Effects of Autonomous Cooperation Enabling Technologies on the Growth of Share Prizes of Logistics Enterprises

Philip Cordes, Christoph Illigen,
Michael Hülsmann

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1 Introduction

Logistics is a sector, which is continuously more driven by value-based management.[1] Decisions on investments in technologies that enhance the logistics processes of logistics service providers require knowledge about their economic effects – expected returns on and risks of the investments. One recently discussed approach is the concept of autonomous cooperation in logistics processes, which describes decentralized decision-making of autonomous logistics objects that interact in heterarchical and non-deterministic systems.[2] Technologies, such as RFID tags or sensor networks, that enable companies to shift their controlling mechanisms from a high degree of external control to a higher degree of autonomous cooperation, are still under development but are already gaining attention in associated research[3] as well as in the logistics practice.[4] However, whereas there is preliminary knowledge about the effects on the ability of logistics companies to cope with the dynamics and complexity of today's logistics processes and business environments,[5] there is still a lack of knowledge about the economic effects of implementing such technologies into the logistics processes of a logistics service provider. In other words: It is not clear, how an implementation or an extension of usage of technologies that enable autonomous cooperation affects the economic value and the associated risks of logistics enterprises.

Correspondingly, the overarching research question, this article intends to address is, whether or not autonomous cooperation leads to positive value and risk effects for logistics enterprises. For this purpose, an empirical study on the development of share prices has been conducted. The share price serves in this case as an indicator for effects on value and risk of logistics companies. The purpose is to analyze the development of the share prices in dependence on publications regarding the usage of technologies that are based on autonomous cooperation.

The aims of this article follow the research process on the basis of KROMREY (2009),[6] according to which it is first necessary to define the research problem. This is conducted in section 2 by presenting the idea of autonomous cooperation and the value orientation of logistics service providers as well as by developing general hypotheses regarding the causal interrelations between autonomous cooperation and the value and risk of logistics companies.

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1 Bowersox, Closs & Stank (2000), Straube et al. (2005).

2 Windt, Hülsmann (2007), Hülsmann et al. (2007).

3 e.g. Jedermann, Lang (2007), Kärkkäinen (2003), Ngai et al. (2008), Böse, Piotrowski & Scholz-Reiter (2008).

4 e.g. Angeles (2005), Folinas, Patrikios (2008).

5 Hülsmann et al. (2006), Hülsmann, Grapp & Li (2008).

6 Kromrey, Strübing (2009).

Second, a methodology for the empirical study to be accomplished has to be developed. This is conducted in section 3 by assigning the growth of share prices (as an observable dimension for the value and risk) and public information about technology-usage (as an observable dimension for the degree of autonomous cooperation) to the general hypotheses and by deducing the underlying assumptions of the empirical study. Additionally, the respective data to be analyzed will be collected and key indicators for its analysis will be developed.

Third, the hypotheses have to be operationalized, tested and the results have to be interpreted in order to gain insights on the research question. This will be conducted in section 4. Finally, section 5 contains a summary of the results and their critical reflection with recourse to further research requirements.

2 Autonomous Cooperation as a Driver for the Value of Logistics Service Providers?

2.1 Autonomous Cooperation of Logistics Processes

Modern information and communication technologies like internet-based tracking and tracing systems[7], RFID tags[8] or sensor networks[9] gain more and more attention in logistics. What these technologies have in common is that they enable logistics objects (e.g. single products, pallets or containers) as well as human entities involved in logistics systems (e.g. employees or customers) to interact with each other, to exchange information and even to render decisions, which formerly would have been rendered by the respective management of a logistics system. One common example is a tracking and tracing system, which allows customers to receive information directly from the respective logistics object.[10] Further developments are expected that will enable logistics objects to decide autonomously, which routes and which transportation options to take, to negotiate with other objects the prices for transport capacities or even to speculate with such capacities and exchange information about promising speculating options via micro pricing strategies.[11] The underlying organizational principle is the idea of autonomous cooperation, which in turn is based on the idea of self-organization that originates in several different disciplines such as biology (autopoiesis[12]), physical chemistry (dissipative structures[13]) or mathematical physics (chaos theory[14]). They all have in common that they describe processes of autonomous order creation. This idea was taken on in the field of logistics, where autonomous cooperation 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"*.[15]

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7 e.g. van Dorp (2002), Stefansson, Tilanus (2000).

8 e.g. Ngai et al. (2008), Angeles (2005), Spekman, Sweeney II (2006).

9 e.g. Jedermann, Ruiz-Garcia & Lang (2009), Jedermann, Lang (2008).

10 e.g. van Dorp (2002), Stefansson, Tilanus (2000).

11 McKelvey, Wycisk & Hülsmann (2009).

12 Maturana, Beer (1980).

13 Prigogine 1955, Prigogine (1969).

14 Lorenz 1963, Mandelbrot (1961).

15 Windt, Hülsmann (2007), p. 8.

According to this definition, five constitutive characteristics of autonomous cooperation can be identified:

- Decentralized decision-making,
- Autonomy,
- Interaction,
- Heterarchy and
- Non-determinism.

Decentralized decision-making means that the decision-making processes in a system are shifted from a central control or management entity to the single system's elements (human as well as non-human elements). Following decision-making theory, this involves the ability of a goal-oriented selection between different action alternatives.[16] Hence, logistics objects in autonomous cooperating processes have firstly own goals, which they pursuit and secondly, they are allowed and enabled to render decisions about the way to achieve these goals.[17] These are also the preconditions for a system's element to be autonomous. Autonomy describes the ability of the elements of a system to decide upon their next steps by themselves.[18] Consequently, the elements have to be able to collect and process information relevant for their decisions and other resources that are necessary in order to execute these decisions. Hence, the elements must be able to interact with each other or with a central management or control entity. Autonomous interacting elements that decide by themselves upon their next steps can only exist in a system that is not 100 percent hierarchically ordered, since hierarchy requires super-ordinate entities that have the power to control elements on hierarchically lower levels. Hence, an autonomous controlled system needs a certain degree of heterarchy.[19] Finally, a heterarchical system structure with autonomous elements leads necessarily to a certain degree of non-determinism, which refers to an impossibility to predict future system states because the system structure is autonomously created by the interaction and the autonomous decisions of the system's elements.[20]

Consequently, an autonomously cooperating logistics system, whether it is in production or distribution logistics, does contain logistics objects – goods, parts, pallets, containers, etc. – that interact with each other via information and communication technologies. Moreover, these objects are able to decide autonomously and independently from a central control entity via certain decision and behavioral rules. The resulting heterarchical system is, to a certain degree, unpredictable in its development and future system states. Accordingly, there

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16 Laux (1998).

17 Windt, Hülsmann (2007).

18 Probst (1987).

19 to the term of heterarchy see Goldammer (2003) based on, McCulloch (1945).

20 Flaemig (1998).

seem to be risks of implementing this organization principle into logistics systems, since an unpredictable behavior might also lead to undesired system states and effects. Hence, the following question arises: why should the status quo of logistics processes – a high degree of external control – be replaced by a high degree of autonomous cooperation through an investment in associated technologies?

WINDT AND HÜLSMANN (2007) mention as the objectives of autonomous cooperation a higher robustness and a better ability to cope with complexity and dynamics.[21] Studies have shown positive as well as negative effects on the robustness of logistics systems[22] and on their ability to cope with complexity and dynamics.[23] However, in order to evaluate the contributions and limitations of the idea of autonomous cooperation and its technological realizations in logistics from an economic perspective, the following question has to be answered: How does an increased degree of autonomous cooperation affect the economic value and the associated risks of logistics companies?

