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THE "DARK SIDE" OF BIG DATA ANALYTICS – UNCOVERING PATH DEPENDENCY RISKS OF BDA-INVESTMENTS

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Abstract

Recently, information systems (IS) literature has shown an increasing interest in Big Data and Analytics (BDA) to gain competitive advantages. The predominant literature focuses on operational effectiveness and how companies use historical information and uncover hidden patterns to differentiate from competition. This paper addresses how the prevailing line of reasoning is limited and how strategic risks from companies' BDA-applications are neglected. Drawing on the theory of path dependency and resource-based view, it aims to expand the hitherto strongly IT-capability-oriented view of competitive advantages from BDA, in particular through greater involvement in current strategy research and by disclosing previously underexposed risk dimensions. A qualitative research shall be conducted to explore possible strategic risk dimensions associated with BDA-investments in greater detail. To reconstruct the process of BDA-investments and capability-building of firms in the maritime logistics sector, a qualitative process study seems appropriate to explore constitutive features of path formation and detect early indicators for path dependency.

Keywords: Big data and Analytics; strategic risks; path dependency theory; qualitative process study

1 Introduction and Research Questions

Within over 20 years of effort and investment, Marriot International has established a revenue management system built on hordes of historic customer data and trained algorithms to beat their competitors with optimal pricing (Davenport, 2006). 11 years ago, a new competitor (Airbnb) emerged and developed a platform that matches hosts and guests by using data sciences to identify individual customer preferences, strongly benefitting from network effects (Gupta and George, 2016). Clearly, both businesses have successfully made use of Big Data and Analytics (BDA) to differentiate themselves from their competitors. However, Marriott's initial success is being increasingly challenged by the new entrant who has a different technology-driven strategic pattern. Consequently, Marriott's approach using BDA for optimal pricing turns out to be a source of rigidity. Similarly, due to heavy BDA-investments and positive feedbacks produced by algorithms, it is becoming increasingly unlikely and inefficient for Airbnb too, to switch to alternative strategic patterns in the advent of future threats. This introducing example of path dependency is illustrative for the potentially beneficial but at the same time harmful strategic consequences of BDA. Former BDA-capabilities may have the potential to stabilize companies' strategic paths and to narrow possible competitive reactions in the future.

Our research question therefore is, **why and how BDA-investments may generate significant strategic risks for businesses' competitive advantages.**

A large body of literature addresses the increasing interest in BDA and its relevance for gaining competitive advantages (see e.g. Barbosa, de la Calle Vicente, Ladeira and de Oliveira, 2018; Davenport, 2014; Erevelles, Fukawa and Swayne, 2016; Grover, Chiang, Liang, and Zhang, 2018; Gunasekaran, Papadopoulos, Dubey, Fosso Wamba, Childe, Hazen and Akter, 2017; Shanks and Sharma, 2017). The predominant line of reasoning seems to be: BDA leverage historic information and uncover hidden patterns to develop new products (Porter and Heppelmann, 2014) or improve organizational processes (Chen, Preston and Swink, 2015). However, this logic is strongly rooted in an operational effectiveness framework and fails to recognize the strategic side effects of this landmark decision. In this paper we are going to discuss potentially threatening implications of BDA-investments for the strategic positioning and the strategic thinking of businesses. With this paper, we seek to make two specific contributions:

1 We are expanding the hitherto strongly IT-capability-oriented view of competitive advantages from BDA, in particular through greater involvement in current strategic research and by disclosing previously underexposed risk dimensions.

2 By building on these (potential) risk dimensions, our empirical approach strives to explore possible strategic risk dimensions associated with BDA-investments in greater detail. Therefore, in the following, we will use the method of a *qualitative process study*, which seems appropriate to identify how BDA-investments create strategic risks for companies. Specifically, a qualitative case study research shall be conducted. By taking a process perspective the authors aim to reconstruct the process of BDA-investments and capability-building of firms in the maritime logistics sector, thereby exploring constitutive features of the self-reinforcing processes of path formation.

