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Strategic adaptivity in global supply chains—Competitive advantage by autonomous cooperation ☆

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Abstract

Global supply chains (GSCs) are confronted with the phenomenon of hyper-competition. For this reason there seems to be an increasing necessity for GSCs to build up competitive advantage in order to survive. Strategic flexibility is assumed to have positive effects on generating required competitive advantage by replicating and reconfiguring competences to manage GSCs, while keeping GSCs stable. Autonomous cooperation and control (ACC) as a management approach may contribute to achieving flexibility in GSCs. Therefore, this paper intends to discuss possible contributions of ACC to creating flexibility and in turn to generating competitive advantage in GSCs.

Keywords: Global supply chains; Competitive advantage; Strategic adaptivity; Competences; Autonomous cooperation and control

1. Introduction

Hyper-linking, hyper-competition, and hyper-turbulence are typical phenomena of ''real-time-economies'' in a world of diversity and change (Tapscott, 1999; Siegele, 2002). These developments have gained more and more popularity in current publications. They indicate the escalating challenges of modern management (D'Aveni and Gunther, 1994; D'Aveni, 1998; Xiao Li and Chuang, 2001; Monge, 1995). Companies no longer have to focus only on managing their original—internal and linear—supply chains (SCs), but are also confronted with multiple demands articulated by worldwide stake and resource holders (Müller-Christ and Hülsmann, 2003) as well as global structures and processes of supply, production, and distribution. These multiple and global demands result among others from the fact that companies have become inter- and multinational players, characterized by e.g. international manufacturing plants, purchasing and sales on global markets, multinational staffed executive boards, and multicultural personnel

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(Hülsmann and Berry, 2004). In consequence, companies are embedded in the more complex and dynamic organization of International Supply Networks (ISNs), which can be described as an assembly of certain logistics systems (Sydow, 2002), alternatively SC webs, which are worldwide interlinked with each other. This means single firms are involved in different global supply chains (GSCs) (Yee et al., 2006) building up networks, and such SC networks again compete among each other on the global market (Seebauer, 2003; Lambert et al., 1998). From such a perspective logistics management has to cope with an increasing complexity and dynamics regarding its systemic structures, as well as its processes and its coordination (Hülsmann and Berry, 2004).

To cope with the current and possibly increasing future demands for GSCs embedded in the structures of a certain ISN, flexibility is needed from the perspective of every company. Flexibility could be seen as an instrument which enables organizations to handle complexity and dynamics, related to their planning and process of strategy building. Therefore, the overarching hypothesis states that flexibility decisively contributes to the generation of competitive advantages. It is expected that competitive advantages increase capabilities of reconfiguration and replication in logistic structures. The necessary flexibility may be achieved externally or internally. The focus could be on external factors such as suppliers (e.g. service quality) or internal ones such as manufacturing flexibility (e.g. technological innovations) in GSCs.

Consequently, the question occurs how flexibility could be created in GSCs. One possible solution could be the concept of autonomous cooperation, which will be presented in this paper. The origins and the idea of this management approach will be introduced, which "deals with the explanation of the autonomous creation of ordered structures in open, interacting, non-deterministic, dynamic–complex systems" (Hülsmann and Wycisk, 2005a).

Therefore, the concept of autonomous cooperation has to be critically discussed as to how far it might contribute to the realization of flexibility and correspondingly to achieving competitive advantage in GSCs. On the one hand, autonomous cooperation might optimize local actions, which result in competitive advantages. Actors in GSCs become more stable, because increasing system robustness is expected through autonomous cooperation. On the other hand, positive emergence of autonomous cooperation might contribute to more logistic efficiency and capabilities in GSCs. Thus, the range of strategic flexibility in a given structure of GSCs is broader than before. In this way it will be analyzed if autonomous cooperation could be transferred to the GSCs of ISNs in general. Thus, it will be questioned how the approach contributes to a flexibilization of GSCs. Finally, it will be examined in how far competitive advantages can be generated for the involved companies.

The paper is divided into four main parts. In the first part, the comprehension of GSCs and the challenges the involved actors are confronted with will be shown and the need of achieving competitive advantages in GSCs. In the second part, the focus will be on the role of flexibility of systems. Here, the requirement for global logistics management to be able to adopt the GSCs to internal necessities and external demands—in regard to the realization of competitive advantages—will be pointed out. This need for adaptivity as the ability to balance stability and flexibility is discussed on the background of the social systems theory. Both parts the first and the second one reflect on certain aspects of complexity theory as well as of the competence-based view. In the third part, autonomous cooperation and control (ACC) as a management concept based on the idea of self-organization will be introduced and its major characteristics will be explained. In the fourth part, several contributions of ACCs to the adaptivity of GSCs and consequently to the realization of competitive advantages in such global and interlinked structures of supply processes in ISNs will be analyzed on the background of the theoretical frameworks given before. The paper ends with conclusions and implications for further research.

