Hülsmann, M.; Grapp, J.; Wycisk, C.: Real-Options-Approach – A Basis for the Economic Evaluation of Autonomous Cooperating Logistics Processes in International Supply Networks?. In: Pawar, K.S.; Lalwani, C.S.; de Carvalho, J.C.; Muffatto, M. (eds.): Conference Proceedings of 12th International Symposium on Logistics (12th ISL). Loughborough, United Kingdom, 2007

REAL-OPTIONS-APPROACH – A BASIS FOR THE ECONOMIC EVALUATION OF AUTONOMOUS COOPERATING LOGISTICS PROCESSES IN INTERNATIONAL SUPPLY NETWORKS?*

Michael Hülsmann[1], Jörn Grapp[2], Christine Wycisk[3]
University of Bremen
[1]michael.huelsmann@uni-bremen.de,
[2]grapp@uni-bremen.de, [3]cwycisk@uni-bremen.de

Acknowledgement
This research was supported by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes - A Paradigm Shift and its Limitations".

ABSTRACT
The main contribution of this paper is to provide an approach for the economic evaluation of Autonomous Cooperation (= AC) in logistic processes. This is a necessary basis for its application to business logistics and to management in general. Therefore, the Real-Options Approach (ROA) will be discussed as a theoretical framework to evaluate AC in International Supply Networks (= ISN).

THE NECESSITY FOR EVALUATING AUTONOMOUS COOPERATION IN ISN
During the 10th International Symposium on Logistics in Lisbon (Portugal) several contributions of the management approach of AC to balance flexibility and stability in ISN were discussed (Hülsmann and Grapp 2005). AC is described as one opportunity to cope with complexity and dynamics, which are caused by typical drivers of change and diversity like hyper-linking, hyper-competition, hyper-turbulence (Tapscott 1999, Siegele 2002) in a global logistics context. In those logistic structures "companies are involved in different supply chain networks which again compete among each other on the world market (Seebauer 2003, p. 62, Lambert et al. 1998). These networks of supply chains shall therefore be characterized as ISN." (Hülsmann and Grapp 2005, pp. 243) Possible conceptual contributions of AC, which is defined by its characteristics of decentralized decision-making, autonomy, non-determinism, interaction and heterarchy (Hülsmann and Windt 2007), are based on the following overarching assumption, from the perspective of ISN-Management: reducing the quantity of systems and sub-systems which have to be controlled (i.e. companies involved in ISN) means they operate independently towards decisions and gain more flexibility. Sub-systems (e.g. local manufacturers) get a general direction (i.e. by ISN-Management) for their decision-making. Thereby they can flexibly decide within a predefined decision frame. As complexity is absorbed by an increased quantity of decision units, stability is ensured since less coordination work is needed. However, there are also conceptual risks of AC: One is the decrease of the total stability caused e.g. by sub-system egoism (e.g. considering only individual sub-system needs) (Hülsmann and Grapp 2005). Positive as well as negative effects of AC have provided the basis for discussion on the 11th International Symposium on Logistics in Beijing (China), where the measurement of the degree of AC via a monitoring concept has been described.

* The authors are pleased to thank Annett Walter for her very valuable support.

Flexibility as well as stability seem to represent significant strategic factors for a strategic ISN-Management (Hülsmann and Wycisk 2005). In this regard the question rises if AC could support abilities of reconfiguration (i.e. transformation of the configuration of competences) und replication (i.e. multiplication of existing processes by standardization) of a company (Teece et al. 1997, Burmann 2002). Both are necessary for the adaptivity of a firm and are assumed to possibly have effects on the company value. In order to prove that the implementation of AC in logistic systems, like ISN, has an impact on the company value its economic advantage in relation to conventionally managed systems has to be evaluated. This in turn creates the need to develop an adequate evaluation system (Hülsmann et al. 2006a). Consequently, this paper's hypothesis is that a sustainable ISN-Management will only implement concepts, methods, and technologies (e.g. formation of autonomous working groups, use of RFID or intelligent freight units) if the economic benefit from increasing the degree of AC is higher than of the degree before. Therefore, it is necessary, that the degree of AC can be systematically evaluated, e.g. by ROA. The following questions and accordingly deduced aims result from the described research context and will be illuminated within this paper:

- **Question 1:** How can AC be evaluated systematically?
  Aim 1: Reasoning the selection of ROA as general possibility for evaluating AC.
- **Question 2:** What has to be understood under the ROA?
  Aim 2: Describing the ROA as a method from financial management.
- **Question 3:** How far does the ROA contribute to evaluate AC in ISN?
  Aim 3: Analyzing contributions of the ROA for evaluating AC in ISN.

