LONGEVITY OF TECHNOLOGICAL COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDERS? A COMPLEXITY SCIENCE BASED ANALYSIS OF AUTONOMOUS CO-OPERATION TECHNOLOGIES

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ABSTRACT

This paper intends to analyse the problem of longevity of technology based competitive advantages for logistics service providers, as it is important from the view of investment theory. Autonomous co-operation technologies are illustrated as an example for technologies that can lead to competitive advantages for companies within international supply networks. However, suchlike technologies can lead to path dependencies, which affect the longevity of these advantages in positive as well as negative ways.

INTRODUCTION

The market for logistics services has become more and more competitive during the last years caused by similarities of offered services as well as an increased number of competitors, resulting beside others from open boundaries (Klaus & Kille 2006). Therefore, these services can either be differentiated through price variations, which can lead to price wars and to a decrease in the margins of logistics service providers. Or a differentiation can be reached by enriching the logistics services with additional value for the customer (Christopher 2005). One possibility to generate "value added services" in so-called International Supply Networks (ISN) (Hülsmann and Grapp 2005) is the implementation and usage of new autonomous co-operation technologies like RFID or Sensor Networks (Hülsmann et al. 2008). They can be used to provide services like quality control for perishable goods or a higher adherence to schedules (Hülsmann and Grapp 2008). Due to the fact that technologies could possibly be copied, imitated or substituted by other competitors, the longevity of suchlike competitive advantages is in doubt (Barney 1991). Hence, this paper aims to answer the following questions: Are autonomous co-operation technologies able to create long-living competitive advantages? Which determinants influence the longevity of suchlike technology based competitive advantages and are there possibilities for logistics service providers to control them? Hence, the objectives of this paper are threefold: (1) A description of autonomous co-operation technologies based competitive advantages for logistics service providers shall be given. (2) A causal identification of challenges resulting from the problem of longevity of technology based competitive advantages and possible drivers for this longevity shall be deduced. (3) Possibilities for the management practice of logistics service providers regarding the extension of the longevity of technological competitive advantages shall be given.

Hence, for a description of technological competitive advantages of logistics service providers, the paper sketches challenges and characteristics for the longevity of technology based competitive advantages in ISN (Hülsmann & Grapp 2008) (section 2). Following that, a brief description of autonomous co-operation technologies will be given and used as an example for technologies that might enable logistics service providers to provide their customers additional values in order to differentiate from their competitors (section 3). Then, positive as well as negative effects on the longevity of technological based competitive advantages resulting from path dependencies will be analysed (section 4) in order to be able to derive implications for on the one hand the management of logistics systems and on the other hand for further research (section 5).

