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The Digital Disruption of Strategic Paths: An Experimental Study

Completed Research Paper

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Abstract

In this paper, we draw on the literatures on path dependence and disruptive innovation to examine in an experimental setting how path-dependent firms respond to digital disruption. As our results indicate, in the face of digital disruption, path-dependent firms tend to renovate the technological foundation on which their strategic path is based if they have the opportunity to reproduce their established strategic path. Our findings also suggest that path-dependent firms equally tend to renovate their technological foundation or the targeted market segment in the face of digital disruption if they are unable to reproduce their established strategic path. Our findings provide insights into the challenges that digitization imposes on established firms, complement the literature on path dependence with insights into path disruption, contribute an integrated view to the literature on disruptive innovation, and offer some guidance to practitioners.

***Keywords**: Digitization, digital disruption, path dependence, disruptive innovation, experiment*

Introduction

Debates on digitization have gained dominance in information systems research. Along with industry trends toward increased transformation of formerly analog products and services into their digital counterparts (Tilson et al. 2010), information systems research not only sheds light on the technological aspects of this process but also illuminates the strategic and organizational impact on firms' businesses that this technological change entails (e.g., Bharadwaj et al. 2013; Yoo et al. 2012). This literature suggests that digitization is not just a matter of firms' functional IT departments to renovate the technological foundation of firms' businesses; instead, it bears strategic relevance, as it can fundamentally change the way firms conduct business.

Much of the literature on the strategic role of digitization emphasizes the business opportunities it provides (Bharadwaj et al. 2013). For instance, firms may drastically increase their profit margin by reducing production costs (Rothmann et al. 2014), rely on new ways to sell their products via web-based distribution channels (Oestreicher-Singer and Zalmanson 2013), increase their profitability by interacting with competent stakeholders in digital environments (Wohlgemuth et al. forthcoming), and release new product value in digital environments that they could not have achieved in the analog world (Pagani 2013). Thus, this literature highlights that firms may benefit greatly from seizing opportunities provided by digitization. However, prior research also indicates that digitization imposes tremendous challenges on established firms (Grover and Kohli 2013). These challenges particularly unfold when incumbents have a history of producing and selling non-digital products and services and are unable to respond to the digitization of their environments (Lucas and Goh 2009; Oestreicher-Singer and Zalmanson 2013). Literature has identified path dependence, referring to the self-reinforcing emergence of a pattern of strategic decisions (i.e., the routinized reselection of strategic options) that can hardly be changed anymore (Sydow et al. 2009), as a key root cause in long-established firms that have been struck by digitization, such as in the music industry (Kunow et al. 2013), the newspaper industry (Koch 2011), the book industry (Schreyögg et al. 2011), and the funeral industry (Wenzel 2015). As a result, the technological change that digitization entails disrupts path-dependent firms and may even lead to their demise (Rothmann and Koch 2014).

Digital disruption, i.e., the discontinuation of successfully reproducing strategic paths (cf. Karimi and Walter 2015), comes with deep social changes of consumption practices and daily interactions (see Tilson et al. 2010; Yoo et al. 2012). Therefore, not surprisingly, it threatens the persistence not only of single path-dependent firms but even of entire industries (Koch 2008; Wenzel 2015). Previous works have holistically highlighted this disruptive impact of digitization on established businesses (e.g., Karimi and Walter 2015; Lyytinen and Rose 2003). Yet, given the far-reaching implications of these technological and social changes for established businesses, we need to gain a more nuanced understanding of how path-dependent firms respond to the disruptive impact of digitization. With its focus on the business opportunities that digitization provides, however, prior literature does not fully illuminate the struggles of path-dependent firms when digitization unfolds its disruptive potentials (Besson and Rowe 2012; Lucas et al. 2013; Sørensen and Landau 2015). Therefore, we draw on the literatures on path dependence (e.g., Singh et al. 2015; Sydow et al. 2009; Vergne and Durand 2010) and disruptive innovation (e.g., Ansari et al. forthcoming; Christensen and Raynor 2003; Tushman and Anderson 1986; Yu and Hang 2010) to define and differentiate between two types of responses—"technological shift" and "market shift"—and to investigate the following research question: *How do path-dependent firms respond to digital disruption?*

To examine our research question, we conducted an experimental study (Berkowitz and Donnerstein 1982). The study focused on a typical decision situation of managers in long-established automotive firms who face the opportunities and challenges of digitization. The results of our experiment indicate that, in the face of digitization, path-dependent firms are inclined to invest in new technology on which their strategic paths are based but do not invest in market segments new to the firm when they have the option of reproducing their established strategic path. Our findings also suggest that path-dependent firms tend to renew the technological foundation of the established strategic path when the strategic option that was predominantly reselected can no longer be selected.