WHY CHOOSING REAL-OPTIONS-APPROACH TO EVALUATE AC?

The development of criteria of the selection of an evaluation concept for AC in logistic processes can be subdivided into two steps: In a first step, the question raises to what extent AC in logistic processes and the economic evaluation of companies are related to each other in general **(General Evaluation Context)**. In a second step, it will be examined whether and to what extent the specific assumptions of the selected range of possible evaluation approaches fit to the evaluation problem of AC **(Selection of a Theoretical Evaluation Basis)**.

General Evaluation Context:

By implementing the idea of AC into logistic systems a higher adaptivity and reaction ability under complex and dynamic environmental conditions and thereby higher robustness of the whole logistics system are expected (**step 1&2**) (Probst 1987, Kirsch 1992, Malik 2000, Hülsmann and Windt 2007). Coming along with the paradigm of AC, companies are faced with the problem of evaluation of AC. Besides the assumed potentials of a higher adaptivity by AC there are also doubts about its cost-benefit-relation and accordingly return-risk-relation of flexibility and vice versa stability effects (Clausen and Kraft 2004, pp. 12). Thus, the question rises if AC provides any options for logistic systems (**step 3**) and if so, which ones are relevant for an increasing adaptivity of a system (**step 4**). Consequently, managers are interested in, how these options do affect the return-risk-relation of a company (**step 5**). Considering these questions, a general evaluation problem of AC-effects in logistic processes can be deduced. To evaluate AC in this context, the Real-Options-Theory could be an appropriate basis as the value of flexibility is explicitly

considered. Objectives of a real-options-based evaluation are: identifying and assessing options of acting as a result of AC in logistic processes (see Figure 1).

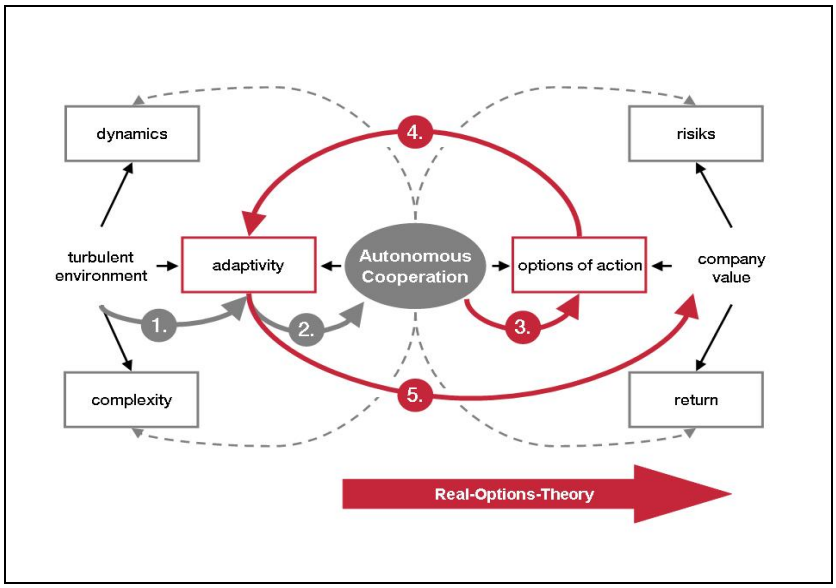

Figure 1. Evaluation Context of AC and Company Value

Selection of a Theoretical Evaluation Basis:

To evaluate AC specific finance scientific requirements - here understood as criteria - for selecting an evaluation concept: flexibility, uncertainty, irreversibility have to be considered: Flexibility is the main characteristic of AC, which has to be evaluated (criterion a). Uncertainty has to be considered as AC is represented by non-linear processes. This can be reasoned with the attribute of autonomy of every single sub-unit that enables to choose between alternative ways of action. Since the next step of every single sub-unit can not be casually predetermined, the entire logistic system behaviour is not predictable (Prigogine 1996) (criterion b). Irreversibility has to be taken into account, because AC represents irreversible processes (Prigogine 1996) (criterion c).

