IMPACTS OF AUTONOMOUS COOPERATION-ENABLING TECHNOLOGIES ON THE CORPORATE VALUE OF LOGISTICS ENTERPRISES

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INTRODUCTION

The idea of autonomous cooperation seems to offer chances to improve efficiency and robustness of logistics processes (ten Hompel 2007). It is based on decentralised decision-making of self-ruling logistics objects that interact in heterarchical and non-deterministic systems (Windt & Hülsmann 2007). For an implementation, new technologies like RFID tags or self-controlling sensor networks are required. These technologies contribute to a higher degree of autonomous cooperation. These technologies are still under development and it has not been causally reasoned yet, if and how the implementation and utilisation of suchlike technologies in logistics processes affects returns and risks of the related companies financially (Hülsmann et al. 2010). Besides a real-option theory-based construction of a logical link between autonomous cooperation and control and the corporate value (Wycisk 2009), it remains still empirically unproved, whether autonomous cooperation-enabling technologies increase or decrease the corporate value of a logistics service providing company.

To answer this question, an empirical study on the development of share prices of 40 logistic service providing companies listed at the stock exchange as an exemplarily marker for the corporate value in dependence on announcements about technologies related to autonomous cooperation and control is conducted. This study compares three different groups of data for 2004 – 2010: the share price development (1) in the whole period without any announcements about technologies in general or related to autonomous cooperation and control, (2) on days directly after announcements about technologies in general, and (3) on days directly after announcements about autonomous cooperation-enabling technologies. Thereby, the share price development shall serve for two purposes: First, the statistical mean will be used as an indicator for effects on the corporate value; the more the share price increases the more positive is the effect of an announcement and vice versa. Second, the standard deviation will be utilised as an indicator for risks; the higher the fluctuation of the share price the higher the associated risk and vice versa. This study allows estimating value and risks effects according to announcements that indicate a planned or completed implementation of technologies in general and autonomous cooperation-enabling technologies in particular.

Besides an introduction in **Section 1** and conclusions in **Section 5** the paper comprises three major sections: **Section 2** will present the concept of autonomous cooperation and deduces the problem of value orientation for the decision-making about investments in technologies for Logistics Service Providers (LSP). A methodology for the empirical study will be carried out in **Section 3** by collecting relevant data (share prices and press announcements from 2004 – 2010) and assigning key indicators for this investigation (sta-

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tistical mean and standard deviation). In **Section 4** the hypotheses will be operationalized, tested and the results will be interpreted to gain insights to the research question.

AUTONOMOUS COOPERATION AS VALUE DRIVER FOR LOGISTICS SERVICE PROVIDERS

There is an increasing interest in the concept of autonomous cooperation and associated technologies. Examples for such technologies are RFID-tags (e.g. Ngai et al. 2008, Angeles 2005), sensor networks (e.g. Jedermann & Lang 2008, Jedermann et al. 2009) or even common internet-based tracking and tracing systems (e.g. van Dorp 2002, Stefansson & Tilanus 2000). They have in common that they increase the degree to which logistics objects are able to decide autonomously, decentralised from a central control entity and based on information that they got from other logistics objects through interactive activities. Hence, hierarchy levels are reduced and the possibility to forecast future developments of the respective logistics systems gets increasingly difficult up to impossible. Therewith, the following characteristics are constitutive for autonomous cooperation processes: autonomy, decentralised decision-making, interaction, heterarchy and non-determinism (Windt & Hülsmann 2007). Several effects of an increase of these characteristics have been already analysed, such as effects on the logistics system's robustness (Hülsmann et al. 2008b) or on its efficiency (Hongler & Gallay et al. 2010). The results of the research on positive as well as negative effects of autonomous cooperation having an impact on the logistics systems performance do not provide concrete information about the effects on the corporate value of the respective logistics enterprise though. However, according to Bowersox, Closs and Stank (2000), the increasing importance of value-based management of logistics processes is one out of the "ten mega-trends that will revolutionise supply chain logistics" (Bowersox et al. 2000). Consequently, it would not be sufficient to base decisions about investments in autonomous cooperation-enabling technologies on insights about their effects on efficiency and robustness of logistics processes. Instead, suchlike decisions are rendered with a focus on the effects on financial management ratios such as the Economic Value Added (EVA) or the Market Value Added (MVA) (Bowersox et al. 2000). More general, investment decisions are rendered in the area of conflict between returns on and risks of investments (Arditti 1967). Hitherto research on robustness and efficiency indicates both positive and negative impacts of autonomous cooperation on rents, for example through an increased strategic adaptivity (Hülsmann et al. 2008a), and on risks, for example through missing compatibility with technologies of business partners (Hülsmann et al. 2010). However, no net effects have been observed up to now on which investment decisions can be based.