Our findings contribute to both research and practice. First, our study complements the literature on digitization that has highlighted and focused on the business opportunities of digitization (Besson and Rowe 2012; Lucas et al. 2013; Sørensen and Landau 2015) with more nuanced insights into the challenges

that digitization imposes on established firms, i.e., responding appropriately to the disruption of strategic paths. Second, our study offers an integrative view on the literature on disruptive innovation (Yu and Hang 2010). Whereas prior literature has approached issues of disruption either from the product/service side (e.g., Tushman and Anderson 1986) or from the market side (e.g., Christensen and Raynor 2003), our study offers a joint analysis of both perspectives and indicates that a technological shift is more likely than a market shift for path-dependent firms. Third, our study complements the literature on path dependence, with its current focus on path emergence and persistence (e.g., Rothmann and Koch 2014; Wenzel 2015), with insights into path disruption through digitization. In particular, our paper provides more nuanced insights into the specific responses of path-dependent firms in this tenuous situation.

We begin by reviewing previous literature on path dependence and disruptive innovation to lay out the theoretical foundations of this paper and to develop our hypotheses. Then, we outline the experimental design and report the results of our study. We conclude our paper by discussing the implications of our findings for research and practice.

Theoretical Background and Hypotheses

In this section, we lay out the theoretical foundations of our paper and develop our hypotheses. We draw from several streams of literature to derive our proposed hypotheses, namely, path dependence theory (e.g., Singh et al. 2015; Sydow et al. 2009; Vergne and Durand 2010) and disruptive innovation (e.g., Christensen and Raynor 2003; Tushman and Anderson 1986; Yu and Hang 2010).

Path Dependence

Path dependence is a process in which the range of strategic options is reduced over time (Singh et al. 2015; Sydow et al. 2009; Vergne and Durand 2010). In contrast to other forms of strategic and organizational stability, such as imprinting (Stinchcombe 1965) and structural inertia (Hannan and Freeman 1984), path dependence theory explains how strategic decision-making becomes entrenched into narrow trajectories (Koch 2008, 2011). In particular, path dependence theory formulates positive feedback, i.e., successful outcomes of strategic decisions, as the central mechanism that drives firms into stably reproduced patterns of strategic decisions. Positive feedback increasingly renders more attractive those strategic options that have generated successful outcomes in previous decision rounds (Koch 2011; Sydow et al. 2009). At the same time, positive feedback on selected strategic options crowds out strategic alternatives by rendering them comparatively unattractive (Dobusch and Schüßler 2013). By increasingly reselecting those strategic options that generate positive feedback and crowding out strategic alternatives, firms may eventually become "locked in" (Sydow et al. 2009), i.e., they maneuver themselves into a situation in which they have a scope of action with only a small range of available strategic options (see Figure 1). An entrenched scope of action may not be problematic as long as the environment remains unchanged, but it does become problematic when the environment changes (Rothmann and Koch 2014): when more attractive strategic options beyond the strategic path emerge, path-dependent firms are unable to leave the path, with high switching costs being one major reason for this phenomenon (Koch 2008; Leonard-Barton 1992; March 1991). Prominent cases that experienced such dynamics of path dependence were the Polaroid Corporation (Lucas and Goh 2009; Tripsas and Gavetti 2000), the newspaper industry (Oestreicher-Singer and Zalmanson 2013; Rothmann and Koch 2014), the music industry (Kunow et al. 2013), the book industry (Schreyögg et al. 2011; Gerlach and Buxmann 2011), and the funeral industry (Wenzel 2015), all of which suffered difficulties in adapting to the radical technological changes that accompanied digitization processes.