2 BDA and Competitive Advantages – State of the current Discussion

It is probably reasonable to examine the current discussion on the role of BDA in achieving competitive advantages on two (interrelated) levels:

A) The first line of discussion focuses on the *direct relationships* between BDA-investments and competitive advantages. The prevailing literature emphasizes the importance of BDA for strategic differentiation by providing a unique value proposition. It thereby focuses on using BDA to create differentiation that avoids competition based on an equal value proposition and to propose a novel value that is perceptible by the customer. In simplified terms, the reasoning is that by using BDA, customer needs hidden "deep in the data" can be satisfied better. On the one hand, this can be achieved through the development of new products or services, and on the other hand, through more efficient processes. As in the example of Marriot, businesses can use large amounts of data and customer analytics to meet customer needs more precisely than their competitors (see e.g. Brynjolfsson, Hitt and Kim, 2011; Davenport and Harris, 2007). However, this reasoning for competitive differentiation is limited and may also be dangerous for companies for three reasons:

First, the discussions at this level are often characterized by a logic of operational efficiency. This means that the use of BDA is primarily linked to competitive advantages in those areas that have an operational character, such as optimized business processes. Operational problems are well-structured, as well as directly linked to an activity, and an optimal solution can be calculated *ex ante*. Therefore, the use of BDA for optimization is highly suitable. However, if companies focus strongly on such an operational effectiveness, their priority is on execution and strategic choices on alternatives take a back seat. The strategic risk here lies in the fact that these actions quickly lead to strategic herd behavior that makes competitors increasingly similar. The increasing convergence of businesses in a same industry will consequently result in strong price competition. (Porter, 2001) This also applies to the Marriot case of pricing, where the optimal price is determined *in situ* and through the application of revenue management and linear optimization models (Davenport, 2006). We note that the BDA literature from practitioners and scholars equally reports BDA-use cases which almost exclusively relate to

well-structured, operational problems, e.g. in the areas of production, warehousing or logistics. The link to the competitive advantages that these actions are intended to achieve is only asserted and contradicts strategic thinking.

Second, although the relation between BDA and competitive advantages is explained with references to the resource-based view (RBV), the reasoning on the strategic value of data and algorithms seems rather questionable. Since data, the corresponding analytics tools, and algorithms are increasingly accessible and tradable (Ross, Beath and Quaadgras, 2013), as well as the underlying logic of value creation is being easy to understand, competitors can imitate the use of analytics. By the time competitors collect the same customer data and analyze them with the same algorithms, this aspect of competitive differentiation will wear off (see Braganza, Brooks, Nepelski, Ali and Moro, 2017; Mazzei and Noble, 2017).

Third, the whole discussion about the importance of BDA for competitive advantages is based on a perspective that is in sharp contrast to strategic thinking. This perspective may be described by the metaphor of digging for gold hidden somewhere deep in the ground. The use of BDA is organized as a discovery process of strategically relevant patterns "deeply hidden" in historic data, which only need to be uncovered with the help of BDA-methods. The fundamental perspective on strategy, however, is that a competitive advantage must be established or created (see e.g. Porter, 1985). Information, of course, is important in this process (see Porter and Millar, 1985), but neither data nor algorithms can provide a direct path to competitive advantages. Sources of differentiation do not exist per se (in the data) but are deliberately produced and are often based on a creative destruction of previous patterns (see Schumpeter, 1942). For managers, relying too much on the above described discovery process can be a fallacy which will potentially lead to a too passive management attitude or being too focused on execution. In the case of Airbnb, the idea of a data-based sharing platform provides a creative destruction of previous accommodation solutions. Data analytics thereby was the enabler rather than the creator of the new sharing idea.

B) In addition, a second line of discussion can be discerned, which refers less directly to data and algorithm effects on competitive advantages, but rather emphasizes *BDA-capabilities*. This perspective is strongly rooted in the resource/competence-based view. In this line of reasoning, information systems (IS) scholars refer to data and algorithms as a valuable resource for competitive differentiation and argue that businesses need to develop BDA-capabilities to combine and deploy their data resources and ultimately transform them into a "competitive force" (Kiron, Prentice and Ferguson, 2014, p. 9). BDA-capabilities are predominantly defined in a way that they reflect BDA-management, infrastructure and talent-related aspects (see e.g. Akter, Fosso Wamba and Gunasekaran, 2016; Barton and Court, 2012; Davenport, Barth and Bean, 2012; Kiron, Prentice and Ferguson, 2014; McAfee and Brynjolfson, 2012; Ransbotham, Kiron and Prentice, 2015; Wixom, Yen and Relich, 2013).