There is a high diversity of methods that enable autonomous cooperation (Windt et al. 2010). Consequently, there is also a high diversity of different technologies that increase the characteristics of autonomous cooperation of logistics processes. Additionally there are many different potential application fields of autonomous cooperation in logistics – from transport to production logistics. Therefore, it can be assumed that the outcomes and effects of a decision to invest in implementing autonomous cooperation-enabling technologies are individually different. Hence, no general statement can be deduced that reflect all individual outcomes and provides security for the rents and risks of associated investments to be expected. However, what can be done is to reveal the average of all the effects of different implementations of autonomous cooperation-enabling technologies on the corporate value and associated risks. Therefore, the first question that arises is, whether or not there is an influence at all of autonomous cooperation-enabling technologies on the rents and risks of logistics companies. Hence, the following hypothesis is the first to be tested in this paper:

H1: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then its economic value does not change.

Second, if hypothesis 1 can be rejected, the question arises, if the influence is positive or negative. In other words: Does the economic value increase or decrease? This corresponds to a positive respectively a negative effect on the rents of an associated investment decision. Hence, hypothesis 2 reads as it follows:

H2: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then its economic value does not increase.

According to March and Shapira (1987) *"(…) risk is most commonly conceived as reflecting variation in the distribution of possible outcomes (…)"* (March & Shapira 1987, p. 1404). A suitable indicator for risks of an investment is the resulting variation of the economic value. Hence, hypothesis 3 has to reflect the interrelation between the use of autonomous cooperation-enabling technologies and the variations of the economic value:

H3: If the degree of autonomous cooperation in the logistics processes of a logistics enterprise increases, then the variations of the changes of its economic value are larger than without a change.

The verification of these three hypotheses provides insights into the average effects of an investment in autonomous cooperation-enabling technologies on rents (average growth of company value) and risks (variation of the company value's growth).

METHODOLOGY TO IDENTIFY VALUE EFFECTS OF AUTONOMOUS COOPERATION

The methodology of this study comprises three central parts for the estimation of an alteration of a logistics company's economic value, of an alteration of a logistics company's degree of autonomous cooperation and of the causal interrelationship: First, assumptions for the empirical framework. Second, the procedure for the data collection. Third, a development of suitable key indicators. The section continues next with the **assumptions**:

To estimate the economic value of a company, the share price of stock market listed companies can be utilised (Rapaport 1986). Following the market efficiency hypothesis (MEH) the value of all shares can be considered as an indicator for the company value at every point in time (Fama 1970). Accordingly, as the MEH assumes that all information is immediately available to all actors in a market an under or over evaluation is not possible (e.g. Franke & Hax 2004). However, several authors also mention that the MEH cannot be applied to real circumstances, since players in the market cannot act endlessly fast and not all information can be communicated immediately (Franke & Hax 2004). For example, the economy bubble in the beginning of the last decade demonstrates that overestimation of stock prices are not impossible (Kriegs & Diehm 2001). Additionally, information diffusion might be hampered due to information retention or media breaks in the communication process (Franke & Hax 2004). Verrechia (1979) demonstrate that in the case of a sufficient number of participants in the market reality is well approximated with the MEH (Verrecchia 1979). Consequently, the share price can be applied as an appropriate indicator for the company value:

Assumption 1: It is supposed that an upturn of cooperation's degree of autonomous cooperation influences the share prices of a company and the company value correspondingly.

To estimate an alteration of a logistics company's degree of autonomous cooperation (2), a way how to determine a change of this degree has to be developed. This paper follows the idea that the realisation of autonomous cooperation can be applied through implementing or increasing the utilisation of technologies enabling logistics objects to decide decentralised and autonomously as well as to interact with each other in a more and more heterarchical and non-deterministic system structure. Thus, it is likely if a company applies suchlike technologies that the degree of autonomous cooperation in its processes increases. Accordingly, the second assumption is formulated as follows:

Assumption 2: It is supposed that a logistics company's degree of autonomous cooperation will turn up when a company implements or extends the usage of a technology that enables autonomous cooperation in logistics processes.