2. Need of competitive advantage in GSCs

One phenomenon mentioned above in the global economy today is the so-called hyper-competition (D'Aveni, 1995; Thomas, 1996). Hyper-competition describes a condition under which businesses move fast to compete in the fields of price–quality positioning, creation of new knowledge, protection as well as penetration of markets and formation of alliances (Wiggins and Ruefli, 2002). Under hyper-competition, established rules are repeatedly challenged, industry boundaries become increasingly ambiguous, and customer loyalty is difficult to maintain. In other words, fast changes in the environment (e.g. development in technology) force

businesses to move rapidly and aggressively in order to build new advantage, while undermining the advantage of their competitors (Wiggins and Ruefli, 2002).

Embodied in specific capabilities or resources, competitive advantage is necessary for businesses to achieve relatively higher performance than that of their competitors (Wiggins and Ruefli, 2002; Lalwani et al., 2007). Its necessity can be explained from a social systems view (Parsons, 1961; Scott, 2002; Checkland, 1981). In order to survive, an organization has to constantly adapt to changing and diverse environmental conditions in order to obtain necessary resources (e.g. information) and opportunities (e.g. consumer demand) (Hicks and Gullett, 1975). But the supply of environment is limited (Sanchez and Heene, 1997), as reflected in aspects like limited natural resources and consumer purchasing power. Better performance than its competitors through competitive advantage would help an organization to secure needed resources and opportunities by better satisfying the requirements of its environment. However, under hyper-competition sustainable competitive advantage is hard to achieve (Piplani et al., 2007) due to fast-moving action on the part of competitors (e.g. producing new generations of products, increased service level) (Williams, 1992). Instead, businesses continually try to develop a series of temporary advantage so as to guarantee the continual inflow of necessary resources.

Under competitive pressure, individual businesses often seek cooperation with members of their respective SCs, wishing to leverage each other's resources (Geoffrion and Powers, 1995). As the organizations involved have the common goal of providing value-added products or services, an SC can be regarded as one single organization, which competes with other SCs (Lambert and Cooper, 2000). Consequently, every SC strives for competitive advantage over other SCs. The removal of trade barriers and technological progress in transport as well as telecommunication allows many SCs to expand beyond their national borders, to enter new markets, and to locate business processes in different countries (Schary and Skjøtt-Larsen, 2001). Under such conditions, the activities, processes, and structures of a number of organizations are interwoven worldwide, and management has to deal with the multiple interrelations between actors situated in different economic, political, and social environments. Thus, SCs with global characteristics (i.e. worldwide inter-linking) can be defined as GSCs, whose significance is recognized by more and more businesses, such as GE, Dell, Philips, etc. (Engardio et al., 2003).

However, the satisfactory performance of GSCs is often impeded by the increasing complexity and dynamics resulting from hyper-competition. From a social systems perspective, complexity is based on the number and variety of a system's elements as well as of relations between the elements. (Patzak, 1982; Cilliers, 1998). As a result of hyper-competition, an SC may be forced to explore foreign markets and confront new competitors around the world. Compared with domestic SCs, additional factors like international differences in demand patterns, different cultures, distinctive local institutions, as well as interactions between them and the GSC represent even more elements and relations. Dynamics describe the variation of a system's state over time (Coyle, 1977). For a GSC, due to the multiple systemic linkages as well as temporal changes, dynamics of the surrounding systems (e.g. rapid changes in competitors' strategies, fluctuating exchange rates, changing local policies) have an impact on the dynamics in logistics processes (e.g. a change in demand due to a fluctuation of the exchange rate leads to the oscillation in inventory) (Hülsmann and Grapp, 2005). The increasing complexity and dynamics imply an immense exchange of data between the GSC and its environment as well as within itself in a short time period. Consequently, there is a higher risk of delayed response to changing demands of the environment and of an information overload for decision-making (i.e. "bounded rationality" to quote Simon, 1957) for the management of GSCs than for that of domestic SCs.

Challenges of increasing complexity and dynamics for GSCs can be observed, for example, in the case of Wal-Mart's failure in Germany. When competing on the global market, Wal-Mart tried to implement its successful US-American business model in other countries. However, this business model failed to work in Germany, as Wal-Mart could not understand the complex business and social environment in Germany, namely the prevalence of discount stores with low profit margins and the power of trade unions (Knorr and Arndt, 2003). After a decade-long struggle for the market, Wal-Mart finally sold its 85 stores in Germany to its rival Metro AG (NBC News, 2006). As a global player, Wal-Mart has extended its SC to many other

countries: but during this process it is not in a position to deal with the complexity and dynamics on all local markets efficiently and thus lags behind its competitors. So what does it need?

In such situations, GSCs need competitive advantage in order to deal with complexity and dynamics more efficiently, and therefore to better adapt to the global environment than competitors. However, which capabilities are needed to achieve competitive advantage in the context of GSCs?

