A sustainable management framework for dilemma and boundaries in autonomous cooperating transport logistics processes

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Abstract: In our modern societies, transport logistics processes and systems seem to have reached their limits for expansion. The effects of transport logistics on the environment and human health contribute to major problems. This situation calls for new approaches for transport logistics and for managing sustainability. In this paper, we pick up the technological innovation of 'Autonomous Logistics Processes', (ALPs) an emerging paradigm using the idea of self-organisation for complex and dynamic logistic systems. The problems of this paradigm are discussed for a management with dilemma and boundaries, which we integrate into a sustainable management framework.

Keywords: sustainability; transport logistics; Autonomous Logistics Processes (ALPs); dilemma; boundaries.

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1 Introduction

The desire and possibility to have goods available nearly anywhere and at any time in our globalising world have contributed to a tremendous increase in transport volume and in delivery frequencies (Freitag et al., 2004). Customer expectations, the pressure of competition on turbulent global markets and virtualisation of logistics companies result in complex and dynamic logistics systems, structures and networks (Picot et al., 1997; Scholz-Reiter et al., 2004). The current development of product individualisation for consumers is leading to an 'atomisation of delivery', meaning that smaller quantities have to be delivered and more frequently (Freitag et al., 2004). Very often, trucks or containers are not fully loaded; for example, in Germany recent reports indicate less than 70% of the transportation capacity is used at a particular time (Bundesamt für Güterverkehr, 2003; Wenning et al., 2005).

As transport is the most important reason for environmental threats in logistics systems (Wu and Dunn, 1995), major problems go along with the situation described: increased air pollution, degrading emissions and the abundant use of non-renewable natural resources (petroleum products) all contribute to a huge challenge to be faced. Additionally, transport logistics is responsible for human exposure to noise and toxic substances and endangering human health (Colvile et al., 2004; Wu and Dunn, 1995). Today, infrastructures as well as economic, natural and social resources are felt to limit the possibility for further expansion of global logistic activities (Scholz-Reiter et al., 2004). Logistic management needs to respond effectively to these growing pressures. In this situation, sustainability has become an increasingly important concept for logistics (Colvile et al., 2004; Wu and Dunn, 1995). However, despite efforts to translate the paradigm into realisable logistics strategies, the goal of sustainability still seems out of reach. McIntyre (2003) acknowledges that in theory the concept of sustainability makes sense but it has proven difficult to put the concept into practice as it "is difficult to 'sell' to senior management because it describes a state in the future that has never been experienced, rather than a specific process or methodology of how to get there" (McIntyre, 2003, p.233).

A promising emerging approach is the use of the self-organisation paradigm for logistics processes to create 'Autonomous Logistics Processes' (ALPs) (Freitag et al., 2004). The main idea of self-organisation operates as a direct challenge to central planning as it decentralises control, planning, information processing and decision-making in transport logistics through the use of innovative information and communication technologies. Central planning is felt to have reached its limits (Scholz-Reiter et al., 2004) and the self-organisation perspective offers a valuable conceptual lens to consider how logistics systems can increase their robustness, flexibility, adaptability and reactivity to respond to changing business environments,

requirements and to changing or partially conflicting objectives (Freitag et al., 2004). Today, ALPs are still a vision because existing technologies have to be further developed before they can be implemented in transport logistic practice. Scholz-Reiter, Windt and Freitag explain how ALPs could be realised in transport logistic processes:

> "Imagine decentralized distributed architectures of intelligent and communicating objects instead of today's centralized control of non-intelligent objects in hierarchical structures: […]. The flow of goods is no longer controlled by a central instance. Instead, the package is finding its way through the transport network to the destination autonomously while constantly communicating with conveyances and nodes and considering demands, e.g. concerning delivery date and costs" (2004, p.358).

Researchers at the University of Bremen, Germany, use existing technologies such as a Radio Frequency Identification Device (RFID) and wireless communication networks (e.g. UMTS), sensors and software engineering technologies to develop 'intelligent' logistics objects and ALPs. Intelligent logistic objects have the capability to control themselves. In transport logistics, these could be transit equipment (e.g. pallets, packages) or transportation systems (e.g. conveyors, trucks). The results of decision-making processes are still predetermined, but the processes are both flexible and adaptive. A large number of intelligent logistics objects can 'choose' autonomously between different possibilities (Scholz-Reiter et al., 2004), for example, which carrier they use for transport. At the inter-organisational level, the decisions of the new technology could influence costs, profits and the sustainability of logistics organisations. ALPs foster anticipation and flexible reaction of the logistics system to complex and dynamic situations, but at the same time, it becomes more difficult for managers to control if and how decision-making processes contribute efficiently to the company's value creation and to its economic, ecological and social objectives.