Figure 2 shows the selection process of a theoretical evaluation basis. Possible evaluation concepts are named on the horizontal axis (Net Present Value, Sensitivity-Analysis, Monte-Carlo-Simulation, Decision Tree Analysis, and Option-Pricing-Model) and are compared according to criterion a), b), and c) on the vertical axis. Every concept has been examined regarding its contribution to each criterion. As a result, especially the ROA seems to be most relevant as a theoretical evaluation basis of AC for the following discussion. Due to its diverse range of options, compared to all considered concepts, only the ROA is fully able to enhance the value of flexibility of investments in one calculation (Trigeorgis 1996), so it meets criterion a). Options permit to calculate investments under uncertainty. Options include the right but not the duty to realize an investment (Copeland and Antikarov 2002). Thus, the higher the degree of uncertainty of an investment is, the higher is the value of flexible acting (option) in the ROA for a company (Trigeorgis 1996), which fulfils criterion b). Options are always bound with capital flows. Taking or not taking an option is a process, which cannot be completely called off without

changing the system status at least regarding the lost or gained amount of capital (Kogut and Kulatilaka 2001). Consequently, the ROA meets also criterion c) of irreversibility.

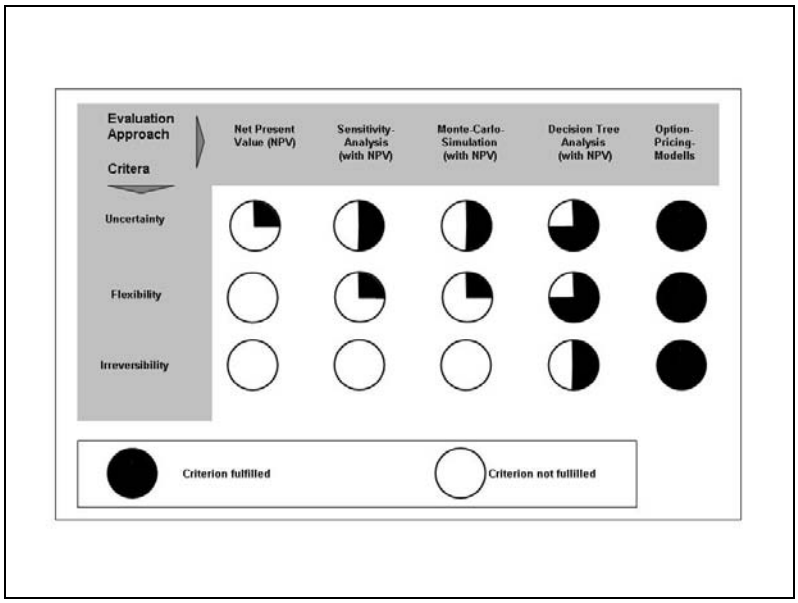

Figure 2. Selection of a Theoretical Evaluation Basis
(Hommel and Pritsch 1999, p. 128)

ROA AS BASIC CONCEPTUAL EVALUATION FRAMEWORK

ROA differs from other financial evaluation approaches in particular, due to its focus on the value of options of flexibility (Trigeorgis 1996). The basic idea of the ROA is to evaluate the profitability of investment projects. Therefore, fundamentals of the options-price theory are transferred on the evaluation process of future projects or investments. In doing so, it is possible to evaluate future options resulting from planned investments in addition to traditional cash flow analysis (Copeland and Antikarov 2002). Hence, it should be possible to identify those options that AC provides in general for logistic systems and to evaluate their financial value (Hülsmann and Grapp 2006). At first, the net present value of the considered system has to be defined (Nowak 2003). The next step would be the assessment of specific options of acting resulting from AC. Different possible types of options can be identified. Hommel and Pritsch (1999) list the following types of options, which represent a main classification of options that can be found in the relevant literature (see also e.g. Trigeorgis 1996, Copeland and Antikarov 2002):