3. Need of adaptivity to gain competitive advantage

Possible means for gaining competitive advantage might be strategic adaptivity. Strategic adaptivity means the ability of an organization to define possible scenarios, develop different approaches to handle each scenario, and take a timely and appropriate approach when a certain scenario occurs (MacMillan and Tampoe, 2000). The emphasis on adaptivity results from the fact that strategic planning fails to work in face of "conflicts of interest or lack of time, information or analytical capability", which reflects the unintended and emergent nature of strategy (Genus, 1995). Strategic adaptivity helps to keep a balance between strategic flexibility and stability (in the following for simplicity referred to as flexibility and stability, respectively). From a social systems perspective, flexibility refers to the ability of the system structure to change (Hülsmann and Wycisk, 2005b; Garavelli, 2003). These changes are enabled by boundary openness of the system (Garavelli, 2003), so that necessary resources can flow in and opportunities can be grasped (Hicks and Gullett, 1975). During this process, the system absorbs a part of the complexity of the environment (i.e. information). Stability refers to the system's ability to keep the information inflow at a manageable level. This means, by ensuring a certain level of closure the system selectively takes only information which is necessary (Luhmann, 1973, 1994).

From a competence-based view, the generation of competitive advantage is based upon unique, valuable, inimitable, and non-substitutable competences (Sanchez and Heene, 2004; Hitt et al., 1998). Therefore, it is desirable for a system to consolidate, develop, and regenerate competences, creating a wide competence spectrum and ensuring a continuous internal readiness for change (Teece et al., 1997). Flexibility contributes to creating competitive advantage just through processes of retaining, developing, and regenerating competences. Two commonly recognized dimensions of flexibility are range of alternatives and response to changes by adopting alternatives. The former counts the number of options, while the latter measures the reaction time (Burmann, 2005). Therefore, it can be stated that an increased number of options as well as shortened time needed for response lead to a higher level of flexibility. These two dimensions of flexibility indicate the abilities of an organization to replicate and to reconfigure its processes and competences (Teece et al., 1997). The ability of replication makes it possible for the organization to multiply existing processes by standardization.

In the context of GSCs, an example can be that the effective communication process via a certain software between two members is adopted by all other members: this can ensure the stable and timely transfer of data throughout the whole chain. On the one hand, this ability of replication enables a fast and efficient growth of the GSC by avoiding waste of money and time on exploring new means for development (Teece et al., 1997). On the other hand, it stimulates the members' understanding of existing competences regarding structures and functions through expanding competences to a large number of elements (e.g. people, functional elements) (Burmann, 2005). In this sense, replication retains existing profitable competences, which are in turn prerequisites for identifying, assimilating, and applying useful external information to generate new competences (Cohen and Levinthal, 1990). The ability of reconfiguration enables an organization to transform the structure of its resources and thus its competences (Teece et al., 1997). This ability enables an organization to develop and generate new competences: one way is to recombine the know-how existing in the organization (e.g. the combination of competences in fast distribution and lean production) and the other is to absorb new knowledge from the environment (e.g. developing innovation competence by recruiting talents) (Burmann, 2005). The new knowledge resulting from both ways can widen choices for coping with changes in the environment and competition. An example in the context of GSCs can be as this: a GSC delivering cell phones can either shorten the delivery time to local customers, or develop a new product better fitting the local cultural preference (e.g. shape and color), or use the combination of both to compete with a rival who introduces a cell phone with popular technical features. Replication and reconfiguration are interdependent with regard

to the creation of flexibility. On the one hand, a large variety of options but slow reaction gives competitors chances to take away resources and opportunities which are important for the operation of the system (Burmann, 2005). Besides, it can happen that the newly developed strategic option is again unable to meet the requirements of the environment, which meanwhile may have been changed. On the other hand, though standardization of processes and products through replication can enhance GSCs' response to changes in the environment, it can weaken the system's ability to address variety in consumer preferences (Burmann, 2005). As a consequence, flexibility featured by a high level of both replication and reconfiguration abilities can contribute to the creation of competitive advantage.

To adapt to the environment, a GSC does not absorb the entire complexity of the environment but only a portion of it. For example, a GSC will seldom try to satisfy all demands from various market segments located in different countries by aligning a too large number of businesses. Instead, it will selectively serve certain segments by forming close cooperation between a reasonable number of businesses. Such sustainment of a relatively stable number and intensity of interrelations between the GSC and its environment can be described as setting a border around the GSC system. This process describes the system closure from a social systems perspective (Hicks and Gullett, 1975). As a GSC's border can become more permeable with an increasing degree of flexibility and the sudden flooding of information may confuse the established relations, the identity of the GSC can be threatened (Hülsmann and Grapp, 2005) and the original GSC may no longer exist. Therefore, stability is a constitutive part of strategic adaptivity and is necessary for the system's survival in the long-run (Maturana and Varala, 1987). Stability allows competences to be embedded in the GSC, which constitutes the basis for development of existing competences and regeneration of new competences. Consequently, stability is a prerequisite for gaining competitive advantage.

An example of strategic adaptivity can be seen in the GSC of Hewlett-Packard (HP), a powerful global player despite ups and downs common to all businesses (e.g. IBM, GM). Over the decades, its core products have been shifted from digital controllers to calculators to personal computers and to printers, which are delivered to customers in different countries. Its competitiveness may be attributed to its competence of innovation and the readiness of its workforce for changes (MacMillan and Tampoe, 2000). Here the competence of innovation is stable and rooted in the GSC of HP, and this competence enables the GSC of HP to adapt its products and respond to the changing consumer needs in time.