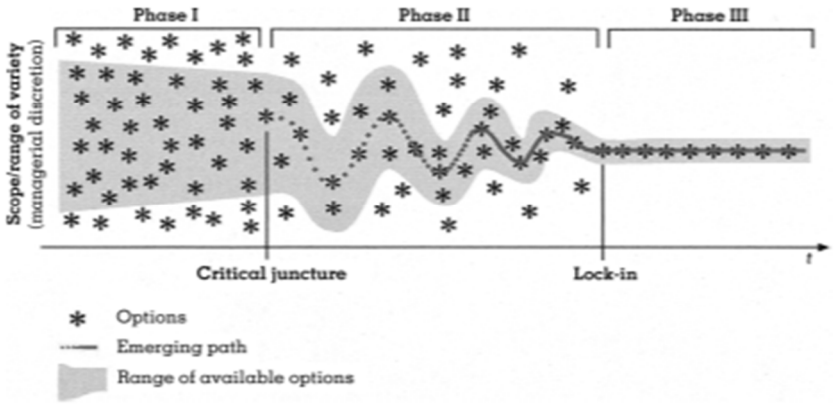

Figure 1. The Emergence of a Path (Sydow et al. 2009, p. 692)

When new strategic options exogenously emerge, the range of strategic options available to decision-makers broadens (Sydow et al. 2009). Although key readings on path dependence suggest that the emergence of new strategic options is the main—if not the *only*—way for firms to regain strategic and organizational flexibility (Sydow et al. 2009; Vergne and Durand 2010), empirical studies in the context of digitization indicate that firms may sustain their strategic path, even if the new strategic option renders the reselection of existing strategic options unattractive while also threatening the survival of these firms (Rothmann and Koch 2014; Schreyögg et al. 2011; Wenzel 2015). While these studies promote a better understanding of this phenomenon by referring to cognitive, normative, and resource-based reasons for the reproduction of strategic paths (see Koch 2008, 2011; Rothmann et al. 2014; Sydow et al. 2009), they do not particularly illuminate the specific responses of path-dependent firms in moments of path disruption, i.e., the discontinuation of reproducing a strategic path when new strategic options emerge.

Studies on path dependence require verification of path dependence as the specific form of rigidity in their data (Sydow et al. 2009). For experimental studies, this verification is based on formulating and testing a related hypothesis (Koch et al. 2009). Given that the emergence of new strategic options broadens the scope of alternatives, path-dependent firms have the option to deviate from their strategic path (Sydow et al. 2009). In the context of digitization and digital disruption, this means that digitization offers new options beyond the established pattern of strategic decisions that firms can exploit to conduct strategic change. In turn, if such events do not occur, positive feedback can gradually narrow the available scope of action and drive firms into a lock-in (Vergne and Durand 2010) due to a lack of disturbance of these self-reinforcing dynamics. Therefore, we hypothesize:

H1: The non-emergence of digitization increases the probability that firms become path dependent.

In the following, we draw on the literature on disruptive innovation to shed further light on the responses of path-dependent firms to digital disruption.

Disruptive Innovation and Digital Disruption

A "disruptive innovation" is a technology that is novel to markets or firms (Christensen and Raynor 2003; Tushman and Anderson 1986; Yu and Hang 2010). Its pervasive effects have found interest in several fields, such as organization and management research (Ansari et al. forthcoming; Henderson and Clark 1990; Tushman and Anderson 1986), technology and innovation management (Abernathy and Clark 1985; Garcia and Calantone 2002), and information systems research (Lucas and Goh 2009; Lyytinen and Rose 2003). Information systems scholars have highlighted the digitization of products and services as a particularly pervasive disruptive innovation (Karimi and Walter 2015; Yoo et al. 2012): it has led to severe disruptions of established businesses and incumbents' competences on which these businesses were based. Tilson et al. (2010) compare the extent of contemporary digital disruptions, i.e., disruptions through digitization, with paradigmatic shifts that steam, rail, and electricity have entailed in the industrial era and emphasize that such technological changes are accompanied by deep social changes that fundamentally transform the business landscape.

Much of the previous literature on digital disruption has focused on the business opportunities that such

paradigmatic shifts provide (Bharadwaj et al. 2013). According to this reasoning, digital disruption creates new "digital options" (Sambamurthy et al. 2003) that firms can exploit to conduct strategic change and advance their businesses. This line of research complements empirical observations of incumbents' challenges of exploiting newly emerging business opportunities that digitization provides (e.g., Koch 2011; Rothmann et al. 2014; Wenzel 2015). These works highlight path dependence as a key reason for incumbents' inability to benefit from processes of digitization, although digitization severely disrupted the firms' strategic paths and threatened their survival. Accordingly, in the face of an ongoing debate about the usefulness of the disruptive innovation concept (e.g., Ansari and Krop 2012; Christensen 2006; Danneels 2004, 2006; Hill and Rothaermel 2003; Yu and Hang 2010), Karimi and Walter (2015) demonstrated that the concept offers useful conceptual vocabulary for gaining a better understanding of digital disruption.