BDA-researchers make use of the prevailing research on IT-capabilities, because "the role of IT-capabilities is well established in IS research" and it "extends our knowledge about the role of technology" in the context of competitive advantages (Kim, Shin and Kwon 2012, p. 341). Within almost 40 years of theoretical and empirical research on IT-capabilities and competitive advantages (see e.g. Andersen, 2001; Bharadwaj, 2000; Bhatt and Grover, 2005; Dehning and Stratopoulos, 2003; Feeny and Ives, 1990; Mata, Fuerst and Barney, 1995; McFarlan, 1984; Porter and Millar, 1985; Stratopoulos and Dehning, 2000), a consensual understanding has emerged that IT resources and capabilities that are readily available constitute commodity inputs to a business (Carr, 2003), whereas IT resources and capabilities that are durably heterogeneous provide a source of sustained competitive advantage (see e.g. Bhatt and Grover, 2005). Durable heterogeneity thereby means that businesses possess resources and capabilities different from their competitors and can preserve it from competitors' replication (see e.g. Lim, Stratopoulos and Wirjanto, 2011). Furthermore, by referring to path dependency theory, scholars argue that a business's historicity of investment decisions and asset accumulation (see e.g. Bharadwaj, Sambamurthy and Zmud, 1999) as well as its idiosyncratic learning processes in knowledge development (Pavlou and El Sawy, 2006) prevent a business's IT-capabilities from commoditization and competitors' replication (see e.g. Piccoli and Ives, 2005).

Reflecting on the dominant perspective of BDA-capabilities and competitive advantages, we argue that the prevailing understanding is problematic and insufficient mainly for two reasons:

First, although it seems plausible that BDA-capabilities can constitute an important resource in a company, it remains somewhat unclear in the present discussion what exactly is meant by BDA-capabilities and to what extent they differ from other, basic IT-capabilities. Capabilities here are deductively derived from RBV theory (e.g. Bharadwaj, 2000 based on Grant, 1995) and tested for their impact on selected performance measures (Fosso Wamba Gunasekaran, Akter, Ren, Dubey and Childe, 2017). However, the prevailing literature still lacks a deeper understanding on how and why BDA-capabilities specifically qualify as a differentiation factor from competition and how they contribute to a company's positioning.

Second, the path dependency theory is reduced to a "sustainability factor" (Dehning and Stratopoulos, 2003, p. 8) that is described as and thereby limited to the historicity of strategic choices: "choices made during the early stages of project planning and implementation impact current choices, decisions, and expected outcomes" (Dehning and Stratopoulos, 2003, p. 9). This reasoning neglects other aspects of path constitution and path dependency that can be found in the respective literature. Moreover, the prevailing reasoning only underlines the beneficial consequences it has on path dependency, and thereby fails to also consider potential risk dimensions.

In summary, there is currently little knowledge about the relationship between BDA and competitive advantages. The existing scientific contributions on this topic predominantly provide only a rather confessing justification for a positive influence of BDA on competitive positioning. The reason for the predominant emphasis on the positive role of BDA seems to be grounded in the following: on the one hand it is routed in the fact that in most studies BDA is viewed rather from an operational effectiveness perspective of process optimization. Consequently, this operational efficiency is then directly linked to being of strategic relevance. On the other hand, we believe that the potential of existing strategy theories is only insufficiently exploited. In particular, the path dependency theory shows different perspectives of strategic risks that could arise for companies using BDA. In the following section, we want to discuss controversial issues about BDA and the resource-based and capabilities-based approach to competitive advantage by offering a more in-depth explanation based on path dependency theory.

3 How can BDA-investments create strategic lock-ins?

3.1 Path dependency theory and BDA

The path dependency theory states that a company's strategic decisions are always embedded in historical processes in the sense that they depend on previous events and decisions (see Schreyoegg, Sydow and Koch, 2003). Within the continuing process of organizational decisions and environmental events, companies will stick to their success patterns and become path dependent. Persistence in a strategic success pattern thereby emerges from self-reinforcing mechanisms (e.g. economies of scale, learning curves or network effects). For example, the stronger the learning curve effects from BDA on a company's capabilities (see Airbnb), the more likely it will be for that company to stick to these capabilities and it will become rigid (Durand, 2001). Once self-reinforcing mechanisms have eradicated all alternative strategic options, a contra-factual persistence of a specific pattern occurs and leads to a strategic "lock-in" (see Koch, 2011; Sydow, Schreyoegg and Koch, 2009).