Finally, the general causal interrelation between an application of autonomous cooperation-enabling technologies and share prices shall be operationalized. Following the MEH (available information influence the share price directly) it can be stated that (a) if the degree of autonomous cooperation influences a company's value and (b) this is reflected in the share price development (assumption 1) and (c) the degree of autonomous cooperation depends on the application of associated technologies (assumption 2), then announcements about an application of autonomous cooperation-enabling technologies will immediately affect the share price. Thus, the causal interrelation "announcement of autonomous cooperation-enabling technologies -> effect on share price -> effect on company value" can be applied. Accordingly the final assumption is:

Assumption 3: It is supposed that a logistics company's degree of autonomous cooperation will turn up when a company implements or extends the use of a technology that enables autonomous cooperation in logistics processes.

In conclusion, the share price is an adequate indicator for measuring effects of announcing an application of autonomous cooperation-enabling technologies on the share price of logistics companies. In other words: If suchlike technologies are applied and this is published, than the share price can be applied to estimate effects on the company value.

In order to reveal and investigate the interrelations the **relevant data** have to be collected and analysed. For collecting the required announcements of each investigated company from 2004 - 2010, the Dow Jones Factiva Database was used. It provides press reports from 28,500 sources covering 200 countries in 25 different languages including 900 newswires (DowJones & Company 2010). Therefore, it can be assumed that once information about the usage of autonomous cooperation-based technologies is released, it is nearly immediately available in the Factiva database. The database this study applies for the analysis is based on a three-step search examination. *The first step* is to seek the entire English speaking Factiva database by LSP company name and no else thematically restrictions. The result of this retrieval constitutes the entire information-base for the succeeding analysis. *The second step* is to filter thematically technology-related press reports (i.e. those addressing the usage of a technology). The result group will be used to check whether the potentially found effects on the company value are only due to the implementation or extension of usage of technologies in general without autonomous cooperation-related reports. For this purpose, a filter list based on conducted expert interviews was created containing commonly used tech terms in logistics (e.g. GPS, RFID or tracing). Additionally, a truncation system for enhancing matching was applied (e.g. synchronis*). *The third step* is to filter autonomous cooperation-related press reports out of the formerly identified technology-related ones. Hence, additional expert interviews were performed focusing on autonomous cooperation-related keywords (e.g. agent-based, communicate or autonomous). This list is a subset of the list with technology-related keywords and is also used with the truncation system. The data collection covers a representative group of 40 logistics companies and related information about utilisation of autonomous cooperation-enabling technologies as well as their share prices. In order to guarantee highest possible comparability, only companies listed at the same trading centre (i.e. Frankfurt Stock Exchange) were analysed reducing the total number of companies considered to 40. Additionally, as the share price development of a particular company depends on plenty of different factors, it is corrected for this investigation by the general market development. Thereby, just the change of a company related stock price independent from the market development can be obtained. Here, the "Deutscher Aktien Index" (DAX) was chosen, since it exhibits the 30 largest German stock market listed companies. The time span of this investigation covers the years 2004 - 2010, since autonomous cooperation is a relatively new concept and related technologies are still under development (Jedermann & Lang 2008). Accordingly, this analysis is based on the share prices of the 40 LSP listed at the Frankfurt Stock Exchange in the time span between January 2004 and September 2010. In order to be able to adjust the share prices to the DAX-development, it is firstly necessary to make them comparable. Hence, the DAX as well as each of the regarded company' share prices have to be normalised. For the normalised DAX/company I, the value X in time t is calculated as:

(1) $X_{DAX;t} = \frac{100}{X_{DAX;t-1}} \times X_{DAX;t}$ for all trading days at the Frankfurt Stock Exchange $t \in \{1 \dots n\}$ and $t_1 = 2004/01/02;\ t_n = 2010/09/30$.

(2) $X_{i;t} = \frac{100}{X_{i;t-1}} \times X_{i;t}$ for all companies $i \in \{1 \ldots k\}, k = 40$ and for all trading days at the Frankfurt Stock Exchange $t \in \{1 \ldots n\}$.

Of concern for this study is the growth G of each trading day, i.e. the difference between the normalised share price of company *i* in time *t* and the normalised share price of company i in time $t-1$. Hence, the resulting formula is:

(3) $\mathrm{G_{i;t}} = \mathrm{X_{i;t}} - \mathrm{X_{i;t-1}}$ and for the normalised DAX (4) $\mathrm{G_{DAX;t}} = \mathrm{X_{DAX;t}} - \mathrm{X_{DAX;t-1}}$

The correction to the general market development requires subtracting the growth of the DAX from the growth of the respective company i. The normalised and adjusted growth for company i in time t, which is the main value to be analysed, is therefore:

(5) $\mathrm{G_{I,adj;t}} = \mathrm{G_{I;t}} - \mathrm{G_{DAX;t}}$

Having the information about how to collect and normalise the relevant data the next section deals with the description of the development of appropriate **key indicators** to analyse effects of relevant technical announcements on a company's value. In the case of a data sample with more than one growth rate it is reasonable to focus on the respective mean (μ) (defined as $\mu = \frac{1}{n}\sum_{i=1}^{n} x_i$) in order to obtain an average value. An increase of the variations of the economic value of a company can be represented by the standard deviation (σ) (defined as $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$) of the growth of the share prices (e.g. Johnson & Bhattacharyya 2011). First, the difference of the adjusted and normalised share prices' mean (μ) growth after respective events and their adjusted and normalised 'normal' mean growth over a certain time period without these events will be examined. Second, the difference of the standard deviation (σ) of the adjusted and normalised share prices' growth after respective events and their 'normal' standard deviation over a certain time period without these events will be compared. Therefore, it is necessary to convert the data into key figures that reflect the arithmetic means and standard deviations of the regarded trading days. Thereby, three disjunctive groups of trading days were considered:

Group a: All trading days of company i except those after a publication of technology-related (including autonomous cooperation-based technologies) press reports; in the following referred to as $n_{i,a}$.
Group b: All trading days of company i after a publication of technology-related (excluding autonomous cooperation-based technologies) press reports; in the following referred to as $n_{i,b}$.
Group c: All trading days of company i after a publication of autonomous cooperation-based technology-related press reports; in the following referred to as $n_{i,c}$.

Thus, the total amount of trading days of a company i n_i contains the three disjunctive groups a, b and c, which can be calculated as follows: $n_i = n_{i,a} + n_{i,b} + n_{i,c}$.

According to the given formulas of the mean and standard deviation, the key figures for all companies are calculated for the three disjunctive groups a, b and c. Thereby, the formulas are adjusted as follows for the mean and the standard deviation (here exemplary demonstrated for Group a):

(6) $\mu_{i;a} = \frac{1}{n_{i;a}}\sum_{t_{i;a=1}}^{n_{i;a}} G_{i;adj;t;a}$ for all companies $i \in \{1 \ldots k\}, k = 40$ and for all regarded trading days at the Frankfurt Stock Exchange.

(7) $\sigma_{i;a} = \sqrt{\frac{1}{n_{i;a}}\sum_{t_{i;a=1}}^{n_{i;a}}\left(G_{i;adj;t;a} - \mu_{i;a}\right)^2}$

Correspondingly, the aggregated arithmetic mean of the normalised and adjusted growth of the open share prices of all the regarded companies $I = \{1 \ldots k\}$ is calculated by the sum of all share prices on each trading day of each group for each company divided by the sum of all trading days of each group of all companies (exemplary executed for Group a):

(8) $\mu_{I;a} = \frac{\sum_{i=1}^{k}\left(\sum_{t_{i;a=1}}^{n_{i;a}} G_{i;adj;t;a}\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;a=1}}^{n_{i;a}} t_{i;a}\right)}$ (9) $\sigma_{I;a} = \sqrt{\frac{\sum_{i=1}^{k}\left(\sum_{t_{i;a=1}}^{n_{i;a}}\left(G_{i;adj;t;a} - \mu_{i;t;a}\right)^2\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;a=1}}^{n_{i;a}} t_{i;a}\right)}}$

EMPIRICAL VALIDATION OF VALUE EFFECTS OF AUTONMOUS COOPERATION

This section develops operationalized hypotheses considering the assumptions in Section 3 to make the general hypotheses in Section 2 accessible to an empirical validation:

$H1_1$: The mean (μ) and the standard deviation (σ) of the growth of the share prices from the days the information came out to the following trading days are not different from the mean (μ) and standard deviation (σ) of the normalised and adjusted growth of the share prices over a representative period.

$H2_1$: If information about the usage of autonomous cooperation-related technologies becomes available, the mean (μ) of the growth of the share prices from the publication day to the following trading days (adjusted by the general market development) is not higher than the normalised and adjusted mean (μ) of the growth of the share prices over a representative period.

$H3_1$: If information about the usage of autonomous cooperation-related technologies becomes available, the standard deviation (σ) of the growth of the share prices from the publication day to the following trading days (adjusted by the general market development) is not lower than the normalised and adjusted standard deviation (σ) of the growth of the share prices over a representative period.