In this interdisciplinary research project logistics systems are regarded as socio-technical systems with different sub-systems and levels (Freitag et al., 2004). Shifting decision making functions from human schedulers (social decision making system) to intelligent logistic objects (technical decision making system) does not only increase the robustness and adaptability of the logistic system, but may also reduce the impact of transport logistics on the environment by increasing capacity utilisation and decreasing transport volume, as well as delivery frequencies in transport logistics. To achieve these goals, Multiagent Systems (MAS) (Wooldridge and Jennings, 1995) are equipped with artificial intelligence and the ability to copy social mechanisms of coordination to model self-organisation in MAS (Schillo et al., 2004). First computer simulations of a transport scenario indicate, for example, that by improved routing ALPs could increase utilisation of transport capacity from 70% to 76.9% (Wenning et al., 2005). In addition, decentralised decision making may allow controlling for an increased number of negative and unintended side-effects of logistics processes through usage of local knowledge. ALPs could therefore reduce some of the environmental problems aforementioned and serve as a technology for a more sustainable transport.

From a management perspective, it is important to understand how the idea of the self-organisation paradigm changes decision-making processes in a logistic organisations and how this is connected to sustainability. Our conceptual contribution is to explore the problems arising from ALPs for logistic managers from a systems perspective. We point out what are the preconditions allowing logistic organisations to profit from the

advantages of self-organisation and to control for unintended and unwanted outcomes of the new paradigm for logistic organisations and society. In this paper, we propose managing the context for ALPs at a meta-management level within a sustainable management framework.

While acknowledging the potential of ALPs with regards to reducing the negative impacts of transport on the environment, we agree with Ashford (2003), that although technological innovations are important, they do not lead to sustainability automatically. The objective of a sustainable management in our context is to capitalise on the advantages of ALPs and to secure an organisation's success, efficiency and sustainability in complex and dynamic economical, ecological and social environments. This can only be achieved if organisations are able to secure the reproduction of critical resources.

For this paper, we identify two management challenges from the paradigm shift from central control to ALPs; firstly, the need to reconcile the dilemmas of central versus autonomous cooperation in decision-making as well as the dilemma of efficiency versus sustainability. Secondly, the simultaneous 'opening' and 'closing' of boundaries in logistics systems has to be managed.

The first dilemma stems from the change in organisational structure and from the shift to a larger amount of decentralised (autonomous) control. In the research project mentioned above it is assumed that logistics organisations cannot escape from facing the self-organisation paradigm in the future. If that becomes a reality, organisations have to develop management strategies to cope with the new situation. The latter dilemma refers to the economic rationalities for managerial decision-making in ALPs. Organisations have to be profitable (efficient) but at the same time they have to maintain their economic, ecological and social resource base (sustainability). That these two objectives are so difficult to combine has led to the assumption that efficiency and sustainability follow different economic rationalities and lead to a dilemma for decision-making (Hülsmann, 2003; Müller-Christ, 2001).

Both the dilemmas are related in the ways that in the future, competing logistic organisations will have to cooperate to realise the full potential of ALPs and to secure the organisational resource base. Hence, from a systems view, organisational boundaries have to be 'opened' on the one hand to realise cooperation and autonomous control and on the other, to sustain the logistic system's resource base. The problem here is that the know-how relevant for maintaining an organisation's competitive position must remain secret despite cooperating via ALPs. Accordingly, a boundary-sensitive management has to be implemented to ensure opening and closing of boundaries.

Before we identify central decision-premises for this boundary management in the third section, we begin with exploring reconciliation strategies for the dilemmas in the next section. In the last part of the paper, we draw conclusions for further research and for practice.

2 Reconciliation strategies for a dilemma management

The relevance of dilemmas has been a concern for management scholars in the USA and in Europe since the 1980s and 1990s, when claims were advanced that one of the main reasons for organisational failure is the inadequacy to cope with paradoxes (e.g. Fontin, 1997; Quinn and Cameron, 1988). In a dilemma situation, a choice has

to be made between at least two equally important and contrary alternative actions (Neuberger, 2002). Dilemmas (synonyms in the literature: paradoxes, dualities) can be destructive if they are ignored (negation). Negation reduces decisions to one extreme and neglects possible choices. Another characteristic of dilemmas is that they remain over time and that new paradoxical situations are likely to follow earlier ones after the first one has been reconciled (Neuberger, 2002; Poole and Van de Ven, 1989). In addition, human resources are important in reconciling the dilemmas (e.g. Evans and Doz, 1989).

