphasis on the fitness of a system often involving numerous aspects that cannot be analytically assessed.	does not exist.