2.2 Value Orientation of Logistics Service Providers

General financial theory states that any corporation is faced with two essential financial questions it has to answer: First, in what should the firm invest money? Second, how to raise this money?[24] Value orientation thereby means that suchlike business decisions are rendered in a way that the bounded equity capital generates a higher return than comparable investment alternatives.[25] Hence, the hitherto focus on the robustness and the ability to cope with complexity and dynamics seems not be sufficient for an economic evaluation of autonomous cooperation and its enabling technologies, since risks and returns of the related investments remain unknown. BOWERSOX, CLOSS AND STANK (2000) mention as one out of the *“ten mega-trends that will revolutionize supply chain logistics”* the increasing importance of value-based management of logistics processes: Whereas the goal orientation of logistics used to be dominated by the focus on decreasing costs or increasing revenues (e.g. through robustness and efficiency of logistics processes), today’s supply chain managers seek to maximize financial management ratios, such as the Economic Value Added (EVA) or the Market Value Added (MVA).[26] This corresponds with an empirical study of the German logistics association (Bundesvereinigung Logistik – BVL), which showed that German

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21 Windt, Hülsmann (2007).

22 Hülsmann et al. (2008).

23 Hülsmann et al. (2006).

24 Brealey (2008).

25 Wöhe, Döring (2000).

26 Bowersox, Closs & Stank (2000).

logistics companies do explicitly demand for a value orientation in logistics.[27] However, Straube et al. (2005) argue that there is a missing link between logistics and the company value, which results in a gap regarding a successful implementation of a value-based management in logistics.[28]

Hence, the decision to invest in logistics processes by implementing technologies that increase the degree of autonomous cooperation has to be rendered under consideration of not only its effects on logistics goals (e.g. high due date reliability[29]) but also on the company value. That raises the following question: How does an investment in technologies that enable autonomous cooperation affect the value of logistics corporations?

2.3 General Hypotheses for Value and Risk Effects of Autonomous Cooperation

Recent studies on the effects of autonomous cooperation outlined that it can provide logistics companies with the ability to cope better with complexity and dynamics due to an increase of the robustness of logistics processes[30] as well as of their efficiency.[31] Wycisk (2009) showed that an increase of autonomous cooperation leads to an increase of the company's strategic flexibility by providing several different flexibility options, which in turn have a positive influence on the company value.[32] Hence, the main hypothesis this paper wants to validate is that autonomous cooperation leads to an increase of the economic value of logistics companies.

This paper follows the critical rationalism as its ontological imperative and basis for the hypothesis formulation. Following Popper (1969), knowledge is always just preliminary because one general characteristic of knowledge is that it can be falsified.[33] Hence, proving hypotheses about the cause and effect chains between autonomous cooperation and the value of logistics companies to be true is not possible. Instead, the respective negative hypotheses will be formulated that can be rejected if the data allows it. This enables an approximation to the true causal interrelationships.

The first question that has to be answered is, if there is an influence at all. Hence, hypothesis 1 reflects the following causal interrelationship:

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27 Straube et al. (2005).

28 Straube et al. (2005).

29 e.g. Nyhuis, Rossi (2009).

30 e.g. Hülsmann et al. (2008).

31 Hongler et al. (2010).

32 Wycisk (2009).

33 Popper (1969).

> **Hypothesis 1.1:** If the degree of autonomous cooperation in the logistics processes of a logistics service provider increases (cause), then its economic value does not change (effect).

If there is an influence of autonomous cooperation on the economic value of logistics companies, the question has to be asked, if this influence is positive. Hypothesis 2 states therefore the following:

> **Hypothesis 1.2:** If the degree of autonomous cooperation in the logistics processes of a logistics service provider increases (cause), then its economic value does not increase (effect).

According to HÜLSMANN ET AL. (2010) there are indicators that autonomous cooperation has also an influence – positive as well as negative – on the risks of logistics service providers and their logistics processes.[34] MARCH AND SHAPIRA (1987) state that *"(…) risk is most commonly conceived as reflecting variation in the distribution of possible outcomes (…)"*.[35] Hence, one indicator for the risk of autonomous cooperation in logistics processes is the resulting variation of the economic value. Therefore, if there is an influence on the economic value, it is also of interest if the influence is subject to large variations or if it even decreases the variations of the economic value of logistics companies. Hence the third hypothesis to be analyzed is the following:

> **Hypothesis 1.3:** If the degree of autonomous cooperation in the logistics processes of a logistics service provider increases (cause), then the variations of the changes of its economic value are larger than without a change (effect).

These hypotheses reflect the overarching research question of this paper, for which a methodology will be developed in the following.

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[34] Hülsmann et al. (2010).

[35] March, Shapira (1987), p. 1404.

3 Methodology for an Empirical Study of Value and Risk Effects of Autonomous Cooperation

3.1 Assumptions of the Empirical Framework

The hypothesis that an increase of the degree of autonomous cooperation in logistics companies by using associated technologies influences the company value raises three main questions for an operationalization:

1. How to measure the alteration of the economic value of logistics companies?
2. How to measure an alteration of the degree of autonomous cooperation in logistics companies?
3. How to measure the causal interrelationship?

To start with the economic value: The value of a company can be regarded as the utility it gains for its owners.[36] Corporations that are listed on stock markets are owned by their shareholders. The main utility that they gain from owning shares is to get dividends and to be able to sell them on the market. The latter is dependent on the share price at the moment the owner wants to sell.[37] Following the information efficiency or market efficiency hypothesis (MEH) does the price of a share reflect its real value at every point in time.[38] The underlying assumption is that once new information that has influence on stock prices is available somewhere in the market, investors will immediately use it to buy or sell shares. Thus, the resulting price in turn fully reflects the available information. In other words, an over- or undervaluation is not possible.[39]

However, several authors – e.g. FRANKE AND HAX (2004) – argue that information efficiency in its strongest sense, which means that all the information is available to every participant in the market and their reaction time is endlessly fast, cannot be expected in real circumstances. Firstly, informational advantages of single persons or groups are possible. Otherwise insider profits would not exist.[40] Also the new economy bubble is a real example of long-time overestimation of stock prices.[41] Secondly, these advantages do not immediately lead to changes

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36 Rappaport (1986).

37 Brealey (2008).

38 Fama (1970).

39 e.g. Franke, Hax (2004), Spremann (2005).

40 Franke, Hax (2004).

41 Krings, Diehm (2001).

in the stock prices that reflect a new equilibrium, due to delays of information diffusion or volitional information retention.[42] Anyhow, VERRECCHIA (1979) shows that as long as the number of participants in the market is large, the stock prices, which are determined by expectations, vary as if the market participants' knew the development.[43] In other words: reality approximates the market efficiency hypothesis when the number of traders is large.

Consequently, the share price does not equal the value of a corporation but it can be seen as a meaningful indicator.[44] This leads to the first assumption for the empirical framework to be developed that enables an operationalization of the economic value of logistics companies:

> Assumption 1: It is assumed that an increase of the degree of autonomous cooperation in logistics processes influences the share prices of a logistics company – positive or negative – in the same correlative direction as their influence on the company value.