Previous research identifies various coping strategies for social and logical dilemmas (e.g. Quinn and Cameron, 1988; Evans and Doz, 1989; Poole and Van de Ven, 1989; Raisch, 2005). The first step towards dealing with a dilemma between two poles is to identify, define and accept it (Hampden-Turner, 1990; Poole and Van de Ven, 1989). Subsequently, four main coping strategies are proposed; temporal separation, spatial separation, spherical separation and synthesis (Hampden-Turner, 1990; Poole and Van de Ven, 1989; Raisch, 2005).

Splitting the social from the technical decision-making systems (see introduction), is a form of spatial separation for the dilemma between central and autonomous control. This split is the main difference to centralisation-decentralisation change process explored in the literature because the result is going to be a novel kind of socio-technical decision-making system. However, we have to draw on existing research as empirical analysis of this innovation can only be effected when ALPs will be realised in future logistics organisations.

In our exploration we focus on the question: How can the dilemma of 'central versus autonomous control' and of 'efficiency versus sustainability' be reconciled within social or technical sub-systems of logistics organisations? Even though, design possibilities are limited in practice and depend on an organisation's existing structures (cp. Raisch, 2005), we discuss the logical implications of the potential alternatives for ALPs.

2.1 Temporal separation

Temporal separation (sequencing) addresses dilemmas by separating its two poles or 'horns' temporarily (Hampden-Turner, 1990; Poole and Van de Ven, 1989). Organisations are 'waving' or 'cycling' between different organisational structures and they change, for example, from centralisation to decentralisation and back again (Hampden-Turner, 1990; Raisch, 2005). The notion 'waving' suggests a movement in waveform between the poles. A waveform can be understood as part of a cycle, spiral or helix operating over time and that is why some authors call this temporal separation strategy 'cycling' (Hampden-Turner, 1990). Further visualisation of sequencing process are offered by Evans and Doz, suggesting that an organisational pendulum swings "over a generation from one desirable quality to its opposite" (1989, p.219). Thus, organisations are 'swinging', 'balancing' or 'oscillating' between contrary poles (Evans and Doz, 1989; Raisch, 2005).

Transferred to our transport logistics situation, multiagent-based ALPs will allow organisations to shift to a higher degree of self-organised structures, in the future. To avoid the tension of the resulting dilemma between central and autonomous control, organisations could also introduce a higher degree of self-organisation in their social decision-making system, but what is the ideal degree of self-organisation in transport logistics? From past experience in organisational practice, we conclude that if the degree is too high, paradigm change would continue until the disadvantages of

autonomous cooperation (e.g. loss of control, or loss of efficiency) outweigh the advantages followed by a sequence of recentralisation efforts (cp. Raisch, 2005). This should be considered when implementing ALPs because the central problem of separating dilemmas temporarily is that just one of the poles may be realised and the other neglected. If the period of time is too long, repercussions of this strategy increase, threaten an organisation's survival and orientation to the other pole might become impossible. Recent empirical research results illustrate, that organisations shifting to extremes – such as too much or too little growth and change – are likely to fail (Probst and Raisch, 2005). Accordingly, the downsides of temporal separation of dilemmas are that in each sequence one pole is ignored and that continuous changes from central to autonomous control could be very expensive. For example, costs for the technological infrastructure of ALPs are high and cooperating logistics organisations rely on each other maintaining it. Other disadvantageous consequences of cycling or oscillating between different organisational structures could be higher rates of employee turnover and a limited ability and willingness of employees to adapt to ever changing work routines (cp. Raisch, 2005).

Temporal separation could also be used to reconcile the dilemma of efficiency versus sustainability in ALPs sequentially rather than simultaneously; in economically 'bad times' organisations could strive for efficiency and in 'good times' for sustainability. The danger is that these good times will never come or will at least not be perceived as such by those making the decisions. Hence, to be effective sequencing strategies have to be accompanied by further measures. For example, monitoring the decisions for efficiency and sustainability could help ensure that the sum of the decisions is not biased towards one of the poles. To avoid the disadvantages of separating the dilemmas temporarily, different hybridisation strategies can be implemented in logistics organisations. Contrary to sequencing, hybridisation allows coping with the problem not by temporal but by spatial or spherical separation.