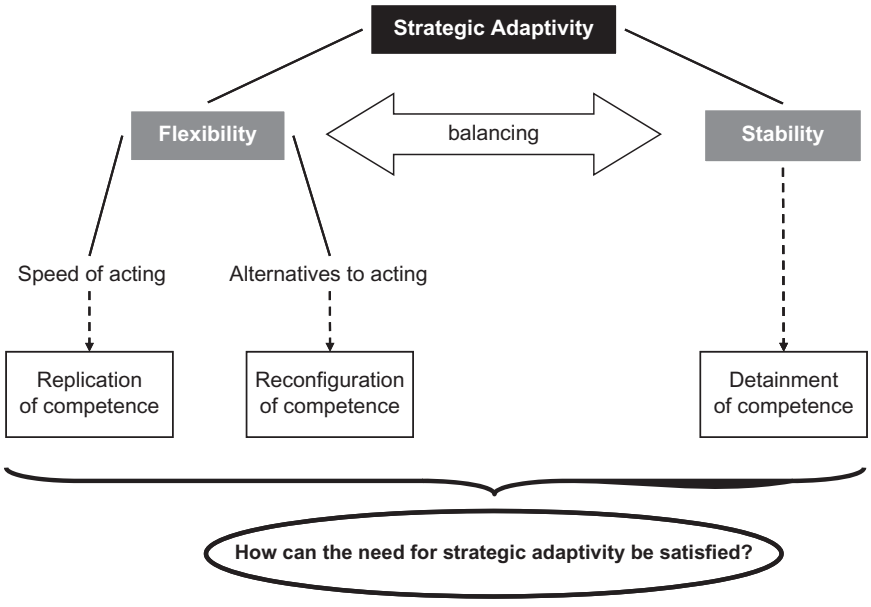

Fig. 1. Strategic adaptivity.

However, how can this deduced need for strategic adaptivity emphasizing both flexibility and stability (see Fig. 1) be satisfied? It has to be examined whether there are appropriate management approaches to gain strategic adaptivity in GSCs.

4. Autonomous cooperation and control as a management approach in global supply chains

A management approach being discussed in management science is ACC. It "describes processes of decentralized decision-making in heterarchical structures. It presumes interacting elements in non-deterministic systems, which possess the capability and possibility to render decisions independently". Its objective "is the achievement of increased robustness and positive emergence of the total system due to distributed and flexible coping with dynamics and complexity" (Windt and Hülsmann, 2007). The concept of ACC comes from complexity science, which deals with open, dynamic, and complex systems (Hülsmann and Wycisk, 2005a). The idea of autonomous cooperation is based on the idea of self-organization, which origins from different disciplines (e.g. cybernetics (Foerster, 1960), chemistry (Prigogine and Glansdorff, 1971), physics (Haken, 1973), biology (Maturana and Varala, 1980), and mathematics (Peitgen and Richter, 1986). The focus of the study of ACC is the autonomous evolution of ordered structures in complex systems.

In order to gain its exact understanding, ACC should be differentiated from similar concepts "self-management" and "self-organization". Among these three concepts, "self-management" is the broadest, describing the ability of a system to set its own goals, to autonomously choose its own strategies as well as its organizational structure, and to obtain the necessary resources on its own (Manz and Sims, 1980). "Self-organization" describes the way of autonomous formation of system structures and processes (Bea and Göbel, 1999; Probst, 1987; Prigogine and Stengers, 1984; Heylighen, 1989). ACC has the narrowest meaning, depicting only processes of decentralized decision-making in the heterarchical structure (Windt and Hülsmann, 2007).

ACC has five constitutive characteristics, namely autonomy, decentralized decision-making, interaction, heterarchy, and non-determinism, which can take various degrees (i.e. a point in a continuum with two extreme values: 0% and 100%) on various levels of logistics systems, i.e. decision system (management), information system (information and communication), and execution system (material and goods flow) (Hülsmann and Grapp, 2006; Ropohl, 1979).

To illustrate the idea of ACC, Fig. 2 visualizes the degree of ACC based on its different characteristics (C1–C5). On a scale from 0% to 100%, a higher percentage indicates a relatively higher level of ACC, and a lower percentage indication stands for a relatively higher level of external coordination in logistic processes. This implies the possibility of a comparison of different logistic processes and levels of logistic systems regarding their individual degrees of ACC. The closed colored areas depict the aggregated degree of ACC of each level in a logistic system (L1–L3) (Hülsmann and Grapp, 2006).