Similar to other streams of literature (e.g., Peteraf et al. 2013; Wohlgemuth and Wenzel 2016), the fragmentation of the literature on disruptive innovation comes along with distinct ideas on the disruptive impact of digital technologies. In particular, according to this literature, disruptive innovation can have a disruptive impact either through changes in markets or technologies (Danneels 2004; Fichman et al. 2014; Karimi and Walter 2015; Yu and Hang 2010). Thus, this literature suggests that path-dependent incumbents are unable to exploit emerging strategic options because their business is tightly linked with (1) an existing market segment, i.e., an existing group of customers with specific needs (Christensen 1997; Christensen and Bower 1996; Christensen and Raynor 2003), or (2) an existing technology (Danneels 2004; Karimi and Walter 2015; Tushman and Anderson 1986).

Christensen's work points to the tight entanglement of businesses with existing customers that render a switch to new strategic options unattractive (Christensen 1997; Christensen and Bower 1996; Christensen and Raynor 2003). Especially in the case of changes in demand through digitization, the linkage of path-dependent firms with existing customers may erode as customers may purchase and consume alternative market offerings and thus shift their demand from an existing to a new product or service. When firms' tight bonds with existing customers erode in the event of digital disruption, path-dependent firms may eventually be incentivized to find new attractive market segments in which they can position their core product or service and, thus, shift their business to new market segments—i.e., a "market shift." Therefore, we hypothesize the following:

H2a: The emergence of digitization leads to a market shift of path-dependent firms.

Contrarily, other scholars suggest that technological innovations can erode the tight bonds of path-dependent firms with an existing technology (Danneels 2004; Karimi and Walter 2015; Tushman and Anderson 1986). When digital technologies emerge, they may destroy the competences on which incumbents' established business models are based (Hill and Rothaermel, 2003; Tushman and Anderson 1986; see also Ansari and Krop 2012; Yu and Hang 2010). Thus, path-dependent firms may be unable to continue relying on the same technology that used to drive the success of their strategic path. Therefore, in the case of the emergence of new digital technologies, path-dependent firms might eventually be incentivized to renew the technology on which their business models are based, thus resulting in a shift toward another technology—i.e., a "technological shift." Thus, we hypothesize the following:

H2b: The emergence of digitization leads to a technological shift of path-dependent firms.

While these hypotheses do not exclude the possibility that previously selected options are reselected, prior literature suggests that path-dependent decision-makers' responses to newly emerging options may differ when they are unable to reproduce the existing business model. In particular, Pentland et al. (2012) emphasize that the elimination of previously chosen strategic options stimulates creativity and opens a repertoire of possible processes that produce products and services (see Danneels 2002), thus causing a technological shift. Yet, path-dependent firms may also use this creativity to position their previous products and services in new market segments (Adner and Snow 2010). Given the disruptive nature of digitization that results from the host of possibilities available for the further development of businesses (Karimi and Walter 2015), a deviation from strategic paths in terms of both a technological and a market shift may become viable for decision-makers. Therefore, we hypothesize:

H3a: The emergence of digitization and the removal of the preferred strategic option leads to a market shift of path-dependent firms.

H3b: The emergence of digitization and the removal of the preferred strategic option lead to a technological shift of path-dependent firms.

Research Methodology

To test our hypotheses, we conducted an experiment. Experiments offer a number of important benefits in light of our research question. First, experimental research "is an excellent way to address questions of causality" (Bono and McNamara 2011, p. 658). Based on the tools they provide, experiments represent a key and proven method to uncover processes underlying phenomena such as path dependence (Koch et al. 2009; Dobusch und Kapeller 2013) and phenomena in digitized contexts, such as online buying behavior (Amirpur and Benlian 2015) and IT usage (Eckhardt et al. 2012). Therefore, the experimental examination of digital disruption of strategic paths appears promising. Second, experiments are well suited to address the limitations of studies based on field data, which most studies on path dependence use (Sydow et al. 2012). Such studies typically face the challenge of being unable to determine the dynamics of path dependence in the face of digital disruption had the impact of this environmental event been different (cf. Durand and Vaara 2009). In contrast to studies relying on field data, our experimental study allows us to control the setting. Thus, an experiment enables us to isolate the desired effects on strategic paths and to control for possible interferences to better investigate strategic decision-making and, in particular, the disruptive impact of digitization on strategic paths (Dobusch and Schüßler 2013; Koch et al. 2009). As a result, our experimental design allows us to make causal inferences on digital disruption and path dependence that complement existing field studies. For this purpose, we developed a software tool ("WheelCorp") on Unipark. This tool helped us verify and test the path-dependent influence of positive feedback on strategic decision-making processes in a controlled setting (Koch et al. 2009) and experimentally test how path-dependent firms respond to digital disruption, i.e., in terms of either a technological shift or a market shift (e.g., Christensen and Raynor 2003; Tushman and Anderson 1986).