2.2 Spatial separation

Spatial separation is a design strategy to split the dilemma and shift the poles to different locations of the organisation (Poole and Van de Ven, 1989; Raisch, 2005). Hence, different locations or sub-systems are provided with profoundly different structures and pursue consistently just one pole of the dilemma in each sub-system. Previous research on reconciling the dilemmas of centralisation and decentralisation with the help of spatial separation or 'ambidextrous' organisations (O'Reilly and Tushman, 2004; Tushman and O'Reilly, 1996) has revealed that splitting an organisation into different structures allows reaching dual objectives efficiently and simultaneously. However, not every organisation is successful in coordinating and integrating the achievements of contrarily designed sub-systems. For example, different organisational cultures and mental models evolve in previously separated units (cp. Raisch, 2005). At some point in the decision-making process, separate sub-systems face the challenge of finding a common solution and mentalities may collide.

In our example, centralised processes and structures in one organisational subsystem (social decision-making system) are combined with decentralised ones in another part of the logistics organisation (technical decision-making system). In this case, the tension between the poles develops between the social and the technical subsystem. In spite of this, coping with the tensions has to be achieved by people. 'Intelligent objects' are

supposed to decide autonomously, but these objects have to be programmed by people according to the requirements of organisations. Accordingly, at some point, decision premises have to be chosen and it will be interesting to observe whether logistics organisations are willing to deal with both the poles of the dilemmas (e.g. efficiency and sustainability), or if they will just try to use the technology of ALPs to maximise one of their objectives. The individuals involved need high interpersonal skills and a high tolerance for ambiguity because in the end, people decide which decision premises are going to be considered.

There are three different design possibilities to reconcile the dilemmas of central versus autonomous control and of efficiency versus sustainability. Firstly, the technical subsystem is designed consistently. Consequently, individuals as for example, truck drivers with the necessary qualifications and skills would have to cope with the dilemmas (cp. Dembski and Timm, 2005). In this case, sustainability would either be regarded as a 'bonus', which can be realised by implementing ALPs. Alternatively, criteria for sustainability would have to be programmed in ALPs and a rule for an agent could be such as 'choose safe oil-tankers for transport only'. Secondly, the technical subsystem design is contradictory and multiagent-based agents represent different poles of the dilemma. Today, this seems possible because agents dispose of rule-based decision-making capable of coping with the contradictions (cp. Langer et al., 2005; Schillo et al., 2004). Thirdly, ALPs are designed consistently as in the first case, but the dilemma of efficiency versus sustainability is not regarded as solved through ALPs. Instead, an additional department for sustainability is implemented in transport organisations, that is, the social decision-making system is also separated spatially. The main task of this sustainability department would be to point out the long-term repercussions of decisions focusing on efficiency. Then again, the difficulty of balancing different mental frames of the members of the subsystems may occur. It seems that spatial separation can only be effective if the contradictory subsystems are regarded as equally important and if their contribution to the well-being of the total system is being rewarded. Spherical separation, another form of hybridisation, can be used to compensate for the detrimental effects of spatial separation.

2.3 Spherical separation

In spherical separation, the horns of the dilemmas are addressed simultaneously and within the same subsystem with the help of coexisting, 'parallel' structures (cp. Raisch, 2005). Depending on their current tasks, people can switch between a primary structure (e.g. hierarchy) and a secondary structure (e.g. project teams, informal networks or communities of practice). Primary structures are designed with the objective of supporting central control ensuring efficiency, while secondary structures allow self-organisation for improved organisational adaptability. The goal of implementing two coexisting organisational structures for the same people is to balance advantages and disadvantages for each individual structure. Prominent examples of organisations, which successfully introduced spherical structures are BP, Siemens, Kraft Foods or General Electric. Instead of permanently changing their organisational structures (see Section 2.1) organisations can focus on improving their parallel structures (Raisch, 2005).

For transport logistics organisations, spherical separation of the social decision-making system offers an alternative design of organisational structures, which could be implemented additionally to ALPs. Spherical separation is interesting

both for the dilemma of central versus autonomous control and for the dilemma of efficiency versus sustainability. The integration problem mentioned in the section on spatial separation could be avoided to a certain extent because the same individuals address the poles of the dilemmas in different 'spheres' (cp. Raisch, 2005). However, the major challenge is here that organisations need people capable of reaching dual objectives, of making contradictory decisions and of coping with a dilemma's tensions. Dilemmas are reflected in every decision-making process and role expectations for individuals can be contradictory. For example, a scheduler has to make decisions for sustainability and efficiency alike, but, some decisions for sustainability might not contribute to an organisation's efficiency and vice versa. In other words, the logical dilemmas might be accompanied by more psychological dilemmas (cp. Argyris, 1988; Cameron and Quinn, 1988). Whether an individual can cope with the dilemma or not, depends largely on this person's skills, tolerance for ambiguity and role expectations.