Only 28 out of the 40 companies were considered, since the remaining 12 comprises fewer than 37 relevant press reports and thus the results could not be proven statistically valuable. Therefore, 28 companies have been analysed regarding individual means, standard variations and number of investigated trading days. For assessing the hypotheses $H1_1$, $H2_1$ and $H3_1$, the aggregated values for every group (Group a, Group b and Group c) have to be compared, since these values reflect the impact of announcements about an implementation of autonomous cooperation-enabling technologies for all considered companies. Thus, at first the aggregated means for all companies are compared:

$$\mu_a = -0.0465; \quad \mu_b = -0.011; \quad \mu_c = 0.0143$$

Correspondingly, the share prices growth is higher after announcements of technology-related press reports (Group b) and still higher after publications of autonomous cooperation-related press reports (Group c) in contrast to the regular share price growth. Next, in order to analyse effects on variations the standard deviations are given:

$$\sigma_a = 2.6551; \quad \sigma_b = 2.7755; \quad \sigma_c = 2.833$$

Again, the share prices variation is slightly higher after announcements of technology-related press reports (Group b) and still higher after publications of autonomous cooperation-related press reports (Group c) in contrast to the regular share price variation.

This indicates that $H1_1$ ($\mu_{I;a} = \mu_{I;c}$ and $\sigma_{I;a} = \sigma_{I;c}$ as well as $\mu_{I;a} = \mu_{I;b}$ and $\sigma_{I;a} = \sigma_{I;b}$) can be rejected, since the data displays differences, especially in the aggregated arithmetic means. Second, $H1_2$ ($\mu_{I;a} > \mu_{I;c}$ and $\mu_{I;a} > \mu_{I;b}$) and $H1_3$ ($\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$) have to be regarded differentiated. Although the data exhibits that the arithmetic mean of the share prices is higher on the autonomous cooperation-relevant days than on average, as well as than on days after information about general technologies got published, the differences are marginal. Hence, there are indicators that hypothesis $H1_1$c can be rejected, but a clear rejection requires a larger amount of data and a deeper analysis about the significance of the differences. For the standard deviations, the data demonstrates also marginal differences. Moreover, both hypotheses cannot be rejected, since $\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$. Following the data and assumptions of the analysis, $H1_1$ can preliminary be rejected. With recourse to the corresponding general H1 that can be interpreted as: If the degree of autonomous cooperation is reflected in the usage of associated technologies, if this usage becomes public to the companies' shareholders in the form of press reports and if the share prices always reflect the true value of a company, then a change of the degree of autonomous cooperation affects a company's economic value. However, regarding the question if there is a positive or a negative effect on growth effects ($H1_2$) and the associated risks ($H1_3$), the data shows an unclear picture: Assuming the observed differences are significant and reflect a general pattern of a causal interrelationship between the use of technologies and the growth of share prices, the data indicates a positive correlation for the use of technologies in general and even stronger for the use of technologies that are associated with the concept of autonomous cooperation. Thus, H2 can be rejected. Moreover, the market seems to award companies that implement or increase the use of technologies in general. One reason could be that the use of technologies is seen as an indicator for being innovative or at least going with technological developments. The data also shows that the market seems to award companies even more that implement or increase the use of technologies that are associated with autonomous cooperation. The reason might also lie in the appraisal of traders that these technologies represent a new and innovative concept that, although not being diffused very much in the logistics practice, might promise additional benefits, such as higher robustness or efficiency of logistics processes. Subsuming, indicators have been found that autonomous cooperation does have a positive effect on the company value (reject H1 and H2) – but also increases the associated investment risks (do not reject H3).

CONCLUSIONS

The results demonstrate a slightly higher growth of the normalised and adjusted logistics companies' share prices, if the usage of autonomous cooperation-based technologies is announced. However, at the same time the related risks (variations) are also higher. Hence, the market expects an increased degree of autonomous cooperation leading to higher return on investments and concurrently to higher risks. However, the share price depends on various influencing factors not limited to the application of autonomous cooperation-enabling technologies. Although the general market development was considered, other possible influencing factors were not. The efficient market hypothesis is often criticised as being an unrealistic reflection of reality. Hence, the assumption that information of press reports is immediately (the next trading day) observable in the respective share prices does not necessarily reflect the truth. These potential limitations of the analysis' validity ascertain further research requirements: First, a deeper investigation of every press report to assign them to a positive, neutral or negative alteration of the degree of autonomous cooperation could help to improve the results. Additionally, a scaling of changes of the autonomous cooperation's degree should be elaborated to classify particular alterations. Second, the amount of both regarded companies and associated press reports can be increased to increase the probability that the (non-)rejection of a certain hypothesis would reflect the corresponding true causal interrelationship.

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