To proceed with the alteration of the degree of autonomous cooperation: The realization of autonomous cooperation takes place through an implementation or the change of usage of technologies that enable the logistics objects (whether they are human or non-human) to decide decentralized and autonomously as well as to interact with each other in a more and more heterarchical and non-deterministic system structure. Examples of suchlike technologies are RFID-tags, sensor networks or agent-based software tools.[45] Hence, if a company implements or extends the usage of some of these technologies, it is likely that the degree of autonomous cooperation of the company's logistics processes increases as a result. Therefore, the second assumption for the empirical framework is the following:

> Assumption 2: It is assumed that the degree of autonomous cooperation will increase when a company implements or extends the usage of a technology that enables autonomous cooperation in logistics processes.

Finally, the causal interrelationship between the share prices and the implementation or extension of usage of autonomous cooperation-based technologies has to be operationalized. That raises the question, how share prices are influenced in general. Following the efficient market hypothesis, available information do directly and immediately affect the share prices in a way that the current share prices always reflect the available information on the market and the associated true value of the shares.[46] Hence, if the degree of autonomous cooperation af-

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42 Franke, Hax (2004).

43 Verrecchia (1979).

44 e.g. Rappaport (1986).

45 Böse, Piotrowski & Scholz-Reiter (2008), e.g. Folinas, Patrikios (2008), Jedermann, Ruiz-Garcia & Lang (2009).

46 Fama (1970) see also, Franke, Hax (2004), Spremann (2005).

fects the value of logistics companies, if this becomes evident in the share prices (assumption 1) and if the degree of autonomous cooperation is dependent on the implementation or extension of usage of associated technologies (assumption 2), then it can be assumed that once information about the implementation or about the usage of autonomous cooperation-based technologies become available they will be immediately reflected in the share prices. Consequently, the third assumption is as follows:

> Assumption 3: It is assumed that the share prices will immediately react[47] when information about the implementation or extension of usage of autonomous cooperation-based technologies becomes available.

Consequently, one possibility to analyze the effects of using or extending the usage of technologies that enable autonomous cooperation is to analyze the development of share prices in dependence on respective information; in other words: the growth of share prices directly after information about the usage of technologies becomes available.

3.2 Methodology for the Data Collection

The object of interest in this study is the degree of autonomous cooperation in the logistics processes of logistics service providers and its effects on the economic value. An increase of the degree of autonomous cooperation is represented by the publication of information about the implementation or the extension of the usage of autonomous cooperation-based technologies in logistics processes. The value of logistics companies is represented by their share prices.

Relevant Stock Market Data

An increase of company value can be represented by the growth of the share prices. Hence, it is necessary to find a representative group of stock market listed companies for which firstly information about their share prices and their growth and secondly information about their usage of technologies are available over a longer time period. Pertinent sources of information about worldwide active stock market listed companies are internet portals with a focus on financial information. One of such portals is the website: http://www.finanzen.net. Searching for the branch “Logistics” leads to a list of 71 stock market listed logistics service providers.[48]

However, the growth of a certain company’s share price on a certain day does not necessarily reflect the effects of company internal alterations, such as an

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[47] This implies the assumption that the share prices will react positively or negatively if there is an influence of autonomous cooperation on the company values, and neutrally if there is no influence.

[48] finanzen.net.

increase of the degree of autonomous cooperation. Instead, the growth of share prices is dependent on a huge amount of influencing factors, one of which is the general market development, such as economic crises.[49] Hence, in order to minimize the risk that the general market development has a strong influence on the data to be analyzed, it is necessary to adjust the regarded growth rates by the growth rates of the whole market. Therefore, the question has to be asked: How much of the growth of the share prices is based on the individual company and how much is based on the general market development? Consequently, only the difference between these two variables is of interest for this analysis.

In order to ensure comparability between the respective share prices adjusted by an index that reflects the general market development, it is reasonable to choose only companies that are listed at the same trading center. 40 out of these 71 companies are listed at Frankfurt Stock Exchange (FSE) and have therefore been chosen for the analysis.

Correspondingly, the selected index for the adjustment of the share prices of the regarded companies by the general market development is the German Stock Index DAX (Deutscher Aktienindex). The DAX reflects the development of the 30 largest stock market listed companies and is generally assumed to be representative for the market development at the Frankfurt Stock Exchange.

The time span that is regarded ranges from January 2004 to September 2010. The reason why it would not be reasonable to go further into the past is that autonomous cooperation is a relatively new concept[50] and the associated technologies are still in development.[51] Hence, if companies have implemented autonomous cooperation-based technologies, the probability is high that they did not do so before 2004. Accordingly, this analysis is based on the share prices of the 40 logistics service providers listed at the Frankfurt Stock Exchange in the time span between January 2004 and September 2010.

The historic data about the share prices of the companies I = {1…40} is publicly available at pertinent Internet portals that provide financial information about stock market listed companies and their historic developments. One of such websites is http://finance.yahoo.com that provided the share price database for the 40 logistics service providers regarded in this study.

In order to be able to adjust the share prices by 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 normalized. For the normalized DAX-value X in time t the formula is:

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49 Edwards, Magee & Bassetti (2007), Welcker (1991).

50 One of the first scientific articles on this subject was published in 2004: Scholz-Reiter, Windt & Freitag (2004).

51 Jedermann, Lang (2008).

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

Correspondingly, for the normalized value of the share price *X* of company *i* at time *t* the formula is:

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

Of interest for this analysis is the growth *G* of each trading day, i.e. the difference between the normalized share price of company *i* in time *t* and the normalized share price of company *i* in time *t*–1. Hence, the resulting formula is:

(3) $G_{i;t} = X_{i_{norm};t} - X_{i_{norm};t-1}$

Correspondingly, the growth of the normalized DAX in time *t* is:

(4) $G_{DAX,t} = X_{DAX_{norm};t} - X_{DAX_{norm};t-1}$

The adjustment by the general market development requires to subtract the growth of the DAX from the growth of the respective company *i*. The normalized and adjusted growth for company *i* in time *t*, which is the main value to be analyzed in this study, is therefore:

(5) $G_{i_{adj};t} = G_{i;t} - G_{DAX;t}$

Finally, the question comes up, which share price on a certain trading day should be selected, since stock markets distinguish between the share price at the beginning of the day (open), at the end of the day (close), the daily high, the daily low as well as the daily mean.[52] Following the assumption of information efficient markets, it would be reasonable to select the share price that is as close as possible to the point in time when the information is published. Hence, the daily high, low and mean value can be sorted out since they do not give any information about the corresponding point in time on the respective day. Consequently, either the price at the beginning or the price at the end of the day can be selected. The appropriate selection, in turn, is dependent on the information that can be gathered and when this information is published.

Relevant Information about Usage of Autonomous Cooperation-based Technologies

Beside the share prices of the 40 regarded logistics companies, the second database that is needed in this study is the available information about the

52 Edwards, Magee & Bassetti (2007).

usage of autonomous cooperation-based technologies of each company and the exact time in which this information became available to the public in the time span between January 2004 and September 2010. One database that provides a wide range of company-related business and economic information is Factiva, provided by Dow Jones. Factiva contains press reports from 28.500 sources from 200 countries in 25 different languages, among which are 900 newswires.[53] Therefore, it can be assumed that once information about the usage of autonomous cooperation-based technologies in one of the 40 stock market listed logistics service providers comes up in form of a press report, whether it is from the company itself or from a newswire that reports about the company, it is nearly immediately available in the Factiva database.

Hence, the database this study uses for the analysis is based on a three-step search enquiry.