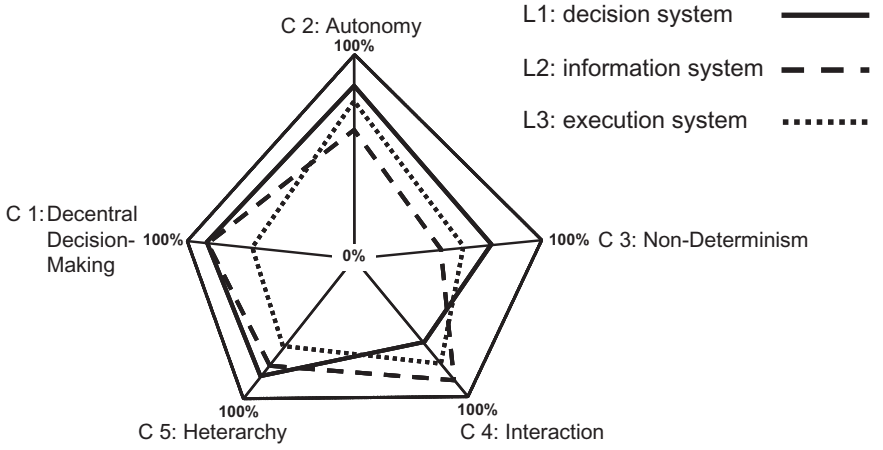

Fig. 2. Constitutive characteristics and degree of ACC.

Autonomy is the first constitutive characteristic of a system. It implies the ability of self-formation, self-control, and self-development. This means, the decisions, relations, and interactions of the elements are independent from the external forces and therefore operationally closed (Probst, 1987). Autonomy is realized through processes of delegation and decentralization (Kappler, 1992). Delegation empowers the elements to make independent decisions at the operational level and thus to partially react to changing environmental demands (Mullins, 2005). Through processes of decentralization, the internal complexity of a company as well as the external complexity can be distributed among its diverse elements. As a result, complexity for management can be quantitatively reduced (Hülsmann and Wycisk, 2005a; Hülsmann and Grapp, 2005). In the context of GSCs, autonomy for personnel means having more power for decision-making. For non-living items, the intelligence enabling autonomous decision-making is endowed by modern information and communication technologies such as radio frequency identification (RFID). However, autonomy in GSCs is relative (Probst, 1987; Varela, 1979), because it is constrained by GSC's objectives, which generally speaking are to maximize the added value observed by final customers (Porter, 1998). When the autonomous decision-making of subsystems results in deviating GSC performance from the desired objective, the management will withdraw this power or the GSC may stop functioning.

The second constitutive characteristic of ACC is *decentralized decision-making*. According to geographic interpretation, a decentralized social system is a system whose subsystems are spatially distributed (Windt and Hülsmann, 2007; Harlegard, 1971), e.g. globally located production sites. According to the interpretation in terms of assigning tasks to various positions, decentralization means to separate tasks of the same nature (Kosiol, 1962). As for decision-making, decentralization refers to the "vertical delegation" of decision-making competences (Hitt et al., 2005), that is, the decision-making competences are shifted from a higher hierarchical level to lower ones in certain contexts. An example in GSCs can be as follows: the decision-making competence is transferred from the headquarters of a global company to its multiple production sites, which further participate in deciding distribution channels for their products delivered to local customers.

Interaction is the third constitutive characteristic of ACC. Under ACC, relevant information for decision-making is exchanged among elements of a system instead of being passed on from the central control unit (i.e. top management). The aim of such interaction processes is to shorten the transfer time of information by connecting directly the demand and the supply side of information without having to go through the central control unit. Nevertheless, fast transfer of information has to be preceded by implementation of advanced communication technology such as Bluetooth (Scholz-Reiter et al., 2005). An example of interaction in GSCs can be the reallocation of retail inventories on different national markets. Instead of being transported back to the manufacturer (e.g. extra inventories from Singapore to US) and then be reallocated (e.g. from US to China), inventories can realize a more efficient and effective flow among retailers through direct communication (inventories being shifted directly from Singapore to China).

The fourth constitutive characteristic of ACC is *heterarchy*, meaning that elements of a system possess a similar degree of influence on the system development. With the increase in the degree of heterarchy, the demand for knowledge and capabilities decreases, since the tasks to be completed are less complex on lower levels. The aim of heterarchy is to achieve redundancy. As every element of the system is equipped with the same assets and abilities due to a high degree of interaction (e.g. job rotation), any one element can undertake the functions of another (Mullins, 2005). An example in GSCs is that other production bases can help to manufacture products of the same specification and quality once unexpected happenings (e.g. strikes) hinder production of a certain production base within a GSC.

Non-determinism is the fifth constitutive characteristic of ACC. Non-deterministic behavior of a system results in various possible states of a system, where unforeseen changes of the system structure occur (Haken, 1983). Here, neither the moment nor the selection of a certain development path can be predicted, despite exact measuring of system states and rich knowledge in operating rules of the system (Prigogine and Glansdorff, 1971; Prigogine, 1996). Though ACC predetermines the rules of decision-making for elements and outlines the desired state of the system by setting common goals for system elements, the way elements can achieve the objective is not stipulated. As a result, the system's behavior

cannot be causally predicted and thus can be considered as non-deterministic. For GSCs, it can be the case that a retailer has different strategies to cope with decrease in consumer demand (e.g. promotion, advertising according to preferences of local customers) or the sourcing unit of the manufacturer has several schemes for choosing suppliers (e.g. all supplies from one supplier or from several suppliers).