- **Options to Wait/Defer:** Option to wait with the execution of an investment and it is possible to let the option be dependent from the realization of a specific random variable (e.g. decision of market-entry of a competitor)
- **Options to Expand:** Option to expand production capacity at x-percent towards the payment of a capital expenditure
- **Options to Innovate:** Option to generate innovative, further investment opportunities (chain of call options) on the basis of a project investment
- **Switching Options:** Option to switch between two options, e.g. between options to break-up or extend/ between options to expand or reduce
- **Rainbow Options:** Option to react on several sources of insecurity

The single value-determining elements to evaluate the option value consist of the value of the risk-carrying object, which corresponds to the value of the innovative opportunity (e.g. methods, concepts, and technologies of AC) or the cash flow that could be generated by the execution of the innovative option respectively. The preferential price stands for the amount of money which will be callable at the date of transaction. The option maturity describes the duration of an option. The standard deviation of the risk-carrying object (volatility) corresponds to the insecurity of the expected payment surplus. The risk-free interest rate is represented by the market interest rate for risk-free assessments, e.g. federal savings bond. Finally, dividends and dividend-resembling payments correspond to cash flows which could be generated at immediate execution of the total investment (first or following investment) during maturity of the option, but flow to competitors who have already entered the market (Nowak 2003, Copeland and Antikarov 2002, Trigeorgis 1996).

POSSIBLE REAL-OPTIONS OF AUTONOMOUS COOPERATION FOR ISN

An example of the textile industry shall illustrate possible real options in an ISN. It is assumed that a textile manufacturer in Hong Kong gets direct orders from different European and American retailers to produce high quality garments. Due to the high competitive situation in this market, the orders for the manufacturer become more and more irregular. As ISN are considered as dispersed production networks, the manufacturer may decide to buy a low price yarn from a South Korean producer. However, this yarn maybe is efficiently woven in Taiwan and ordered from there. The company in Hong Kong gets zippers and buttons for its production from a Japanese company etc. Consequently, many different companies located in different countries build up the entire supply chain (Natarajan 1999). Additionally, it is assumed that the distribution processes between the single actors of an ISN are self-organizing. That could mean for example, containers shipping different types of yarn, zippers or buttons are equipped with AC technologies such as RFID tags and micro chips inheriting all information needed to schedule their way from Japan and South Korean to China by their own. Thus, the containers become smart parts within the logistic process and coordinate their way according to their individual logistic objectives (e.g. time, costs, quality and/or quantity) to their destination point. They are able to gather information from their environment (e.g. traffic news, weather prediction) and also exchange information between themselves. What kinds of real options additionally result from those "new" capabilities of an autonomous cooperating ISN compared to one without AC?

To exemplify the existence of additional real options through AC, two types of real options (options to expand and options to innovate) are selected, where the benefit from AC seems to be obvious in the context of the case study:

- **Options to Expand:** Option to expand production capacity at x-percent towards the payment of a capital expenditure. Due to the irregular character of orders entering the observed supply chain, phenomena such as over- or under-capacities of resources and pre-products could occur (also known under the term "bullwhip effect") (Forrester 1961). Without AC, the risk of a bullwhip effect seems to be high, since the quantity and series of orders from European and American retailers are unpredictable. The ability of flexible reactions of a linear configured ISN in order to switch between the quantities of distributed goods is limited. However, Hülsmann et al. (2006b) examine that autonomous

cooperated systems are capable of handling additional complexity better then linear structured systems (until a critical degree of dynamics). For an ISN this means that through implemented AC technologies, options to expand offer e.g. coping with irregular quantities of orders (e.g. optimized information processes). Through self-organizing processes between the smart distributed goods, there is a higher margin of good pieces, which could be distributed in the same ISN then in linear structured ISN.

- **Options to Innovate:** The implementation of AC-methods, -technologies or –concepts into the observed ISN could be itself understood as an option to generate innovative, further investment opportunities. The risk-carrying object might be assumed as an innovation of production processes by investing in AC-related technologies such as RFID tags to optimize local material flows. The value of this option then would be represented by the amount of money, which is e.g. saved by reducing throughput times in warehouses or simply by the possibility to take part in autonomous cooperating supply chains. In order to prepare the implementation of AC technologies, the ISN-Management has to fix a certain preferential price with suppliers/sellers of AC-related technologies. However, the maturity to realize this specific option is limited, e.g. AC-technologies could become that popular over time that their acquisition cost will decrease and are affordable for the whole branch. In this case, on the one hand, they would not provide a competitive advantage anymore but on the other hand, AC technologies are then maybe an essential feature to stay competitive.