THE RELEVANCE OF LONGEVITY OF TECHNOLOGY BASED COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDER

Nowadays, phenomena like real-time economies (information are available and interchangeable in real-time caused by the performance of computer systems) (Siegele 2002) and hyper-competition (increasing rivalry of competitors due to global interdependencies of purchasing, producing, and sales) (D'Aveni 1995), logistics service providers have to face complex and perpetually changing settings of environmental requirements (Hülsmann and Berry 2004). Beside the increasing rivalry and increasing number of competitors (Klaus and Kille 2006), this results from cost increases (e.g. gasoline) (Pfeiffer 2008), and increasingly ambitious customer demands regarding quality and speciality of logistics services (Ullmann 2006). Furthermore, the margins of Logistics service providers are decreasing over time. This can be reasoned in difficulties to pass increasing costs down to customers, which is a result of long-term contracts, a rise of customers' bargaining power, and price competition, provoked by the high number of competitors (Klaus and Kille 2006). Hence, growth potentials for logistics service providers can be realized through "Value Added Services" (e.g. packing of goods, mounting, quality control) (Pfeiffer 2008). Every added service, that allows customers of a certain company to improve its own services (e.g. Amazon`s Over Night Express) and therewith to demand higher prices from its own customers, constitutes higher values for this company (Porter 2008). In consequence, this influences their preparedness to pay higher prices for the logistics service provider's services. Moreover, if no competitor is able to imitate or substitute this service, its uniqueness entails, that no competition for prices will emerge and higher margins for logistics service providers are possible. Therewith, a logistics service provider's survivability depends on his ability to create competitive advantages by offering unique services and the possibility to reach higher margins (De Wit and Meyer 2005). However, to maintain this survivability the competitive advantages have to be long living. Hence, the longevity of competitive advantages is jeopardised by the competitors trying to offer the same or a similar service for the market. In this case, the longevity can be described as the ability of the advantage to resist against the behaviour of competitors, due to difficulties respectively impossibilities to imitate the companies' competences the advantage is based on (Porter 1985). Thereby, an advantage becomes long living, which leads to a durable unique selling proposition for the logistics service provider and a possibility to reach higher margins than competitors. Furthermore, the longevity of competitive advantages is also important from the view of investment theory. Technology based competitive advantages usually result from investments in the respective technologies and their implementation. Investments can be defined as target-oriented input of funds for the acquisition of goods or services (e.g. the several technology parts) (Perridon and Steiner 2002). To gain competitive advantages (target orientation), there are acquisition- and labour costs (input of funds) for the several technology parts and for their implementation into the working process. Due to the fact, that an investment with the aim to create competitive advantages commits capital, the importance of the longevity depends on the possibility of the investment's amortisation (Perridon and Steiner 2002). According to Müller-Stewens and Lechner (2005), the possibility to create competitive advantages as well as its longevity, presupposes several factors: Firstly, competitors have to be heterogeneous in order to be able differentiate themselves from others. This heterogeneity and therewith the longevity of technological competitive advantages depends on the market's characteristics, due to the fact that the longevity is determined by the market's imitation,- innovation,- and substitution-rate (Rasche 1994). To be heterogeneous they need to be equipped with different resources and competences. Regarding this, a higher rate of imitation and substitution can be a driver for homogeneity, whereas a higher rate of innovation, depending on the innovation-capability of several companies, can be a driver for heterogeneity and vice versa. Secondly, a logistics service provider must be able to use the heterogeneity for improving his own efficiency. That means competitive advantages cannot be created, if a logistics service provider is unable to create them by using the advance (e.g new technology) in opposite to the competitors. Thirdly, the value of a service offered by a logistics service provider is defined by the customers. Hence, the decision weather the company's service is useful is solely rendered by the customers and cannot be influenced directly by a logistics service provider. In consequence, the heterogeneity between companies can only lead to competitive advantages, if the logistics service provider is able to offer "value added services" for his customers and if that leads to the customers' willingness to pay higher prices for this service. In summary, the heterogeneity, which is essential for the possibility to gain competitive advantages depends on the market's characteristics and the customer's as well as the competitor's behaviour. This, in turn, influences again the characteristics of the market. The market can be seen as an aggregation of several competitors, operating independent from each other. Moreover, logistics service providers often act in so-called International Supply Networks (ISN). This results from co-operations of several logistics service providers with competitors during the different working processes (e.g. subcontractor), as well as from co-operations with other companies (e.g. bargainers, producers etc.). In consequence, logistics service providers can be embedded in the structures of different ISN (Hülsmann and Cordes 2009), leading to a higher amount of possible connections and linkages and co-evolutionary processes between competitors in ISN as well as between different ISN. Therefore, from the view of complexity theory ISN can be described as complex adaptive logistics systems (CALS) (Wycisk et al. 2008). Thereby, the question arises, how technology based competitive advantages can be achieved for logistics service providers.