The first step is to search the entire English speaking Factiva database by the name of each logistics service provider to be analyzed and no else thematically restrictions. The result of this search constitutes the entire information-base for the following analysis.

The second step is to filter those press reports out of the entire amount of press reports found that are thematically technology-related, which means that the usage of a technology is addressed. This group of data will be used in order 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 and not due to technologies that are associated with autonomous cooperation in logistics. For this purpose, in the course of expert interviews a list has been developed that contains 185 keywords that are associated with technologies in logistics. These keywords range from specific technologies that are commonly used in logistics, such as GPS or RFID, to words that describe tasks of technologies in logistics, such as synchronization, tracing or tracking. Furthermore, a truncation system is used in order to match not only verbs and their conjugations but also associated nouns, e.g. synchronis* would match synchronize, synchronizes as well as synchronization. If none of these keywords is mentioned in a press report, the probability is assumed to be high that this press report does not contain information about the usage of technologies. Therefore, a search algorithm was used that sorted out these irrelevant press reports. Although it is not guaranteed that all of the remaining reports contain information about the implementation or extension of usage of technologies in logistics, it can be assumed that a significant share of it does.

The third step is to filter those press reports out of the remaining technology-related press reports that are thematically related to technologies, which are associated with the concept of autonomous cooperation. For this purpose a

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53 DowJones & Company (2010).

second round of expert interviews has been conducted in which a second list with autonomous cooperation-based technologies related keywords was developed. These keywords range from specific technologies that can be associated with the idea of autonomous cooperation, such as RFID or agent-based systems, to words that describe what these technologies do (e.g. locate or communicate), how they do it (e.g. wireless networks, decision algorithms) and what features result from their usage (e.g. smart parts, learning machines). This list is a subset of the list with technology-related keywords and is also used with the truncation system. Hence, the search algorithm was adapted and again used to sort out all press reports that did not mention autonomous cooperation-based technologies. Again, this does not guarantee that all of the remaining press reports contain information about the implementation or extension of usage of autonomous cooperation-based technologies. However, the probability is assumed to be high that the remaining press reports contain a large share of reports that inform about such an implementation or extension of usage.

Summary of Collected Data

With the collected data about the share prices as well as the press reports that contain information about the implementation or extension of usage of autonomous cooperation-based technologies, the question arises how they can be combined in order to be able to test the developed hypotheses 1.1-1.3. The idea is to oppose the normalized and adjusted growth rates of each logistics company to the days, on which information about the implementation or extension of usage of autonomous cooperation-based technologies became available. This raises again the question regarding the appropriate share prices (open or close) for this analysis.

Referring to the efficient market hypothesis, it is assumed that if there would be an influence of information about autonomous cooperation on the company values, then the normalized and adjusted growth rates would immediately react. However, the existing data gives information about the days on which information got available to the public, but it does not give any information about the exact time of the day the information got published. Hence, neither the open nor the close price of a share on a certain day would necessarily reflect all the information that was published on the same day. Rather, it is possible that information became available after the trading center has already closed. Hence, the next point in time for which there is a certainty that the information of a certain day is reflected in the share price is the open value of the following trading day.

In summary, the existing data to be analyzed in this study contains:

1. The normalized growth rates of the (open) share prices of all 40 logistics companies regarded in this study (adjusted by the normalized DAX development) on all trading days between January 2004 and September 2010.

2. All press reports out of the Factiva database that contain one of the keywords that indicate a technology relation of each of the 40 logistics companies between January 2004 and September 2010 and their publishing dates.
3. All press reports out of the Factiva database that contain one of the keywords that indicate a relation to autonomous cooperation-based technologies of each of the 40 logistics companies between January 2004 and September 2010 and their publishing dates.

3.3 Development of Key Indicators for the Data Analysis

In order to test the developed hypotheses with the collected data, the following question have to be answered:

Is the normalized and adjusted growth of the share price of a logistics company different when information about the implementation or extension of usage of autonomous cooperation-based technologies became available, than on all other trading days?

In the case of a data sample with more than one growth rate it is reasonable to focus on the respective mean (μ)[54]. An increase of the variations of the economic value of a company can be represented by the standard deviation (σ)[55] of the growth of the share prices.[56]

Hence, in order to analyze a reaction of share prices on certain events– the effect of a certain cause – it is reasonable to focus on two main indicators:

First, the difference of the adjusted and normalized share prices' mean (μ) growth after respective events and their adjusted and normalized 'normal' mean growth over a certain time period without these events.

Second, the difference of the standard deviation (σ) of the adjusted and normalized share prices' growth after respective events and their 'normal' standard deviation over a certain time period without these events.

Therefore, it is necessary to convert the gathered data into key figures that reflect the respective arithmetic means and standard deviations of the regarded trading days. Thereby, three disjunctive groups of trading days were considered:

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54 The arithmetic mean is defined as $\mu = \frac{1}{n}\sum_{i=1}^{n} x_i$.

55 The standard deviation is defined as $\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \mu)^2}$

56 e.g. Bleymüller (2008), Johnson, Bhattacharyya (2011).

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 $n_{i,c}$.

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

For this purpose it is first necessary to select all normalized and adjusted growth rates for the three groups:

$G_{i;a}$ for all companies $i \in \{1...k\}$ with k=40 and for all trading days without relevant press reports $t_{i;a} \in \{1...n_{i;a}\}$.

$G_{i;b}$ for all companies $i \in \{1...k\}$ with k=40 and for all trading days after a technology-related press report about a company *i* was published $t_{i;b} \in \{1...n_{i;b}\}$.

$G_{i,c}$ for all companies $i \in \{1...k\}$ k=40 and for all trading days before which an autonomous cooperation-based technology-related press report about a company *i* was published $t_{i;c} \in \{1...n_{i;c}\}$.

Accordingly, the first key figure necessary is the arithmetic mean of the normalized and adjusted growth rates of the share prices on all trading days between January 2004 and September 2010 for every single regarded company without those after a publication of technology-related (including autonomous cooperation-based technologies) press reports (group a):

(6) $\mu_{i;a} = \frac{1}{n_{i;a}} \sum_{t_{i;a}=1}^{n_{i;a}} G_{iadj;t_{i;a}}$ for all companies $i \in \{1...k\}$ with (*k*=40) and for all regarded trading days at the Frankfurt Stock Exchange without the days after relevant press reports $t_{i;a} \in \{1...n_{i;a}\}$.

The second and third key figures are the arithmetic means for the trading days after information regarding the usage of general technologies (group b) and autonomous cooperation-based technologies (group c) became available.