POSSIBLE RISKS & LIMITATIONS OF APPLYING THE REAL-OPTIONS APPROACH ON AUTONOMOUS COOPERATING ISN

It seems to be a key problem to estimate whether an investment into a new technology, method, or concept of autonomous cooperating logistic processes will be economically successful or not. The question is, which opportunities for risk mitigation across an ISN do exist?

According to Spinler et al. (2003) possibilities for hedging against risks will be considered. Risk mitigation could be possible through risk hedging and sharing. The ISN-Management respectively is understood as buyer and its suppliers as seller (i.e. provider or producer of AC-technologies). It has to face the risk that the chosen innovation might lead to possibly increasing inefficiency in its production processes, whereas suppliers have to carry the risk that they do not find a buyer for the option they offer. Via option contracts among ISN-organizations those individual risks presumably can be mitigated. The ISN-Management could decide flexible, when and to which extent to execute an option, e.g. flexible choice among AC-supplying companies. The supplier themselves should sign long-term contracts to enhance the probability that they will not risk to operate unprofitable (Spinler et al. 2003).

Another aspect is the general applicability of the ROA for evaluating AC that is not completely proved yet. According to Arnold (2005), Hommel and Pritsch (1999) at first, the process of calculation of the options-values in general are said to be complicated. Consequently, the risk of incorrect calculations and mistakes could occur in evaluating options resulting of autonomous cooperating ISN. Secondly, the value of a real-option is seen as quite difficult to forecast due to uncertain future developments of its determining factors. Especially in the field of ISN, the aspects of dynamics e.g. in sudden upcoming customer demands, could worsen the attempts

of evaluating options. Similar risks could be seen in the calculation of volatility that is based on foretime information, whose validity cannot be guaranteed. Thirdly, in general the life expectancy of real-options is not scheduled as financial options are. This also could lead to false results in the real-options-analysis (Arnold 2005, Hommel and Pritsch 1999). However, the ROA seems to be an established financial approach in theory and practice due to its ability to evaluate options of acting regarding their flexibility.

CONCLUSION & FUTURE RESEARCH TASKS

A consistent measurement and evaluation system of AC for ISN-Management is still missing. This article has shown that one possible evaluation approach could be the ROA due to its ability to evaluate flexible options of acting. Furthermore, options to expand and to innovate could be identified in AC logistics systems. However, the objective for future research must be to integrate a monitoring concept (presented on 11th ISL) and ROA as evaluation approach (presented on 12th ISL) - into one overarching system, in which the degree of AC, contributions and realization requirements are combined.

REFERENCES

Arnold G (2005) "Corporate Financial Management", 3rd edt, Edinburgh: Prentice Hall.

Burmann C (2002) "Strategische Flexibilität und Strategiewechsel als Determinanten des Unternehmenswertes", Wiesbaden: DUV.

Clausen U, Kraft V (2004) "Status und Perspektiven von Telematikanwendungen in der Verkehrslogistik zur Unterstützung von Logistikprozessen", in Logistik-Management, Vol 6, No 4, pp. 12 – 21.

Copeland TE, Antikarov V (2002) "Realoptionen: Das Handbuchbuch für Finanzpraktiker", Weinheim: Wiley.

Forrester JW (1961) "Industrial Dynamics", New York: Wiley.

Hommel U, Pritsch G (1999) "Marktorientierte Investitionsbewertung mit dem Realoptionenansatz", in Finanz- und Portfoliomanagement, Vol 1, No 2, pp. 121 - 144.

Hülsmann M, Grapp J (2005) "Autonomous Cooperation in International-Supply-Networks – The Need for a Shift from Centralized Planning to Decentralized Decision Making in Logistic Processes", 10th ISL - Innovations in global Supply Chain Networks, 03-05 July 2005, Lisbon, Portugal, in Conference Proceedings, Pawar KS et al. (eds), Loughborough, UK, pp. 243 - 249.