COMPETITIVE ADVANTAGES FOR LOGISTICS SERVICE PROVIDERS BASED ON AUTONOMOUS CO-OPERATION TECHNOLOGIES

One way to create competitive advantages can be seen in the use of innovations (Freiling and Reckenfelderbäumer 2004). One example for such innovations are autonomous co-operation technologies (Hülsmann et al. 2008). Autonomous co-operation 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"* (Windt, Huelsmann 2007; p. 8). Its aim is to achieve a higher robustness of the whole system by enabling it to cope with dynamics and complexity (Hülsmann and Windt 2005). Its origins can be found in the idea of self-organisation, which was described in multiple academic fields (e.g. physics, biology and chemistry). The research field of self-organisation intends to analyse how complex systems create ordered structures autonomously. The concept of autonomous co-operation depends on different characteristics. These are decentralised-decision making (system elements render own decisions), autonomy (elements act without control of super-ordinate entity), interaction (elements interact with others to get relevant information for rendering decisions) and non-determinism (future system states are unforeseeable caused by unpredictable behaviour of the systems elements) (Hülsmann and Grapp 2006). Hence, no system is controlled autonomously as well as none is controlled externally to a degree of 100 percent. Therefore, these characteristics can only be realised to a certain degree. In spite of first research results, the field of self-organisation is still a young science at a stage of developing (Hülsmann and Wycisk 2005). Hence, to cope with logistical requirements in different ways, a need for intelligent systems with adaptive capabilities can be assumed (Wycisk et al. 2008). Autonomous co-operation can be used by the implementation of technologies like RFID or sensor networks, which enables the logistics service provider to control the temperature and humidity of goods and therewith might allow a logistics service provider to offer special transportation services for perishable food. The use of methods like autonomous routing as well as approaches like collaborative vehicle routing and scheduling, aims for decentralised intelligence and enables single system elements (e.g. the goods) to render decisions (Hülsmann and Grapp 2008). These single system elements, endowed with own decision-making rules and routines can be called "Smart Parts" (McKelvey et al. 2008). Hence, the question arises how autonomous co-operation can lead to competitive advantages. According to Hülsmann et al. (2008), the implementation and use of autonomous co-operation technologies can lead to a higher flexibility through supporting the replication of competences. Furthermore, a reduction of complexity is realised by arranging the complexity between the subsystems (autonomy) and the complexity the management has to absorb decreases as well as for the subsystems a smaller environment and less co-ordination efforts occur. The decentralised-decision making can lead to a faster availability of relevant information between the "Smart Parts", what allow them to render decisions in shorter times and leads to a faster adaptation to changing environments. Another effect, resulting from a higher degree of interaction, is the exchange of information between the "Smart Parts" instead of passing information from the management to the "Smart Parts". Due to the higher rate of interaction, it becomes easier for the "Smart Parts" to get relevant knowledge for solving problems, rendering decisions and developing own competences. In result, the flexibility enables a system to react faster on changing environments than other systems. Thereby, a competitive advantage might be realised (Hülsmann et al. 2008). Another way to gain competitive advantages can result from the access of the "Smart Parts" to competences of other system elements. These competences can be combined with own competences and developed to new ones. So, the advantage results from a higher amount of competences alternatives and the possibility to meet challenges from the environment in a more adequate way. Nevertheless, a higher degree of flexibility can have negative impacts. The increase of information on individual processes and the unpredictability of the behaviour of the "Smart Parts" can lead to the management's inability to regulate the "Smart Parts". Moreover, the "Smart Parts" can aim for their own goals, which are possibly indifferent to the environmental requirements or the goals of the whole system. Therefore an egoism of the "Smart Parts'' can hamper the creation of competitive advantages (Hülsmann et al. 2008). In conclusion, an implementation of autonomous co-operation technologies can lead to a higher flexibility and therewith to a possibility to gain competitive advantages. Therefore, the question arises, which aspects determine the longevity of those competitive advantages based on autonomous co-operation technologies.

ANALYSIS OF DRIVERS AND BARRIERS FOR THE LONGEVITY OF COMPETITIVE ADVANTAGES BASED ON AUTONOMOUS CO-OPERATION TECHNOLOGIES

The longevity of technology based competitive advantages can be affected by the phenomenon of path dependency in different ways. Path dependencies describe processes of reducing action-alternatives over time, caused by positive feedback loops. They can lead to so-called lock-in situations in which one technology dominates others, although others might be technologically superior (Arthur 1989). According to Sydow et al. (2005), path dependent processes include three stages. Stage one describes the search process, in which different action-alternatives (e.g. different technologies) are available and decisions are rendered more or less randomly. Once a self-reinforcing process, which means that the selection of one alternative increases the probability that it will be selected again, has started a so-called "critical juncture" occurs. This initiates the second stage, which is called "path formation". Different alternatives are still available but their probabilities to be selected decrease irreversible with every further selection. The "lock-in" initiates finally the path dependency, in which only one action alternative respectively only one technology is left being attractive despite the possibility that other action alternatives respectively technologies are superior (Sydow et al. 2005).

In the context of ISN the scenario of a technological path dependency regarding the implementation of autonomous co-operation technologies can be described as it follows: In the first stage just a few logistics service providers might implement autonomous co-operation technologies (e.g. RFID-chips). Interactions and interdependencies between actors in ISN might lead to an increase of the attractiveness for other actors to invest in the respective technology as well (e.g. RFID-readers). With an increasing amount of actors in the network that use the same technologies and that are dependent on each other, the probability that actors invest in the same or similar technology in order to be able to co-operate with them might increase as well. These self-reinforcing processes might, in turn, lead to an increase of the imitation- and substitution rate and therewith to an acceleration of the respective technology's diffusion in the network. This can finally lead to a lock-in situation in which logistics service providers need to implement a certain technology in order to be able to participate in the respective ISN.