(7) $\mu_{i;b} = \frac{1}{n_{i;b}} \sum_{t_{i;b}=1}^{n_{i;b}} G_{iadj;t_{i;b}}$

(8) $$\mu_{i;c} = \frac{1}{n_{i;c}} \sum_{t_{i;c}=1}^{n_{i;c}} G_{iadj;t_{i;c}}$$

The standard deviations of the respective normalized and adjusted growth for the three groups of trading days are calculated as:

(9) $$\sigma_{i;a} = \sqrt{\frac{1}{n_{i;a}} \sum_{t_{i;c}=1}^{n_{i;a}} (G_{iadj;t_{i;c}} - \mu_{i;a})^2}$$

(10) $$\sigma_{i;b} = \sqrt{\frac{1}{n_{i;b}} \sum_{t_{i;b}=1}^{n_{i;b}} (G_{iadj;t_{i;b}} - \mu_{i;b})^2}$$

(11) $$\sigma_{i;c} = \sqrt{\frac{1}{n_{i;c}} \sum_{t_{i;c}=1}^{n_{i;c}} (G_{iadj;t_{i;c}} - \mu_{i;c})^2}$$

Correspondingly, the aggregated arithmetic mean of the normalized and adjusted growth of the open share prices of all the regarded companies *I= {1…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:

(12) $$\mu_{I;a} = \frac{\sum_{i=1}^{k} (\sum_{t_{i;a}1}^{n_{i;a}} G_{iadj,ta})}{\sum_{i=1}^{k} (\sum_{t_{i;a}=1}^{n_{i;a}} t_{i;a})}$$

(13) $$\mu_{I;b} = \frac{\sum_{i=1}^{k} (\sum_{t_{i;b}=1}^{n_{i;b}} G_{iadj,tb})}{\sum_{i=1}^{k} (\sum_{t_{i;b}=1}^{n_{i;b}} t_{i;b})}$$

(14) $$\mu_{I;c} = \frac{\sum_{i=1}^{k} (\sum_{t_{i;c}=1}^{n_{i;c}} G_{iadj,tc})}{\sum_{i=1}^{k} (\sum_{t_{i;c}=1}^{n_{i;c}} t_{i;c})}$$

The associated standard deviations are therewith:

(15) $$\sigma_{I;a} = \sqrt{\frac{\sum_{i=1}^{k} (\sum_{t_{i;a}=1}^{n_{i;a}} (G_{iadj;ta} - \mu_{i;ta})^2)}{\sum_{i=1}^{k} (\sum_{t_{i;a}=1}^{n_{i;a}} t_a)}}$$

$$(16)\quad \sigma_{I;b} = \sqrt{\frac{\sum_{i=1}^{k}\left(\sum_{t_{i;b}=1}^{n_{i;b}}(G_{iadj;tb} - \mu_{i;tb})^2\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;b}=1}^{n_{i;b}} t_b\right)}}$$

$$(17)\quad \sigma_{I;c} = \sqrt{\frac{\sum_{i=1}^{k}\left(\sum_{t_{i;c}=1}^{n_{i;c}}(G_{iadj;tc} - \mu_{i;tc})^2\right)}{\sum_{i=1}^{k}\left(\sum_{t_{i;c}=1}^{n_{i;c}} t_c\right)}}$$

4 Empirical Validation of Value and Risk Effects of Autonomous Cooperation

4.1 Operationalization of the Hypotheses

In order to make the general hypotheses developed in 2.3. accessible to an empirical validation, it is necessary to develop corresponding operationalized hypotheses that consider the assumptions given in 3.1:

Hypothesis 2.1: If information about the usage of technologies that are associated with autonomous cooperation becomes available (cause), the share prices do not react, neither in a positive nor in a negative way (effect). More precisely: 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 (adjusted by the general market development) are not different from the mean (μ) and standard deviation (σ) of the normalized and adjusted growth of the share prices over a representative period.

Hypothesis 2.2: If information about the usage of technologies that are associated with autonomous cooperation becomes available (cause), the mean (μ) of the growth of the share prices from the days the information came out to the following trading days (adjusted by the general market development) is not higher than the normalized and adjusted mean (μ) of the growth of the share prices over a representative period (effect).

Hypothesis 2.3: If information about the usage of technologies that are associated with autonomous cooperation becomes available (cause), the standard deviation (σ) of the growth of the share prices from the days the information came out to the following trading days (adjusted by the general market development) is not lower than the normalized and adjusted standard deviation (σ) of the growth of the share prices over a representative period (effect).

If the usage of autonomous cooperation-based technologies would not have any influence on the company value than the arithmetic mean of all trading days of a company and the respective standard deviation would not be significantly different from the arithmetic mean and standard deviation of the trading days after a press report was published that gives information about the implementation or extension of usage of autonomous cooperation-based technologies.

Hence, hypothesis 2.1 can be formulated as:

(18) $\mu_{i;a} = \mu_{i;c}$ and $\sigma_{i;a} = \sigma_{i;c}$ for the individual companies and

(19) $\mu_{I;a} = \mu_{I;c}$ and $\sigma_{I;a} = \sigma_{I;c}$ for the aggregated data of all companies regarded.

In order to check if this is also the case with the trading days after a press report was published that gives information about the implementation or extension of usage of technologies in general; the following equation has to be proved also:

(20) $\mu_{i;a} = \mu_{i;b}$ and $\sigma_{i;a} = \sigma_{i;b}$ for the individual companies and

(21) $\mu_{I;a} = \mu_{I;b}$ and $\sigma_{I;a} = \sigma_{I;b}$ for the aggregated data of all companies regarded.

If hypothesis 2.1 can be rejected, the question regarding the direction of differences arises.

Hence, **hypothesis 2.2** can be formulated as:

(22) $\mu_{i;a} > \mu_{i;c}$ for the individual companies and

(23) $\mu_{I;a} > \mu_{I;c}$ for the aggregated data of all companies regarded.

In order to check whether potential differences between the arithmetic means are due to the implementation of technologies in general and not due to autonomous cooperation-based technologies, it is also necessary to test the following hypotheses:

(24) $\mu_{i;a} > \mu_{i;b}$ for the individual companies and

(25) $\mu_{I;a} > \mu_{I;b}$ for the aggregated data of all companies regarded.

Consequently, **hypothesis 2.3** can be formulated as:

(26) $\sigma_{i;a} < \sigma_{i;c}$ for the individual companies and

(27) $\sigma_{I;a} < \sigma_{I;c}$ for the aggregated data of all companies regarded.

Correspondingly, it is necessary to check whether potential differences in the standard deviations are due to the usage of autonomous cooperation-based technologies or due to technologies in general. Hence, the following hypotheses have also to be tested:

(28) $\sigma_{i;a} < \sigma_{i;b}$ for the individual companies and

(29) $\sigma_{I;a} < \sigma_{I;b}$ for the aggregated data of all companies regarded.

Finally, the results of the hypotheses testing have to be transferred to the general hypotheses, developed in Section 2.3. That means that, if hypothesis 2.1, 2.2 and 2.3 can all be rejected, it is assumable that the implementation or extension of usage of autonomous cooperation-based technologies leads to a higher company value and a lower variation of the value, which indicates a lower risk.

4.2 Hypotheses Testing and Result Interpretation

Out of the 71 stock market listed logistics companies, 40 companies are listed at the Frankfurt Stock Exchange. These 40 companies are the basis of the analysis. However, only 28 out of the 40 companies were regarded in this analysis, since the rest comprises fewer than 37 autonomous cooperation-related press reports. Hence, the results of these companies could not be proven statistically valuable, as the database was too weak and therefore they were considered as outliers and ignored for the succeeding evaluation. Hence, the remaining group of companies for which the hypotheses testing is conducted accounts for $k=28$ ($l=\{1\ldots28\}$). Figure 1 provides an overview of the companies that are analyzed, the individual means and standard deviations of their normalized and adjusted growth rates on the trading days of the three regarded groups as well as the associated numbers of found press reports.