Again, there are different design possibilities; the technical sub-system could be designed consistently or contradictory (see Section 2.2) and the social subsystem could be equipped with parallel, dual structures. To eliminate these dual structures and the opposition between a dilemma's poles, logistics organisations would have to find a way of reconciling the poles within one single organisational structure as offered for example in matrix or network structures (cp. Raisch, 2005). This design perspective is called 'synthesis' (Poole and Van de Ven, 1989). However, this approach with synthesised contradictory demands is even more challenging for employees.

The literature review in this section indicates that there is probably no 'one best way' for designing organisational structures of organisations implementing ALPs. Before a choice can be made, existing decision-making structures, processes, contextual factors and the skills of an organisation's human resources should be considered. The latter becomes even more important, when organisations have to cope with simultaneous opening and closing process of organisational boundaries in ALPs. In the next section, we discuss decision-premises for a boundary management in transport logistics organisations.

3 Decision-premises for a boundary management

Realisation of ALPs and a sustainable management in transport logistics requires organisations to reconsider their relationships to their organisational environments, to cooperate with competing organisations and to change decision-making structures. Particularly small and middle-sized organisations have to cooperate in ALPs if they want to profit from the economic and ecological benefits such as increased flexibility, capacity utilisation and decreased transport volume. Accordingly, ALPs can only be realised if organisations are able and willing to open their boundaries. As indicated in the introduction, opening organisational boundaries in selected aspects may require closing boundaries in other regards. The difficulty is that the notion of boundaries is paradoxical and their nature, shape, etc., is difficult to comprehend. Speaking of boundaries, we refer to a difference between distinct entities (cp. Derrida, 1982; Luhmann, 1998; Spencer-Brown, 1994). The objective of a boundary management or a boundary-sensitive management in the context of ALPs is to enable a logistics organisation's flexibility and adaptability to changing environments while at the same time ensuring its stability and robustness.

We refer to concepts of New Systems Theory (Luhmann, 1995) to outline several elements of a boundary management that is able to fulfil the task of making organisational boundaries more permeable without endangering the integrity of the organisation as a whole. New Systems Theory seems to offer an adequate understanding of organisational boundaries as it puts the issue of difference and thus the problem of boundaries, at the core of its notion of organisation. Organisations are understood as recursive networks of decisions, where every decision connects to previous decisions and functions as reference point for further ones. Concerning decisions, New Systems Theory refers to a particular form of distinction based on sense. It can be argued that organisations "come into being by permanently constructing and reconstructing themselves by means of using distinctions, which mark what is part of their realm and what not" (Seidl and Becker, 2006, p.9). Correspondingly, the problem of maintaining boundaries is directly linked to the self-reproduction of the organisation. If organisations are self-referential systems, boundaries have a recursive character with regard to the organisation's operations. Boundaries are the result of these operations, while at the same time functioning as determinants of further operations.

If we follow the assumption that the self-reproduction of an organisation is essentially a recursive process of reproducing its boundaries, boundary management implies finding ways to influence this process. We draw from Luhmann's reference to Herbert Simon's notion of decision premises, which Luhmann considers as 'forms of structuring decision-making contexts' (2002, p.45). According to New Systems Theory, the interior of organisational boundaries is articulated by decision premises like decision programmes, persons, communication channels (Luhmann, 2002) and organisational culture (Baecker, 2000). These decision premises determine which decisions are made in an organisation and thus structure the reproduction of the organisation as a recursive network of decisions. Correspondingly, the reconfiguration of organisational boundaries, that is, process of opening as well as closure of boundaries, has to be mediated through decision premises. Referring to these premises, we present some ways to open and close organisational boundaries (cp. Table 1).