On a system level, which refers to the perspective of an ISN, path dependencies and the resulting homogenisation tendencies can lead to a decrease of the whole systems' innovation capabilities (Hülsmann and Cordes 2009). The less heterogeneous the elements within a system are, the less incentives do they have to interact with each other (Wycisk et al. 2008). Hence, the possibilities to react on other elements' actions with changed behavioural rules decrease as well, which refers to a decrease in the element's learning abilities. In consequence, the respective system forfeits innovative capabilities (Hülsmann and Cordes 2009). However, path dependencies can as well function as drivers for systems' common identities. According to Luhmann (1984) the survivability of systems depends, beside others, on their abilities to differentiate from their environment by creating boundaries. Therewith, the systems�really stability can be assured (Luhmann 1984).

On the level of the systems‛ single elements, which means in an ISN of the involved companies, a path dependent homogenisation might lead on the one hand to decreasing possibilities to differentiate from competitors. Difficulties in gaining respectively maintaining competitive advantages by implementing respectively using autonomous co-operation technologies increase with every additional company within the ISN that uses this respective technology as well. In consequence, the longevity of technology based competitive advantages might decrease with an ongoing homogenisation resulting from developing path dependencies. On the other hand, the development of technological path dependencies presuppose that involved organisations learn from each other in terms of repeating respectively imitating action alternatives that lead to success in the past (e.g. investments in autonomous co-operation technologies). Furthermore, once a path has emerged learn effects occur from long-lasting usages of certain technologies. This, in turn, might lead to economies of scale (e.g. decrease of transportation costs while transporting a higher amount of goods) as well as economies of scope (synergistic effects e.g. common attendance of technology parts). From the perspective of single logistics service providers these effects might extend the longevity of competitive advantages gained through the usage of autonomous co-operation technologies.

CONCLUSIONS

One major strategic question logistics service providers have to face is the problem of creating long-living competitive advantages based on technological developments in highly competitive markets. Those competitive advantages are necessary in order to differentiate a company from its competitors by offering a certain technological-based value added service for customers. Therefore, the paper intended to provide an analysis of chances and risks for the longevity of competitive advantages induced by autonomous co-operation technologies (e.g. RFID, Sensor Networks).

Competitive advantages result from the heterogeneity of logistics service providers on a distinct market, which allows differentiating one competitor from each other. The development of a certain technology might result in the emergent creation of technological paths, which comprise processes of reducing decision-making alternatives regarding the adaption of technologies to environmental changes over time, caused by positive feedback loops. Therefore, the effects of technological developments on the longevity of such competitive advantages can vary in the range of positive as well as negative impacts on the level of ISN and of one single company. On the level of ISN one positive effect can be an increasing capability of the whole system (ISN) to differentiate itself from other value-adding networks based on a certain advantage in the use and application of a distinct technology. This might result in an improvement of the system’s stability. On the same level (i.e. ISN) one exemplary negative effect might be the reduced capability to invent new technologies, because the positive feedback loops of the past can result in a homogenous system’s behaviour, which prevents the actors within such a system from learning. Therefore, the system might erroneously rely on previously successful technologies, which might be not capable to deal with changed environmental demands of the future. Similar positive as well as negative effects can be assumed on the level of individual companies (i.e. logistics service providers) within an ISN. Examples for this are economies of scale based on inter-corporate learning (positive effect) and a reduction of technological-based options for a strategic differentiation on the long run (negative effect).

Therefore, it cannot be stated in general for the management practise that a technological advantage might automatically result in a strategic one. Furthermore, it depends on the net effect of a technology. Positive as well as negative impacts on the longevity of a technological-based advantage of an ISN or a logistics service provider have to be taken into account for strategic investment decisions about the development and implementation of technologies. Hence, the management of such organisations has to control the development of emerging technological paths and their implications for the respective organisation in order to reduce the risks resulting from homogeneity and in order to utilize chances of learning. Therefore, further research has to provide the management of ISN and logistics service providers with methods and instruments that allow evaluating technologies regarding their strategic implications.

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REFERENCES

Arthur, W.B. (1989) "Competing Technologies, increasing returns, and Lock-In by historical events", in The Economic Journal, Vol. 99 No. 394.

Barney, J. (1991) "Firm Resources ans Sustained Competitive Advantage", In Journal of Management, vol. 17, no. 1, pp. 99-120.

Christopher, M. (2005) "Logistics and Supply Chain Management: Creating Value-added Networks", Harlow et Al.