Investigation period: 2004 - 2010	All trading days without technology-related and autonomous cooperation-related press reports		All trading days with technology-related press reports (excluding autonomous cooperation-related press reports)		All trading days with autonomous cooperation-related press reports		Number of investigated press reports		
	Group a		Group b		Group c				
Company	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Arithmetic mean	Standard deviation	Total number	Technology-related	Autonomous cooperation-related
AirTran Holdings Inc.	-0.0111	1.8126	-0.2127	3.6689	-0.0220	1.9894	7156	4185	1310
AMCOL International Corp.	-0.0287	3.0663	0.2890	4.0574	-0.1873	5.7036	854	504	141
Brambles LtdShs	0.0421	2.2110	0.1563	2.6608	0.0640	3.0098	1012	455	116
C.H. Robinson Worldwide Inc.	-0.0320	3.0714	0.1458	3.6551	0.1826	3.7304	1228	538	367
China Merchants Holdings Co. Ltd.	0.1535	5.3727	-0.4658	3.7915	0.9317	5.8877	805	374	113
Con-Way Inc.	0.0196	2.2003	-0.0788	2.5539	-0.2768	2.8706	1595	956	395
Dai Nippon Printing Co. Ltd. (DNP)	-0.0607	1.9363	0.0186	2.2167	-0.1081	1.8850	1376	1189	497
Deutsche Post AG	-0.2396	1.4268	-0.0015	1.4794	-0.0398	1.6599	27569	15756	6563
DP World Ltd.	-0.2477	2.5212	-0.1044	2.6479	0.0218	2.8134	2906	1631	561
FedEx Corp.	0.0030	1.9910	-0.1880	2.0470	0.0054	2.2120	18918	13288	4746
Hamburger Hafen und Logistik AG	0.0714	2.5046	-0.0974	2.2812	-0.1433	1.5570	732	484	387
Heyde AG	-0.0991	1.6832	-0.6684	3.0145	0.2686	2.7473	197	197	146
Kawasaki Kisen Kaisha Ltd.	-0.0761	2.9875	-0.2459	3.4701	-0.0979	3.5208	3895	1548	560
Landstar System Inc.	-0.0293	2.7472	0.0859	2.9465	0.5563	3.8489	1093	558	226
Logwin AG	-0.1347	2.5369	-0.1637	2.5703	-0.3731	2.7690	573	416	146
Metcash LtdShs	-0.0002	2.0557	0.0005	1.8643	-0.3227	2.1660	653	419	69
Neopost S.A.	0.1937	9.8767	-0.1335	4.3223	-0.0935	3.6057	1277	872	485
Nippon Express Co. Ltd.	-0.0262	2.2245	-0.1675	2.4356	-0.1677	2.2316	3217	899	503
Pacer International Inc.	-0.0826	2.6426	0.0940	3.5721	-0.6711	4.0369	881	498	175
Rowan Cos. Inc.	-0.0526	2.8665	-0.2581	3.2531	0.2597	3.1784	2043	1127	516
Siam Cement PCL	-0.0556	2.1481	0.0833	2.3451	0.0212	2.2893	4938	3256	932
Swisslog Holding AG (N)	-0.1522	2.2212	-0.2449	3.7114	0.1573	2.0788	1668	798	407
Teleplan International N.V.	-0.0657	1.9966	0.4076	3.6489	0.0087	1.9555	555	513	401
Tsakos Energy Navigation Ltd.	-0.1824	2.3252	1.9492	1.4959	0.1709	2.4579	890	426	878
TUI AG	-0.0732	1.4459	0.0590	1.6948	-0.0692	1.8971	13958	6847	2286
United Parcel Service Inc.	-0.0430	1.6024	-0.0601	1.7008	-0.0595	1.8610	20377	13583	5932
Werner Enterprises Inc.	-0.0371	2.3449	-0.5144	2.4525	0.3136	3.0112	1065	600	203
Yamato Holdings Co. Ltd.	-0.0554	2.5243	0.0083	2.1564	0.0696	2.3497	2019	1487	220
Aggregated Values	**-0.0465**	**2.6551**	**-0.0110**	**2.7755**	**0.0143**	**2.8330**	**123,450**	**73,404**	**29,281**

Figure 1: Analyzed companies, individual means, standard deviations and no. of press reports.

Exemplarily, the individual values for the company FedEx Corp. will be presented. A total amount of 18,918 press reports have been found. Out of these an amount of 13,288 contain at least one of the technology-related keywords (see appendix 1) and an amount of 4,746 contain keywords that can be associated with autonomous cooperation-based technologies (see appendix 2). Between January 2004 and September 2010, FedEx Corp. was traded at the Frankfurt Stock Exchange on $n_{FedEx}=$ 1,743 days. However, several trading days are assigned to more than one press report. In order to prevent that they are counted more than once, each day is assigned to only one press report. Hence, the regarded trading days for the groups b and c differ from the amount of found press reports. The group c is calculated as the difference of the overall trading days and the groups b and c. Therewith, the regarded trading days for the groups a, b and c account for $n_{FedEx;a} = 35$, $n_{FedEx;b} = 269$, $n_{FedEx;c} = 1{,}439$.

The calculated arithmetic mean of the normalized and adjusted growth rates on the trading days of group a accounts for $\mu_{FedEx;a} = 0.003$; the associated standard deviation for $\sigma_{FedEx;a} = 1.991$. However, the arithmetic means of the normalized and adjusted growth rates on these trading days account for $\mu_{FedEx;b} = -0.188$ and $\mu_{FedEx;c} = 0.0054$; the associated standard deviations for $\sigma_{FedEx;b} = 2.047$ and $\sigma_{FedEx;c} = 2.212$. For the equations given in **hypothesis 2.1** the FedEx Corp. values are:

(18)* $\mu_{FedEx;a} = 0.003 \neq \mu_{FedEx;c} = 0.0054$

and $\sigma_{FedEx;a} = 1.991 \neq \sigma_{FedEx;c} = 2.212$

(20)* $\mu_{FedEx;a} = 0.003 \neq \mu_{FedEx;b} = -0.188$

and $\sigma_{FedEx;a} = 1.991 \neq \sigma_{FedEx;b} = 2.0470$

Hence, $\mu_{FedEx;b}$ is 0.191 lower and $\mu_{FedEx;c}$ is 0.0024 higher than $\mu_{FedEx;a}$; $\sigma_{FedEx;b}$ is 0.056 and $\sigma_{FedEx;c}$ is 0,221 higher than $\sigma_{FedEx;a}$.

Correspondingly the equations given in **hypothesis 2.2** read as follows:

(22)* $\mu_{FedEx;a} = 0.003 < \mu_{FedEx;c} = 0.0054$

(24)* $\mu_{FedEx;a} = 0.003 > \mu_{FedEx;b} = -0.188$

The equations given in the **hypothesis 2.3** account for:

(26)* $\sigma_{FedEx;a} = 1.991 < \sigma_{FedEx;c} = 2.212$

(28)* $\sigma_{FedEx;a} = 1.991 < \sigma_{FedEx;b} = 2.047$

Therefore, on the one hand the normalized and adjusted share prices of FedEx Corp. grew on average stronger on the days' information about the usage of autonomous cooperation-based technologies at FedEx. Corp. became available than on overall average but they shrank on the days after information about technologies in general was published. On the other hand, the share prices varied more on these days than on the overall average and on the days after information about general technologies got published.

In order to analyze whether or not there is a pattern observable that confirms or disconfirms these differences over all the regarded companies, it is necessary to compare the aggregated values. The corresponding total amount of press reports that have been found in the Factiva database for the time span January 2004 to September 2010 is 123,450. Out of these press reports the total amount of reports that contains at least one of the keywords for a technology-relation (see appendix 1) is 73,404. The total amount out of these press reports that contain at least one of the keywords for an autonomous cooperation-based technology-relation (see appendix 2) is 29,281. By subtracting the press reports that are double or more on a certain day the following values result:

$\sum_{i=1}^{k=28} n_a$=22,338, $\sum_{i=1}^{k=28} n_b$=7,214 and $\sum_{i=1}^{k=28} n_c$=11,495.