The expected consequences of implementing ACC in GSCs are autonomous formation of order (McKelvey, 2004), which leads to robustness and positive emergences of a system (Windt and Hülsmann, 2007). Robustness means the ability of a system to resist external disturbances and restore its normal functions. In the context of GSCs, robustness can be a GSC's ability to cope with volatile market demands. Positive emergences refer to the new qualitative characteristics of a system, which enables a better fit of the system and its environment (Haken, 1993). Positive emergences are not attributed to individual system components, but are results of synergetic effects of the interacting elements (Hülsmann and Wycisk, 2005a). In the context of GSCs, positive emergence can be the high speed in offering service, which depends on the close cooperation between distributors and producers with the help of advanced communication and information systems.

If ACC as a management approach can be applied to GSCs, what are its contributions to the creation of adaptivity and competitive advantage?

5. Contributions of autonomous cooperation and control to the creation of adaptivity and competitive advantage in global supply chains

In the following, ACC's contributions to adaptivity and consequently to competitive advantage will be analyzed by linking its individual constitutive characteristics with flexibility and stability. At the same time, its negative impacts upon competitive advantage will also be discussed.

On the one hand, ACC leads to a higher level of flexibility of GSCs through stimulating competence replication. *Autonomy* allows shifting complexity of a GSC to its subsystems and elements so that complexity is reduced to partial complexity (Hülsmann and Grapp, 2005). The quantitative level of complexity decreases for the management, which now only needs to establish guiding policy, encourage the creativity of local elements (Forrester, 1958), and design basic competences for the future development of local elements (Sanchez, 1997). For subsystems and elements, a smaller environment suggests the handling of fewer changes with less coordination efforts (Hülsmann and Grapp, 2005). With *decentralized decision-making*, the spatial proximity of elements (e.g. local production bases, R&D centres) leads to fast responses to a changing environment, because the time needed for generating decisions becomes shorter with the availability of relevant information (Hülsmann and Wycisk, 2005a). However, the timely generation and implementation of decisions are preconditioned by the necessary competences, e.g. competence in extracting useful information available to the GSC elements, which are gained through *interaction*. As in an autonomously cooperating GSC relevant information is exchanged between elements instead of being passed from management to local elements, there tends to be a higher degree of *interaction* between these elements (e.g. data transfer among different warehouses) (Laux and Liermann, 1993). With *heterarchical structure*, different elements get easy access to knowledge and competence of each other. To support its elements to solve problems, management may arrange transparency regarding the existing pool of competences (e.g. by encouraging personnel exchange among local elements). Thereby, elements can further develop these competences locally and make use of them. With competences being replicated at local elements (e.g. highly reliable product design, user-friendly design), bottlenecks of operation can be overcome (e.g. understanding between different SC stages), compatibility can be achieved (e.g. application of new technology), and a unified image of the GSC can be established (e.g. innovativeness concerning design and distribution). Consequently, this process of competence replication can lead to a higher level of flexibility. From the competence-based view, such a process may lead to synergetic effects within the GSC and enable the GSC as a whole to react faster to the changing environment than its competitors (Sanchez and Heene, 2004). As a consequence, competitive advantage is realized.

On the other hand, ACC leads to a higher level of flexibility of GSCs through encouraging competence reconfiguration. Because of a more detailed overview concerning relevant information (e.g. exchange rates, local policies, transportation infrastructure) for a specific task and the basic competences enabled by the *heterarchical* structure, GSC ele-

ments can identify more clearly the gap between their current competences and the expectation of the environment. Consequently, endowed with *autonomy*, they are able to reconfigure various patterns of competences, which allow better adaptation to their environment and *decide independently* which competences should be used in face of concrete situations. *Non-deterministic* array of actions encourage new ways to solve problems in trial and error processes (Hülsmann and Wycisk, 2005a). On the one hand, GSC elements can retain effective competences through these processes (Wolf, 2003). Besides, due to the context-specificities (e.g. local communication infrastructure, cultural preference), GSC elements have to absorb external information and combine it with existing competences to cope with certain tasks (Macharzina, 2003). Meanwhile, through the *interaction*, a GSC element can get access to competences of other elements, which can be developed into new competences when combining with existing competences of this element. Consequently, this process of reconfiguring competences may contribute to achieving more flexibility in GSCs. From the competence-based view, this process keeps building new competences within the GSC, which is likely to have more alternatives to meet the challenges of the environment than its competitors. In this way, competitive advantage can be achieved.

As shown above, by implementing ACC the flexibility of GSCs may be enhanced with processes of competence replication and reconfiguration. Flexibility then facilitates the development and application of competences from the common pool by GSC elements. These processes are described by Sanchez and Heene (2004) as processes of competence building, leveraging, and maintaining. A cumulative large variety of competences open to all subsystems increase the possibility of effective and rapid response to the changing environment with existing knowledge or with the ability to increase necessary knowledge. They assist the GSC in obtaining limited resources and opportunities ahead of its competitors, who are still striving to develop comparable competences (Teece et al., 1997). In GSCs, some competences can be understood as customer-tailored designing regarding products (e.g. cultural preferences of shape, color) and services (e.g. lead time). As such competences are created and shared by elements of whole GSCs, the aggregated effect like customized products, short delivery time, and high service level raises the perceived value of goods by customers on different local markets. Thereby, consumers prefer these GSCs' goods to those of other GSCs. This continuous process of diffusing competences and stimulating new competence building leads to better performance of the GSC and therefore competitive advantage.