D'Aveni, R.A. (1995) " Coping with hypercompetition; Utilizing the new 7S's framework", in Academy of Management Executive, Vol. 9 No. 3.

De Wit, B.; Meyer, R. (2005) "Strategy Synthesis - Resolving Strategy Paradoxes to Create Competitive Advantage", London.

Freiling J., Reckenfelderbäumer M. (2004) "Markt und Unternehmung – Eine marktorientierte Einführung" in die Betriebswirtschaftslehre", Wiesbaden.

Hülsmann, M.; Cordes, P. (2009) "Autonomous Co-operation and Control in Complex Adaptive Logistic Systems – Contributions and Limitations for the Innovation Capability of International Supply Networks", In Proceedings of The First International Conference on Complex Sciences: Theory and Applications, Shanghai, China, February 23.-25., 2009.

Hülsmann, M.; Grapp, J. (2008) "Economic Success of Autonomous Cooperation in International Supply Networks? – Designing an Integrated Concept of Business Modelling and Service Engineering for Strategic Usage of Transponder-Technologies." In Pawar, K.S. et al. (ed.): Integrating the Global Supply Chain. Conference Proceedings of 13th International Symposium on Logistics 2008 (13th ISL), Loughborough, United Kingdom.

Hülsmann, M.; Grapp, J.; Li, Y. (2008) " Strategic Adaptivity in Global Supply Chains - Competitive Advantage by Autonomous Cooperation" in International Journal of Production Economics, Special Issue: Manufacturing Systems – Strategy & Design, Volume 114, Issue 1, 2008, pp. 14 – 26.

Hülsmann, M.; Grapp, J. (2006) " Monitoring of autonomous cooperating logistic processes in international supply networks" in Pawar, K.S., Lalwani, C.S., de Carvalho, J.C., Muffatto,M. (Eds.), Competitive Advantage Through Global Supply Chains. Conference Proceedings of the 11th International Symposium on Logistics. Loughborough, United Kingdom, pp. 113–120.

Hülsmann, M.; Windt, K. (2005) " Selbststeuerung – Entwicklung eines terminologischen Systems", Bremen.

Hülsmann, M.; Wycisk, C. (2005) " Unlocking Organizations through Autonomous Co-Operation – Applied and Evaluated Principles of Self-Organization in Business Structures." 21st EGOS Colloquium: »Unlocking Organizations«. June 30th – July 2nd, 2005. Berlin. Web-publication: http://www.egos.org. 25 pages.

Klaus P., Kille C. (2006) "Die Top 100 der Logistik – Marktgrößen, Marktsegmente und Marktführer in der Logistikdienstleistungswirtschaft", Hamburg.

Luhmann N. (1984) „Soziale Systeme: Grundriss einer allgemeinen Theorie", Frankfurt.

McKelvey, B.; Wycisk, C.; Hülsmann, M. (2008) "Designing Learning Capabilities of Complex 'Smart Parts' Logistics Markets: Lessons from LeBaron's Stock Market Computational Model". International Journal of Production Economics, accepted.

Müller-Stewens, G.; Lechner, C. (2005) „Strategisches Management: Wie strategische Initiativen zum Wandel führen", Stuttgart.

Perridon, L.; Steiner M. (2002) „Finanzwirtschaft der Unternehmung", München.

Pfeiffer, K. (2008) "Zuverlässigkeit zählt", Logistik heute, Vol.11.

Porter, M.E. (1985) "Competitive advantage: Creating and sustaining superior performance", New York.
Porter, M.E. 2008, "The Five Competitive Forces that Shape Strategy", Harvard business review, vol. 86, no. 1, pp. 78-93.
Rasche C. (1994) "Wettbewerbsvorteile durch Kernkompetenzen: ein ressourcenorientierter Ansatz", Wiesbaden.
Sydow J.; Schreyögg G.; Koch J. (2005) „Organizational Paths: Path Dependeny and Beyond", 21st EGOS Colloqium, June 30 – July 2, 2005, Berlin, Germany.
Siegele, L. (2002) "How About Now?", in Economist, Vol. 362.
Ullmann, W.; Jordans, I. (2006) "Untersuchungen zur Standortfrage von Logistik-Standorten unter dem Einfluss der EU-Osterweiterung", Berlin.
Wycisk, C.; McKelvey, B.; Hülsmann, M. (2008) "'Smart parts' logistics systems as complex adaptive systems", International Journal of Physical Distribution and Logistics Management. Vol. 38, No. 2, 2008, p. 108-125.