Our experimental design is based on a one-factorial between-subject design (Shadish et al. 2001) with one control group and two treatment groups manipulating digitization on two levels (potentially leading to either a market or a technological shift). The control group helped us experimentally verify the path-dependent influence of positive feedback on strategic decision-making processes (Koch et al. 2009; Rothmann and Koch 2014; Sydow et al. 2009), whereas the treatment groups A and B facilitated the investigation of responses of path-dependent firms to digital disruption in terms of either a technological shift or a market shift (e.g., Christensen and Raynor 2003; Tushman and Anderson 1986) in an experimental setting. While treatment groups A and B received the identical manipulation, treatment group B participants were not able to reselect the preferred strategic option. In treatment group A, this possibility was still available. The scenario puts the participants in charge of the innovation strategy of a firm holding the position as the Innovation Manager of an international automotive firm. The Innovation Manager is in charge of selecting between four different machines that produce steering wheels for the automotive industry. Because the firm produces only one product, the choice of machine is directly linked to the firm's product/market concept of the firm. The chosen scenario has proven effective and suitable because participants are familiar with the functionality and purpose of this product. Furthermore, the illustrated situation allows us to simulate different settings that are common in real-life strategic decision-making, such as decisions that are consequential for the firm's strategic development, aspiring cost savings, and strategic thinking and acting. The experiment follows the same logic for the three groups. Our control condition did not receive a manipulation. Therefore, we presented no information about digital disruption.

We recruited 241 participants (94 female) on the platform Mechanical Turk (MTurk), an online labor market created by Amazon that has recently gained use among social scientists as a source of survey and experimental data in research areas such as marketing, management, and information systems (e.g., Sheehan and Pittman 2016; Chandler et al. 2013; Paolacci et al. 2010). MTurk has become a reliable source for data collection (e.g., Buhrmester et al. 2011, Holden et al. 2013). Therefore, "today, it is not uncommon to read empirical articles that are entirely based on data collected using MTurk" (Paolacci and Chandler 2014, p. 148). In general, questions may arise about who the "workers" are and why they participate and choose to complete MTurk tasks. Accordingly, the eligibility of the participants was of high importance in our research setting, where we targeted participants with substantial working experience and exposure to strategic decision-making (for details, see below). Prior research on the motivation of MTurk participants found payment to be an important, though not essential, factor for participants'

participation (e.g., Paolacci et al. 2010). Furthermore, especially in high-income regions, interest in research and having fun are becoming more important motives for becoming an MTurk participant. In fact, the design of data collection through MTurk coincides to a certain extent with "gamification"—the application of game mechanism and game design techniques in non-game contexts to engage and motivate people based on basic desires and needs, such as competition, achievement, status, and altruism (Santhanam et al. 2016)—and thus stimulates these motives (such as gaming as a result of gamification) of MTurk participants. Thus, we used the MTurk platform to conduct our research. This helped us extend beyond findings from commonly used student samples in strategic and organizational contexts.

The selection process of the participants was threefold. First, the study was limited to participants living in the U.S. and whose ratio of approved/submitted Human Intelligence Tasks (HITs), which represent individual tasks (e.g., surveys, transcriptions), was higher than 95 percent (see Chandler et al. 2013). Our study was only displayed to participants fulfilling these criteria. Second, we stated a substantial list of requirements for participation. Among others, we required participants to have substantial experience with strategic decision-making, managerial experience, working experience of more than ten years, and working experience in top or middle management. Possible MTurk participants decided whether they fulfill these requirements based on a self-evaluation. Third, in a post-hoc analysis, we controlled for several factors to ensure the quality of responses, e.g., through attention and manipulation checks, asking personal questions on the participants' motivation to participate, their work history, demographics, etc. (see Table 1). We used several manipulation checks in order to ensure that the participants understood the task at hand and that their professional and personal situation—e.g., position, working experience, managerial experience, strategic decision-making experience, leadership experience, size of responsible team/employees, annual salary, position, company size, industry, time spent etc. (see Table 2)—was suitable for the research setting. We randomly assigned the participants to the treatment groups A and B and the control group. The participants' average age was 39.01 years (σ = 9.4), with an average of 17.7 years of working experience (σ = 3.4). We dropped nine questionnaires due to partial information on dependent variables, lack of working experience, strategic decision-making, and/or managerial experience.