In addition, ACC helps to strike a balance between flexibility and stability required by GSCs. With increasing flexibility, a GSC's border becomes permeable as a result of a large number of dynamic relations with the environment (e.g. different suppliers at different time points who can supply products to competing GSCs). This represents a big challenge for the traditional centralized form of management, which is subject to bounded rationality (Simon, 1957) and easily gets lost in a mass of information. Inappropriate decisions can lead to chaos in the GSC and consequently the GSC can lose its stability. ACC has the potential to weaken its negative influence (Hülsmann and Wycisk, 2005b). The reason is that the distributed handling dynamics and complexity under ACC provides the opportunity to form system-stabilizing competence patterns (Windt and Hülsmann, 2007). *Autonomy* and *decentralized* decision implies fast response of a GSC element to the external disturbance, and its competences to solve problems enabled by *heterarchy* and *interaction* prevents the disturbance spreading to other elements and the whole GSC. With a combination of flexibility and stability resulting from the implementation of ACC, the GSC is in a position to address the changing demands of the customers and other social groups (e.g. government concerning laws and regulations) ahead of competitors without losing its identity. Consequently, competitive advantage of the GSC can be secured by keeping both flexibility and stability to a reasonable extent.

Nevertheless, there can be negative impacts upon GSCs performance, and thus competitive advantage (Hülsmann and Grapp, 2005). The increased degree of flexibility implies an asymmetrical distribution of information between the management and GSC elements. The lack of detailed information on individual processes and the unpredictability of GSC behavior implied by non-determinism can result in the management's inability to effectively regulate its elements (Hülsmann and Wycisk, 2005a; Bruns-Vietor, 2004). Consequently, subsystems may misuse autonomy and take actions fitting their own needs but incompatible with environmental

requirements. On the other hand, processes of decentralization may lead to egoism of GSC elements, which focus only on their own systems' borders and lose the view of the whole GSC. Such egoism can endanger the GSC's stability by diminishing its identity. Besides, to give non-living elements autonomy and making them intelligent requires a high investment in technology. As the concept of ACC is still in its developing phase, the lack of empirical proof of its effects on creating competitive advantage can result in unwillingness of GSC members to invest in expensive technologies. Therefore, opportunism of GSC elements and decreased controllability can deviate GSCs from the desired state, while a financial investment in technology can negatively influence the GSCs' efficiency.

It can be concluded from the above discussion that ACC in general leads to adaptivity and consequently competitive advantage of GSCs, which implies the ability and readiness of the GSC elements to timely and effectively deal with external complexity and dynamics featuring the phenomenon of hyper-competition (Teece et al., 1997) (Fig. 3).

6. Conclusions and outlook

In this paper, the contribution of ACC to adaptivity and competitive advantage of GSCs is analyzed through linking the five constitutive characteristics of ACC to competence replication, reconfiguration, and detainment from a competence-based view (Sanchez and Heene, 2004). By striking a balance between flexibility and stability (Hülsmann and Wycisk, 2005b), ACC helps GSCs to respond timely and effectively to the complex and changing environment, while keeping their key identity. With an increasingly enlarged competence spectrum available to all members, GSCs implementing ACC can obtain competitive advantage, which puts them in a better position to secure necessary but limited resources for their long-term