Table 1 Decision premises and boundary strategies in ALPs

	Decision programmes	*Communication channels*	*Persons*	*Organisational culture*
Opening	Collective strategies	Decentralisation of social system	Qualification	Reflection
Closing	Fostering organisational identity	Management accounting adjusted to decentralisation	Identification	Culture development

3.1 Decision programmes

Decision programmes can be considered as basic decision premises (Luhmann, 2002). Mingers (2002) states that decision programmes are "what would usually be called procedures or plans – they specify how decisions should be made, […] or what goals should be pursued" (p.110). Decision programmes are adopted 'to provide guidelines for evaluating the correctness of decisions' (Luhmann, 2002, p.45). Strategies can be regarded as decision programmes, because they imply certain goals, ends, intents (Macmillan and Tampoe, 2000) or 'targets for where the organisation wants to be in

the future' (Segal-Horn, 2004, p.140). Strategies provide basic reference points for decision making processes in organisations, thereby determining their scope of operations. As organisations have to broaden this scope, if they intend cooperating with other organisations in ALPs collective strategies could proof more effective than individual organisational strategies. Following a collective strategy means to coordinate actions 'toward the achievement of ends shared by the members of interorganisational networks' (Astley and Fombrun, 1983, p.577). Collective strategies can help organisations to perceive that the simultaneous realisation of cooperative and competitive behaviour is for their own benefit. For example, in terms of sustainability, collective strategies could include common goals on how to protect and reproduce the resource base on which the continued existence of transport logistics organisations depends. Further collective strategies could deal with the objective to reduce side effects of the transport logistics business on natural and social environments – a task, which is far too demanding just for an individual organisation. ALPs could support these collective strategies by agents programmed in a way that, for example, environmentally friendly decisions are preferred. Thus, collective strategies in ALPs could change the understanding of logistics organisations for their environments; an organisation's long-term success may depend not only on its goal achievement but also on the existence of its competitors, natural and social environments.

From a systems perspective and from the perspective of the dilemma management described in the second chapter, opening organisational boundaries with the help of collective strategies requires counterbalancing closing mechanisms. In highly integrated logistics networks, individual organisations have to control for effects that could destabilise their identity. Collective strategies may not always allow evaluating which decisions are in an individual's organisations best interest. Hence, we propose fostering individual organisations' identities as a way of compensating for opening with the help of collective strategies. According to Albert and Whetten (1985), organisational identity expresses what is perceived as central, enduring and distinctive about an organisation's character. As such, organisational identity offers a general reference point for an organisation's operations in situations characterised as uncertain and contingent, for example, when simple decision programmes do not provide sufficient guidance. Hatch and Schultz (1997) emphasise that organisational identity is based upon meanings and symbols grounded in organisational culture. Correspondingly, all explicit efforts to foster a strong organisational identity also have to take into account this link to organisational culture.

Issues like formulating corporate visions and corporate mission statements are basic aspects of designing formal organisational identity. For a corporate mission statement to be effective, Mendenhall (2006) suggests that it should be 'audacious and bold in nature' and 'written simple enough so that anyone inside or outside the organisation can understand it'. For example, for a logistics organisation in ALPs a corporate mission statement could 'Become the best and most sustainable transport logistics organisation in the world'. Potential tensions between collective strategies and the measures to foster organisational identity have to be balanced within the dilemma management.

3.2 Communication channels

Another way of conditioning decisions within an organisation is through configuration of communication channels, which permit the 'circulation of information with a binding

impact on the system' (Luhmann, 2002, p.46). For ALPs, we have to differentiate again between communication channels in the social and the technical decision-making system. While it is obvious that communication channels in the technical decision-making system are decentralised and boundaries opened, it is interesting to explore the role of communication channels for boundary openings in the social system.

Communication channels based upon strong hierarchies usually correspond to organisational boundaries closed strongly. Boundaries can be opened through the delegation of decisions from higher levels of the organisational hierarchy to subordinated ones (cp. Picot et al., 1997; Ashkenas et al., 1995). This decentralised decision-making enables the organisation to process larger amounts of information and increase its capacity to absorb environmental complexity. Correspondingly, a certain degree of decentralisation of the decision-making structure could be considered a necessary prerequisite for successful implementation of ALPs. For a centralised organisation, the difficulty of delegating decisions to an autonomous technical system is that it has no experience in structuring local decision-making processes.