Hence, the sum of these values is the overall amount of regarded trading days of the 28 companies: $\sum_{i=1}^{k=28} n$ =41,047.

The aggregation of the individual arithmetic means leads to the following values:

$\mu_{I;a}$ = -0.0465; $\mu_{I;b}$ = -0.011; $\mu_{I;c}$ = 0.0143

As it can be seen in Figure 2, by considering all analyzed companies there is an observable difference that does not confirm the numbers depicted in the example of FedEx Corp, but indicates a tendency:

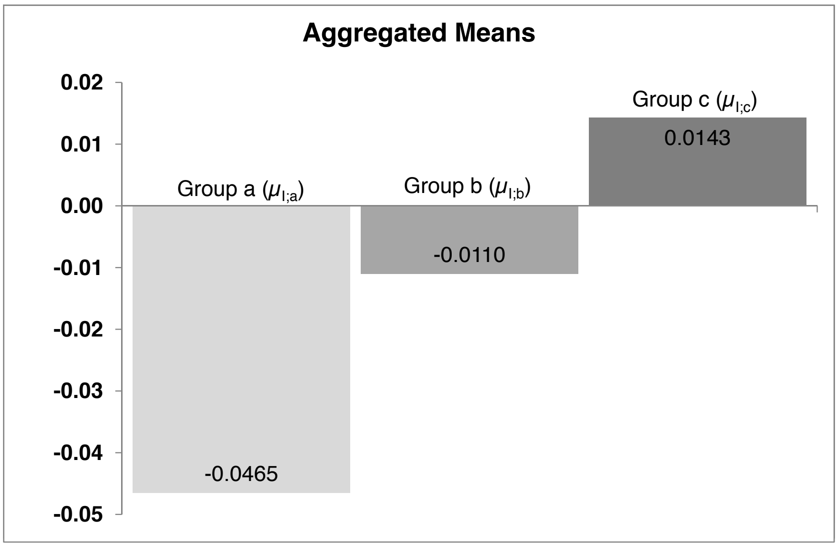

Figure 2: Aggregated arithmetic means.

Compared to group a, the normalized and adjusted share prices grew on average stronger (respectively decreased less) on the days after information about the usage of technologies was published (group b) (Diff.= 0.0355) and increased even more on the days, this information contained keywords that can be associated with the concept of autonomous cooperation (group c)(Diff.= 0.0608).

Correspondingly, the standard deviations for the normalized and adjusted share prices can be calculated:

$\sigma_{I;a}$ = 2.6551; $\sigma_{I;b}$ = 2.7755; $\sigma_{I;c}$ = 2.833

As it can be seen in Figure 3, there is also an observable difference between the standard deviations, which confirms the assumed pattern, observed in the example of FedEx Corp: The standard deviations for the share prices on the days after autonomous cooperation technology-related news got published (group c) are slightly higher than the standard deviations over all the trading days (group a) (Diff.= 0.1779); the standard deviation of the share prices is also higher on days with general technology-related announcements (group b), compared to group a (Diff.= 0.1204).

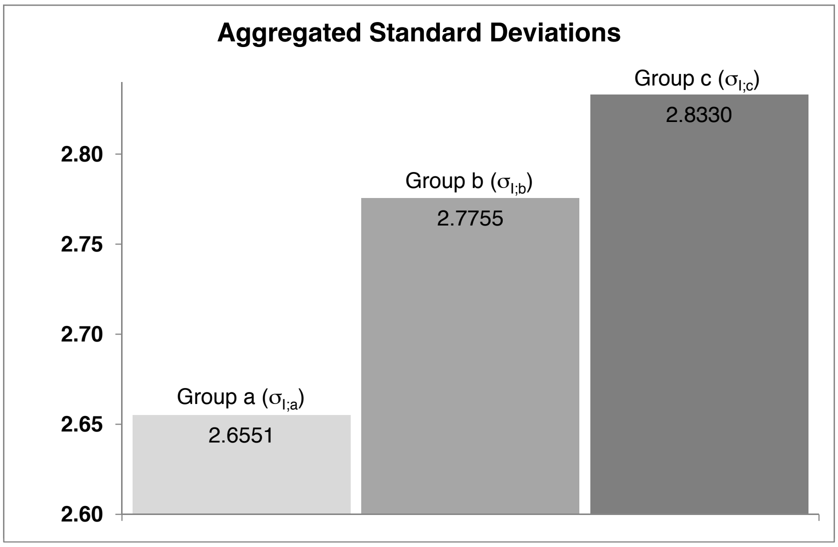

Figure 3: Aggregated standard deviations.

Consequently, the equations for the hypothesis 2.1 read as follows for the aggregated values:

(19)* $\mu_{I;a} = -0.0465 \neq \mu_{I;c} = 0.0143$

and $\sigma_{I;a} = 2.6551 \neq \sigma_{I;c} = 2.833$

(21)* $\mu_{I;a} = -0.0465 \neq \mu_{I;b} = -0.0110$

and $\sigma_{I;a} = 2.6551 \neq \sigma_{I;b} = 2.7755$

For the hypothesis 2.2 the data shows the following:

(23)* $\mu_{I;a} = -0.0465 < \mu_{I;c} = 0.0143$

(25)* $\mu_{I;a} = -0.0465 < \mu_{I;b} = -0.0110$

The equations given in hypothesis 2.3 finally read as follows:

(27)* $\sigma_{I;a} = 2.6551 < \sigma_{I;c} = 2.833$

(29)* $\sigma_{I;a} = 2.6551 < \sigma_{I;b} = 2.7755$

What does this data indicate about the validity of the developed hypotheses?

First of all, on a preliminary basis hypothesis 2.1 ($\mu_{I;a} = \mu_{I;c}$ 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 shows that there are differences observable, especially in the aggregated arithmetic means.

Second, **hypothesis 2.2** ($\mu_{I;a} > \mu_{I;c}$ and $\mu_{I;a} > \mu_{I;b}$) and **hypothesis 2.3** ($\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$) have to be regarded differentiated. Although the data shows 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 2.1 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 show the following: First, the differences are also marginal. Second, for both hypotheses counts that they cannot be rejected, since $\sigma_{I;a} < \sigma_{I;c}$ and $\sigma_{I;a} < \sigma_{I;b}$.

How can these results now be interpreted in order to gain insights on the overarching research question of this working paper?

Following the data and the underlying assumptions of the analysis, hypothesis 2.1 can preliminary be rejected? With recourse to the corresponding general hypothesis 1.1 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 (hypothesis 2.2) and the associated risks (hypothesis 2.3), the data shows an unclear picture: Assuming the observed differences are significant and reflect a general pattern of a causal interrelationship between the usage of technologies and the growth of share prices, the data indicates a positive correlation for the usage of technologies in general and even stronger for the usage of technologies that are associated with the concept of autonomous cooperation. Hence, the market seems to award companies that implement or increase the usage of technologies in general. One reason could be that the usage 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 usage 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.

Therefore, the data can be seen as an indicator that hypothesis 1.2 can be rejected: It does not seem to be true that the economic value does not increase, if a company increases its degree of autonomous cooperation by investing in associated technologies.