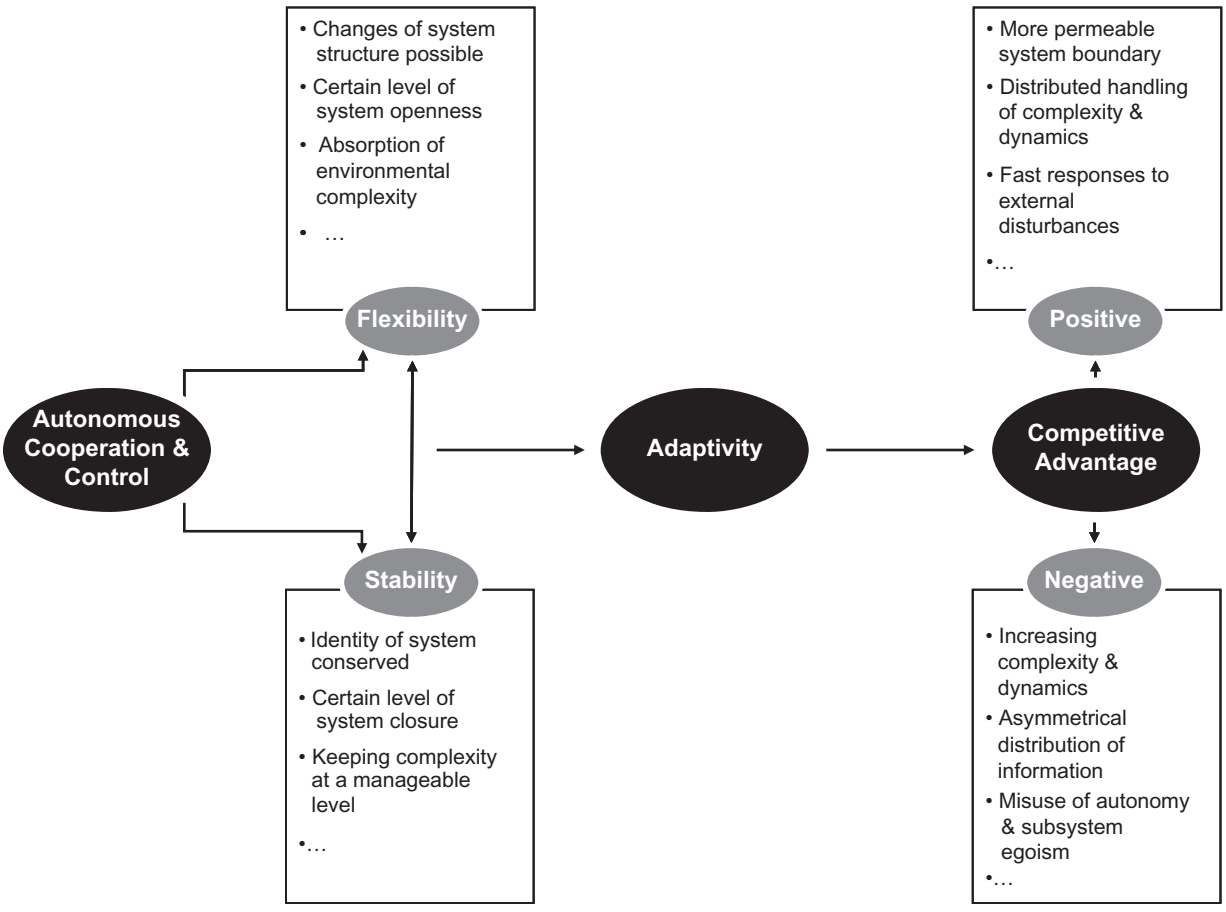

Fig. 3. Selected positive and negative effects of ACC on competitive advantage in GSCs.

viability. Nevertheless, the existence of possible negative effects of ACC on GSCs' performance has to be considered, as the decision of implementing ACC depends on the estimated weighted effects—positive as well as negative ones. Because of this ambiguity of ACC for GSC the implementation of such technologies or control concepts cannot be judged generally, but requires a context-sensitive and individual evaluation.

Additionally, some limitations can also be observed in this research. First, this paper so far provides only a theoretical conceptualization of ACC's contributions to creating adaptivity and in turn competitive advantage. The transfer of ACC's ideas in a practical logistic context remains a challenge for future research tasks. Secondly, though stating ACC can have various degrees, this paper has not answered the question how to measure ACC and to find out its optimum degree for different GSCs. This shows the need for further studies on the measurement of ACC in GSCs. Thirdly, the implementation of ACC depends to a large extent on advanced information and communication technology, because specific technologies allow an increase in the degree of ACC in GSC processes. The linkage between the technology and the characteristics of ACC has not been addressed in this paper, but it is important for management practice, where it has to be decided how to implement ACC's ideas. Fourthly, the application of the discussed management approach bears cost/benefit implications. This means the issue of cost–benefit analysis with regard to an evaluation of ACC will have to be considered.

Considering these limitations, this paper sees the necessity for further research in the following aspects. Empirical research on ACC's contributions to creating adaptivity and competitive advantage (e.g. surveys and case studies) may give more validity to the theoretical conceptualization. Besides, research on measuring the degree of ACC allows a better understanding of ACC's contribution in specific contexts (i.e. different kinds of GSCs). Moreover, research on relevant technology enabling ACC might increase the possibility to transfer theoretical results to practice. Finally, research on estimating cost–benefit and risk–return relations with the application of ACC assists management in making investment decisions.

Nevertheless, the conceptual discussion above on the contributions of ACC to competitive advantages and the corresponding ability of a logistic system to cope better with complexity and dynamics is able to deliver a theoretical backbone for the evaluation and implementation of ACC technologies, approaches, and concepts (e.g. RFID, Autonomous Adaptation of Vehicle Schedules, Adaptive Business Process Model) in logistics practice. For the development of an instrument that allows the logistics management, a rational choice of appropriate and efficient ACC technologies, approaches, and concepts, the discussion before explains the general connection between ACC, adaptivity, and competitive advantages, but needs the transformation in an empirically proofed causal model of interrelations. This model can also reflect on other determinants of competitive advantages—not only on complexity, adaptivity, ACC, and characteristics of a certain GSC, but, in combination with those mentioned, it can also consider other impact factors like characteristics of markets, customers, competitors, and internal resources, etc. as explaining variables of competitive advantages. This future research will lead to a more complex, sophisticated, and comprehensible understanding of the implications of ACC for achieving competitive advantage in GSCs.

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