As indicated in the section on dilemma management, decentralisation can also have negative effects such as neglecting organisational goals. Measures to close boundaries can compensate for these effects. One important task is to find alternative ways to coordinate local operations toward organisational goals including environmental and social objectives. In this regard, management accounting adjusted to decentralised structures has an important function (cp. Picot et al., 1997). Management accounting informs local decision-makers on all levels of the organisation about goals and other decision-relevant aspects. This enables operating on the basis of implicit behavioural norms instead of explicit directives. Furthermore, management accounting has to visualise the degree of achieving objectives, specifically it provides the means for effective self-regulation of decision-makers, as well as a possibility for superior levels of the hierarchy to check the results of local decisions. Environmental Management Accounting (EMA), in particular, provides local decision-makers with information about the environmental aspects of an organisation's operations in physical as well as in monetary terms (cp. Bennett et al., 2003). It enables organisations to benefit from the enhanced information processing capability and increase the sensibility towards their environments. EMA can be considered as an important instrument in developing long-term strategies. As ALPs represent a particular form of decentralising decisions, it is necessary to integrate them into the corresponding accounting systems. Agent-based knowledge management systems supporting decision-making on the level of the technical system could be used to generate the basis for any information.

3.3 Persons

The comprehensive amount of the literature on 'boundary spanners' (synonyms: linking pins, gatekeepers, strategic planners or regulators (cp. Adams, 1976; Aldrich and Herker, 1977; Kiessling et al., 2004) indicates that management theory is aware of the relevance of persons (people, human resources) with regards to managing boundaries. Boundary spanners are defined as

> "persons who operate as exchange or linking agents at the periphery or boundary of the organization with elements outside it and who link two or more systems whose goals and expectations are likely partially conflicting." (Halley, 1997, p.153)

For this reason, tolerance for ambiguity can also be considered as an important skill of boundary spanners. Furthermore, boundary literature emphasises qualities like respectfulness, tolerance, reliability, honesty or sincerity (cp. Williams, 2002). Skills and abilities of boundary spanners can be improved with the help of specific qualifications, for example, in the areas of bargaining, influencing, negotiating and mediating.

Qualification seems especially important when considering that ALPs imply a delegation of decision-making processes to a technical system. In this case, traditional boundary roles concerned with the coordination of operational decisions in a logistics network change. In ALPs, contacts between people working on the operational level could become more important regarding the actual configuration of inter-organisational relations. These persons are perceived as the 'faces' of the organisations. Dembski and Timm (2005) compare the situation of a truck driver in today's centralised logistics systems and in tomorrows ALPs. Today, a truck driver follows instructions from the scheduler or logistics management with hardly any scope for own decisions. In the future, the situation could change in the way that the technical decision-making system supports the truck driver who then has to make final decisions on whether to accept or refuse an order (Dembski and Timm, 2005). Concerning increased capacity utilisation, the truck driver's capability to schedule the tour himself just based on technical support is important. This potential increase in responsibility has to go along with a corresponding qualification.

Lack of loyalty, outflow of knowledge (Ortmann and Sydow, 1999) and neglect of the organisation's interests could be the consequences of opening boundaries on the individual level. Therefore, boundary spanners have to identify with their logistic organisations. In addition to a differentiated system of incentives, personal identification with the organisation is one way to help boundary spanners closing organisational boundaries. This identification process can be supported by corporate mission statements: "When individuals internalise a sense of mission, it imbues them with meaning and that sense of meaning and purpose in turn triggers high levels of intrinsic motivation." (Mendenhall, 2006). Another prerequisite is transparency of an organisation's goals because this provides support for the decision-making of boundary spanners like the truck driver mentioned. In case that a logistics organisation wants to strive for sustainability, the subgoals of this objective should be explicated as detailed as possible. Furthermore, it is crucial that organisational culture reflects these goals and underlying values.

3.4 Organisational culture

Organisational culture can be defined as the "pattern of basic assumptions that a given group has invented, discovered or developed in learning to cope with its problems of external adaptation and internal integration" (Schein, 1984, p.3). It is implicit in all actions of the organisation's members. This general definition of organisational culture fits with New Systems Theory's notion that organisational culture functions as a decision premise. While it is readily comprehended that organisational culture has an important influence on the configuration of organisational boundaries, it is less obvious how organisational culture can be developed to support the regulation of boundaries. In the language of New Systems Theory, organisational culture is the only decision premise which cannot be decided upon (Baecker, 2000).

It can be assumed that strong organisational cultures (Deal and Kennedy, 1982) complicate opening process in ALPs as this could make organisation stick to traditional patterns of perception and problem solving (Schreyögg, 1989). Even if we assume that changes in organisational culture have to be understood as evolutionary processes, a fundamental condition to influence these processes is a proper reflection of organisational culture and its impact on the organisation's operations. This reflection, optimally taking place at all levels of the organisation, can be considered as a process of opening organisational boundaries revealing the contingency of traditional patterns within the organisation. Understanding this contingency implies the insight that things could be handled in a different way. Fundamental convictions like the refusal to cooperate with competitors can suddenly be questioned. While this understanding of contingency is the first step of absorbing more environmental complexity, it has the potential to erode the foundations of the organisation's operations. This can be avoided by defining a general direction for culture development, which has to be guided by appropriate measures like corresponding human resource policies.