The question regarding the associated risks is addressed by hypothesis 2.3 and its corresponding general hypothesis 1.3. Assuming the observed differences are significant and reflect a general pattern of a causal interrelationship between the usage of technologies and the variation of growth of share prices, the data indicates the following relations:

First, the market seems to appraise the implementation or increase of usage of technologies in general to be connected with a certain risk. This is represented by the higher volatility of the growth of share prices on the respective days. One explanation could be that the implementation of new technologies is usually connected with costly investments, whereas the associated benefits resulting from these investments are not assured. Additionally, new technologies might include risks of inherent errors, which are not explored by the time of the investments, which could lead to operational problems.

Second, the market seems to appraise the implementation or increase of usage of autonomous cooperation-based technologies with a higher risk compared to other technologies. The reason for this might lie in the fact that the idea of a fully autonomously controlled logistics process is still a vision that is not realized yet. The associated technologies that enable logistics objects to interact autonomously and to decide decentralized from a central management upon their next steps in heterarchical and non-determinant system structures are still under development. Hence, the idea has not proven to be successful yet and to lead to benefits that outperform the associated costs and risks.

Therefore, the data can be seen as an indicator that hypothesis 1.3 cannot be rejected: It seems to be true that the economic value does vary more, if a company increases its degree of autonomous cooperation by investing in associated technologies. This insight gains in significance, as the data indicates also that the implementation or increase of usage of technologies in general seems to lead to lower variations of the growth of share prices than the average.

Subsuming, indicators have been found that autonomous cooperation does have a positive effect on the company value but a negative effect on the associated investment risks.

5 Conclusions and Critical Reflection

The central research question of this working paper is the interrelationship between the degree of autonomous cooperation and the value and risks of logistics companies. The chosen research approach is an empirical study of the observable dimensions growth of stock market prices and publication of information about the usage of autonomous cooperation-based technologies. The analyzed data shows that the normalized and adjusted growth of logistics companies' share prices is on average higher on the trading days after information about the usage of autonomous cooperation-based technologies got published, compared to trading days without such a publication. However, the variation of the growth is also slightly higher. Hence, this indicates that the market expects the concept of autonomous cooperation and the respective implementation or extension of usage of associated technologies to lead to higher return on investments but also to higher risks.

These results correspond to several existing studies whose subject is to analyze effects of autonomous cooperation on indicators such as the robustness or the efficiency of logistics processes.[57] It has been shown for instance, that an increase of autonomous cooperation can foster the replication and reconfiguration of organizational competences. This, in turn, contributes to the logistics company's ability to balance between a high stability on the one hand and a high flexibility of logistics processes on the other hand.[58] The latter, in turn, is realized through so-called flexibility options, for instance the option to change transportation routes or the option to reduce capacities on short term.[59] Overall, a higher degree of autonomous cooperation can contribute to the strategic adaptivity of logistics companies, which is essential for achieving and maintaining competitive advantages on logistics markets.[60] Investors seem to acknowledge suchlike effects that can result from the concept of autonomous cooperation in general and from the usage of associated technologies, which might explain the higher arithmetic mean of growth of the adjusted share prices: They expect future benefits of increasing the degree of autonomous cooperation in logistics processes.

However, studies have also shown that implementing new technologies and approaches into logistics systems bears several risks. For instance, companies incorporate strategic risks when they implement a new technology, which itself as well as its effects are not widely investigated up to now. They act as so-called

[57] see for instance Hongler et al. (2010) for the efficiency of decentralized control of logistics processes or Hülsmann et al. (2008) for the effects on the robustness.

[58] Hülsmann, Grapp & Li (2008).

[59] Wycisk (2009).

[60] Hülsmann, Grapp & Li (2008).

first movers[61] by introducing these technologies in the market. Therewith, they bear the entire risks and costs caused by the implementation whereas most technologies are easily imitable and competitors benefit through the observable first movers' experience.[62] Other possible risks are, beside others, operations risks, supply risks or reputation risks[63] that can be increased through the usage of autonomous cooperation technologies.[64] The results of this working paper show that investors seem to be aware of suchlike risks and that they evaluate them to be higher compared to "standard" technologies that have already proven to be successful. This might explain the higher standard deviation of the growth of the adjusted share prices: The expected future benefits are taken into perspective through the expected higher variations of those benefits, including possible losses.

However, the results of this working paper have to be reflected critically since the chosen methodology comprises a few shortcomings that might put the validity of this result into perspective, three of which are discussed in the following:

First of all, the share price is of course not only dependent on the usage of technologies. Instead, there is a large amount of potential influencing factors, which are only partly taken out of the analysis by the normalization and the adjustment of the share prices by the development of the DAX.

Second, the efficient market hypothesis is often criticized to be an unrealistic reflection of the 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. Instead, it could be possible that it takes a while for the diffusion of share price-relevant information.

Third, the keywords that are the basis for the selection of press reports that contain information about the usage of (autonomous cooperation-based) technologies is based on expert interviews, but might either be too narrow or too wide. The former would lead to a disregard of press reports important for the analysis. The latter would mean that irrelevant press reports would be considered. Furthermore, the pure mentioning of an autonomous cooperation-based technology does not necessarily mean that the degree of autonomous cooperation is increased and it does not provide any information regarding the extent to which the degree of autonomous cooperation is changed. These aspects might blur the results of this analysis.

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[61] Regarding first mover advantages and risks see Howell, Higgins (1990).

[62] Hülsmann et al. (2010).

[63] Harland, Brenchley & Walker (2003).

[64] Hülsmann et al.(2010).

These potential limitations of the validity of the analysis lead to further research requirements. Three possible extensions of the empirical study are the following:

First, it is necessary to look deeper into every press report and to assign them to a positive, neutral or negative alteration of the degree of autonomous cooperation. Additionally, a classification is necessary that assigns the individual alterations to a certain scale, which would answer the question, to which extent the degree of autonomous cooperation has been changed.

Second, the amount of both regarded companies and associated press reports can be increased in order to increase the probability that the (non-) rejection of a certain hypothesis would reflect the corresponding true causal interrelationship in the real world.

Third, statistical tests are necessary in order to analyze whether or not the differences in the normalized and adjusted share prices growth can be regarded as significant and with the acceptance of which α respectively β mistake.

Nevertheless and despite these limitations of the analysis, implications for the logistics practices can be deduced: The implementation or extension of usage of autonomous cooperation technologies in order to increase the degree of autonomous cooperation in logistics processes might lead to positive value but to negative risk effects. Therefore, it is reasonable for logistics service providers to take the option to invest in autonomous cooperation-based technologies into consideration in dependence on their individual risk aversions.

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Strategic decisions on the investment in autonomous cooperation-based technologies, such as RFID-tags or sensor networks, require knowledge about the returns and associated risks to be expected. Therefore, the question arises, whether or not autonomous cooperation leads to positive value and risk effects for logistics enterprises. For this purpose, an empirical study on the development of share prices of logistics companies in dependence on the use of autonomous cooperation-based technologies has been conducted. Means and variations of the adjusted growth of share prices serve as indicators for effects on value and risk of logistics companies. The publication of press reports about the usage of autonomous cooperation-based technologies serves as indicator for alterations of the degree of autonomous cooperation in a company. The results of this study show that share prices grew stronger but varied more when logistics companies published information about the use of autonomous cooperation-based technologies. This indicates positive value effects but a high risk of associated investments.

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