3.2 A controversy on path dependency theory and BDA-capabilities

Although a narrowing of options for strategic action describes a negative development, self-reinforcing mechanisms nevertheless provide a good economic reason to stick to the path. Path dependency theory thus describes historical processes that can lead to companies being trapped in paths and unable to be open to change (e.g. technological changes). With path dependency theory we identify a controversy for discussion of BDA-induced strategic patterns as path dependency can be both

beneficial and harmful to capability development (for a general discussion, see Vergne and Durand, 2011). An important basis for achieving competitive advantages is that companies are able to change their resource base and, for example, react to technological dynamics ("dynamic capabilities", Eisenhardt and Martin, 2000). Although the view of dynamic capabilities is not reduced to mere adaptation measures, it nevertheless implies a necessary strategic flexibility. As stated before, building a BDA-capability requires historicity of e.g. past investments and training of algorithms. In the "ongoing process" of organizational processes, big data algorithms form a self-reinforcing mechanism that increasingly leads to a consolidation of the underlying strategic patterns (see Schreyoegg, Sydow and Koch, 2003). This positive feedback occurs from network-like effects of algorithms due to their historicity. They reconstruct and stabilize strategic patterns and lead to operational efficiency, e.g. as the algorithm navigates more and more precisely and becomes more valuable. This path dependency is particularly problematic in the case of technological dynamics, since self-reinforcing mechanisms – if left intact – have the potential to neutralize the impact of critical events on companies (Wenzel, Wagner and Koch, 2017). Reactions to new developments or new competitors continue to be based on the established strategic pattern. A strategic change is difficult and often only occurs with great delay. An initial temporary competitive advantage then becomes a significant competitive disadvantage.

As a result, path dependency seems to be an advantage to capabilities but at the same time represents a threat to the sustainability of that advantage for two reasons: it might overestimate historic internal success patterns and it might overlook external indication for change. Consequently, this conflicting logic reveals the necessity for scholars and managers to make sense of such problematic features of beneficial consequences of path-dependent capabilities and the risks of rigidities and path-dependent strategic lock-in.

4 Empirical Research Design

The present study relates to the question of why and how BDA-investments can generate strategic risks for companies. We focus on risks from the perspective of the path dependency theory (strategic lock-ins). Although there are fundamental theoretical studies pointing to strategic risks of lock-ins, to our knowledge there are no empirical studies investigating the possible self-reinforcing mechanism of algorithms. Accordingly, we have developed a *process-oriented qualitative case study design* that is significantly open and explorative on one hand, but at the same time integrates the basic theoretical perspectives (Wrona and Gunnesch, 2016; Wrona & Bauer (forthcoming). Previous knowledge is used as a sensitizing tool that is intended to provide thought-provoking impulses for potential BDA-related risks and path constitution.

In our study, we focus on the *maritime logistics industry* which is particularly affected by the technological change (Saxon and Stone, 2017; OECD, 2018). The incumbent firms in this industry face intense competition on cost and efficiency and are highly pressured to develop BDA-solutions to stay competitive. In addition, the industry faces the entrance of new participants in the market, including established technology companies with more advanced BDA-skills (e.g. Amazon, Alibaba), as well as start-ups developing highly specialized BDA-solutions. We conclude that the strategic developments of maritime logistics companies constitute "revelatory" cases to understand the focal phenomenon (Yin, 2014). Companies in the maritime logistics sector are in the process of investing in and developing BDA-solution. We aim to analyze the strategic development process of these firms over a period from 2008 until 2018 and trace the path of BDA-development and capability-building. Arguing that after 2008, maritime logistics companies who "survived" the financial crises all face a comparable situation of recovery and strategy development, and that the topic of BDA started to gain significant attention, this seems an appropriate start for a period of investigation.

To do so, we gather *primary* and *secondary qualitative data* to examine the strategic development of the maritime logistics industry as well as the development paths of the incumbent players in the market. *Basically*, we are planning to collect *primary data* by *semi-structured interviews* with managers of different firms within the affected industry who are or who have been involved in BDA-investments to increase the competitiveness of their companies. The interviews will be open but theoretically guided

by *path constitution analysis*. Therefore, constitutive features such as type and intensity of BDA-investments, perceived BDA-capabilities, triggering events, self-reinforcing processes, lock-in, or multiple actors who reproduce the path (Sydow, Windeler, Müller-Seitz and Lange, 2012) will be included to gain an understanding of the self-reinforcing processes of path formation.

Data analysis (within-case/cross-case) will be carried out by using the *Gioia* approach of coding (Eisenhardt, 1989; Gioia, Corley and Hamilton, 2012; Trochim, 1989) to compare and contrast how companies progress to make use of BDA and how that effects their competitive strategy and positioning over a time period of ten years. The *Gioia* approach is characterized by a comprehensible and reliable form of interpretation that avoids the impression of arbitrary or cherry-picked coding. Furthermore, coding combines both, the level of informants' meanings about a phenomenon (e.g. BDA-processes) and the level of scientific theorizing about this phenomenon by using a 1st- and 2nd-order category-system. In addition, various *secondary data* from company documentation and industry reports are collected to develop a general overview of industry trends and to further obtain a better understanding of the context of BDA-applications in the maritime logistics sector. In addition, complementary *quantitative data* on industry developments are used to assess the development stages of the industry over that time period.