A broad reflection of organisational culture gives important hints with regards to the benefits and limits of ALPs. On the basis of this reflection it is possible to assess necessary changes or even to acknowledge that ALPs may not be a viable strategy for the particular organisation. Changes in organisational culture should be used to foster cooperative relationships with other organisations and to minimise opportunistic behaviour between partners. For transport logistics organisations striving for sustainability, organisational culture could be an important way of keeping the idea of sustainability alive.

We have argued that boundary management is essential in the context of ALPs and thus a prerequisite for benefiting from their positive environmental effects. However, boundaries also determine the way organisations perceive and act towards their environments. Accordingly, boundary management should be considered as an important element of a general sustainable management approach. But, it should be emphasised that, due to the aforementioned characteristics of boundaries, there are no blueprints for managing boundaries. Decision programmes, communication channels, personnel and organisational culture seem to be essential factors for the configuration of boundaries. Yet, their meaning may vary in different organisational contexts. Accordingly, each organisation has to find its own particular way of dealing with the problem of opening and closing boundaries.

4 Conclusions

This paper discusses the consequences of an emerging innovation for transport logistics (ALPs), which is based on the paradigm of self-organisation. ALPs are a new possibility to foster sustainability in transport logistics and to reduce some of today's environmental hazards for example, by increased capacity utilisation. In this paper, we propose first approaches towards a sustainable management framework, including a management of dilemmas and boundaries. We describe potential benefits and challenges that can be expected from this new technology for logistics management, for human resources and for participating logistics partners.

In terms of sustainability, it seems important that transport logistics organisations unfold the contradictory relationship of 'efficiency versus sustainability' to their

employees and partners and that they debate openly potential coping strategies. Dilemmas in ALPs can be reconciled with the help of temporal, spatial and spherical separation or with a mixed strategy. Temporal separation of the dilemma of central versus autonomous control has been the strategy of many highly centralised logistics organisations. However, today these organisations feel the pressure to decentralise. One of our insights is that we do not recommend continuing with the strategy of temporal separation by implementing highly decentralised processes and structures only. A more realistic solution strives for a balance in central and autonomous control in the technical and social decision-making systems. Spatial or spherical separations are more appropriate strategies to cope effectively with the dilemma of central versus autonomous control. These strategies balance the downsides of temporal separation. However, requirements concerning employee's social skills and tolerance for ambiguity are high. Further research on dilemmas could explore more intensively the relationship of dilemmas and boundaries and the role of human resources. While dilemmas have been analysed in the literature and in this paper from an individual or organisational perspective, it remains unclear how dilemmas affect inter-organisational relationships. We sense that dilemmas have to be reconciled additionally on an inter-organisational level, which could be particularly true for the dilemma of efficiency and sustainability.

We have also emphasised that managing boundaries is an important task if ALPs and sustainability should be successfully implemented and sustained in logistics networks. Increased decentralisation and sustainability both require a boundary management which – as we have shown – is not a trivial task. A first step towards the management of boundaries is raising the awareness for the importance of boundaries in organisations. Subsequently, it is necessary to find appropriate ways of regulating boundaries. We have argued that decision programmes, personnel, communication channels and organisational culture are important decision premises and thus have to be the starting points for the management of boundaries. Finally, we emphasise that a boundary management is not only a supportive function for the implementation of a sustainable technology. We suggest conceiving of it as an essential element of a sustainable management to configure organisation-environment-relations in a sustainable way.

Future research on boundaries should find out more about the role of trust for ALPs within and across organisational boundaries as a balance of trust and control forms the basic requirement for logistics competitors to cooperate in ALPs and to search for more sustainable solutions for transport logistics. Additionally, in future research the focus on the social aspect of managing dilemmas, boundaries and sustainability in ALPs should be explored. More emphasis has to be given to the role of the participating actors, managers and employees from cooperating logistics organisations. A management of participation can complement the dilemma and boundary managements suggested and thus add to the Sustainable Management framework for transport logistics organisations.

Logistics organisations today feel the pressure to secure their existence in tough competition and in a world with finite resources. In the future, ALPs may offer a partial solution to this problem challenging the relationships of organisations and their economic, natural and social environments.

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