Hülsmann M, Grapp J (2006) "Monitoring of Autonomous Cooperating Logistic Processes in International Supply Networks", 11th ISL - International Symposium on Logistics, 09-11 July 2006, Beijing, China, in Conference Proceedings, Pawar KS et al. (eds), Loughborough, UK, pp. 113 - 120.

Hülsmann M, Scholz-Reiter B, Freitag M, Wycisk C, De Beer C (2006a) "Autonomous Cooperation as a Method to cope with Complexity and Dynamics? – A Simulation based Analyses and Measurement Concept Approach", in Proceedings of the International Conference on Complex Systems (ICCS 2006), Boston, MA, USA.

Hülsmann M, Windt K, Wycisk C, Philipp T, Grapp J, Böse F (2006b) "Identification, Evaluation and Measuring of Autonomous Cooperation in Supply Networks and Logistic Systems", 4th International Logistics and Supply Chain Congress – The Era of Collaboration Through Supply Chain Networks, 29 November-01 December 2006, Izmir, Turkey, in Conference Proceedings, Baltacioglu T (ed), pp. 216 - 225.

Hülsmann M, Windt K (eds) (2007) "Understanding Autonomous Cooperation &

Control - The Impact of Autonomy on Management, Information, Communication, and Material Flow", Berlin: Springer.
Hülsmann M, Wycisk C (2005) "Contributions of the Concept of Self-Organization for a Strategic Competence-Management", The 7th International Conference on Competence-Based Management: Value Creation through Competence-Building and Leveraging, 02–04 June 2005, Antwerp, Belgium, web-publication, 20 pages.
Kirsch W (1992) "Kommunikatives Handeln, Autopoiese, Rationalität: Sondierungen zu einer evolutionären Führungslehre", München: Herrsching.
Kogut B, Kulatilaka N (2001) "Capabilities as Real Options", in Organization Science, Vol 12, No 6, pp. 744 - 758.
Lambert DM, Cooper MC, Pagh JD (1998) "Supply Chain Management: Implementation Issues and Research Opportunities", in The International Journal of Logistics Management, Vol 9, No 2, pp. 1 - 19.
Malik F (2000) "Strategie des Managements komplexer Systeme: ein Beitrag zur Management-Kybernetik evolutionärer Systeme", Vol 6, Bern: Habil Universität St. Gallen.
Natarajan RN (1999) "Logistics, Strategy, and Supply Chain: Making the Right Connections in the Information Age", The 4th International Symposium on Logistics, 11-14 July 1999, Florence, Italy, in Muffato M, Pawar KS (eds) Logistics in the Information Age, pp. 209.
Nowak K (2003) "Marktorientierte Unternehmensbewertung – Discounted Cash Flow, Realoption, Economic Value Added und der Direct Comparison Approach", Wiesbaden: DUV.
Probst GJB (1987) "Selbstorganisation, Ordnungsprozesse in sozialen Systemen aus ganzheitlicher Sicht", Berlin: Parey.
Prigogine I (1996) "Die dissipativen Strukturen", in Böcher W (ed) Selbstorganisation, Verantwortung, Gesellschaft – Von subatomaren Strukturen zu politischen Zukunftsvisionen, Opladen: Westdt Verl.
Seebauer P (2003) "Logistikentwicklungen - Nachdenken lohnt sich", in Logistik Heute, No 4, pp. 62 - 63.
Siegele L (2002) "How about now? A Survey of the Real-Time Economy", in The Economist, Vol 362, pp. 18 - 24.
Spinler S, Huchzermeier A, Kleindorfer P (2003) "Risk Hedging via Options Contracts for Physical Delivery", in OR Spectrum, Vol 25, pp. 379 - 395.
Tapscott D (1999) "Creating Value in the Network Economy", in Harvard Business School Press, Boston.
Teece DJ, Pisano G, Shuen A (1997) "Dynamic Capabilities and Strategic Management", Strategic Management Journal, Vol 18, No 7, pp. 509 - 533.
Trigeorgis L (1996) "Real Options: Managerial Flexibility and Strategy in Resource Allocation", Cambridge, Massachusetts: MIT Press.