By using both data sets, retracing the *chronological proceedings* (Bluhm et al. 2011), acknowledging the historical background of the focal phenomenon (Hirschheim and Klein, 2012) and observing the processual nature of strategic path dependency (Sydow, Schreyoegg and Koch, 2009) allows us to reconstruct the process of BDA-investment and the capability-building of a focal firm. This will allow us to understand how past patterns (BDA-investments, decisions) influence 1) current and further development of BDA-capabilities and 2) current strategy development as well as current strategic decisions and actions.

We contribute to current literature and management practice in several ways:

First of all, the present process study has the potential to expand the current, sometimes one-sided *theoretical discussion* on the strategic importance of BDA. The study shows to what extent short-term rational BDA-decisions can generate strong strategic risks in the medium to long term by maneuvering companies into a lock-in situation. In a climate of on-going technological developments, previously very successful companies can lose their competitive position and can even be forced to withdraw from a market. Discussions about the simplistic transfer of the operational advantages of BDA-investments to the strategic level may thus be viewed in a more differentiated way by the risk of strategic lock-ins.

Second, by taking a process-related view of how *future strategic lock-ins* can arise as a result of BDA, the strategic risks are brought more into focus. This allows the frequently used argumentation patterns to be questioned, which, for example, simply ties the strategic advantages of BDA-investments to currently successful examples such as Google or Amazon.

Third, the study also has the potential to *contribute back to path research* by adding *algorithms* to the established self-reinforcing mechanisms such as increasing returns or network effects. It can illustrate how algorithms become better and more powerful the longer companies work with them, i.e. the longer they remain stuck in their strategic patterns.

Fourth, it provides theoretical guidance on how to *monitor path dependency* of a company and respective industry. It traces the process of BDA-investments, the development of BDA-applications and its use, the capability-building and its effects inside and outside the organization. Considering multiple levels of analysis, it takes into account the actors involved and the company's environment, their interactions and temporal occurrence. A continuous scanning of the BDA-development process allows to *detect early indicators for path dependency* – particularly at an early development state.

Finally, the study may also create an awareness in companies that successful BDA-investments today may result in major risks in the future. Since many companies are on the threshold of data-driven business models, the inclusion of algorithms as a cause of strategic inertia can be an important finding that leads companies to make their BDA-investments more consciously. Of course, strategic lock-ins do not form a kind of fate that companies cannot escape. If they are aware of the possible risks, they

can address a corresponding path management at an early stage that may help to break patterns and redeploy resources to create new future options and overcome a lock-in (Garud and Karnøe, 2001, p. 6). In this way, knowledge of possible future strategic lock-in risks leads to a broadening of a *company's repertoire to act* today.

This study deals with strategic risks of BDA-investments from the perspective of the path dependency theory. Further contributions by the authors are intended to extend this perspective to *other types* of strategic risks. A *qualitative experiment* is planned to explore possible risk dimensions of BDA-investments with a group of managers in the maritime logistics industry. Instead of observing BDA related risks in the field or asking for them in interviews, the researchers create a situation and manipulate events within this situation (Fromkin and Streufert 1983; Kleining, 1986; Weick, 1965).

5 Contribution to a Track's Theme

With our research, we aim to contribute to the track theme "Strategic management issues stemming from BI&A and big data". Academics and practitioners are interested in the question how the rapidly increasing possibilities of BDA can be leveraged to create and maintain a competitive advantage. we respond to a couple of calls for research: We respond to Sena et al.'s (2017) call for a complementary view on internal processes (e.g. capabilities) and their outcomes (e.g. profitability, productivity). We also respond to Fiorini et al. (2018) who call for an analysis of the mechanisms that foster BDA-capability-building for companies to gain a competitive advantage. And finally, to Hazen et al. (2014, p. 77) who call for further investigation on the idiosyncratic path firms need to undertake to create and maintain competitive advantage based on BDA.

Finally, our research fits into the explicit promotion for *multidisciplinary research* as it advances the interdisciplinary view on BDA from IS and strategic management lenses. It theoretically and conceptually investigates the relationship between competitive advantages and BDA-capabilities and raises new questions for further (empirical) investigation for both, IS and strategic management scholars.

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