Motivation Classification	Relative Frequency (in Percent)	Examples
Spending free time	29.4	"Something to do in spare time"; "It's a fun way to send my spare time!"; "Pass free time"; "too much free time"
Gaming, fun	38.6	"It is interesting"; "I like the game aspect"; "Spare time, curious what this site is all about"
Monetary reward[1]	15.7	"extra income"; "my work is MTurk"; "to make some extra cash for my hobby"
Science	12.3	"help science"; "Learning, science, active participation in research and filling free time at the computer"
Sharing opinion	4.0	"I enjoy studies… They are exciting because I can actually have a say about new products and things."; "I have a say"

Table 1. Motivation for Participation

To minimize suspicion, participants were told they would be part of a study on strategic decision-making in the innovation context. After opening the study request, the participants were informed about the basic idea of the experiment and had the opportunity to get to know the rationale of the software tool with a set of four machine alternatives that produce steering wheels for domestic and international markets. Participants were then instructed on how to use the software and were presented with an identical start page that displayed the main components of the experiment. This was done to allow participants to establish a common frame of reference in order to ensure that the context and background of their

[1] Note: Participants solely referring to monetary rewards (and in combination with other aspects such as lack of working experience, managerial experience, and position) have been removed from the sample due to a lack of eligibility for the research purpose.

experimental experiences were homogeneous across treatments and that the disparities across different treatments were caused only by different treatment stimuli (see Helson 1964). Participants were given $2 for participating in the study that, as discussed above, is regarded as a sort of score in a game in our setting rather than a monetary incentive. In order to ensure that participants were kept motivated throughout the study, one participant with the best overall results (i.e., the lowest percentage of budget used) was given an additional incentive of a $100 Amazon gift certificate after completing the study. We identified the best overall results with the help of the lowest percentage of budget used, the highest score on the variable of optimal decision, and time spent. The optimal decision was the one with the lowest overall costs in a certain decision round, all costs taken together. A specific alternative is superior in every decision round during the course of the experiment.

Sample (N=232)	Value	SD	
Female	91		
Male	141		
Age	39.01	9.04	
Working experience (in years)	17.07	3.04	
Managerial experience (in years)	12.52	4.04	
Size of responsible group	27.56	65.86	
Average salary	123,500	45,500	
Marital status	Single (35.6%); Married (55.2%); Divorced (7.8%); Other (1.4%)		
Highest education	High School (10.3%); Bachelor (61.5%); Master (16.1%); MBA (7.5%); PhD (4.5%)		
Industries	Automotive (11.7%); Aerospace (11.0%); Banking (12.3%); Chemical (11.7%); Energy (18.2%); Education (8.0%); Food (6.9%); Law (1.7%); Manufacturing (10.9%); Insurance (2.0%); Other (5.6%)		
Company size	1–99 employees (34.5%); 100–499 employees (33.3%); 500–999 employees (9.8%); 1000–4999 employees (8.0%); 5000+ employees (14.4%)		
Position[2]	"I am part of the top management" (23.6%); "I am part of the middle management" (59.8%); "I am an employee with managerial and leadership functions (e.g. team leader)" (11.5%); "I am an employee without managerial and leadership functions" (2.9%); "I am a stay-at-home mum/dad" (1.1%); "I am just working on MTurk" (0.6%)		

Table 2. Descriptive Details of the Sample

Before starting a process of consecutive decision rounds, we asked several questions in order to make sure that the participants were eligible and suitable to participate in the study. In line with previous work (e.g., Koch et al. 2009), participants were advised to make several consecutive decisions among a set of four alternative machines. For each decision, participants were given a budget of 100 money units. Participants had no time restrictions for making a decision. After seven minutes in one decision round, we displayed a friendly reminder and provided the option for further explanation of the game. No participant made use of this option. On average, the participants spent 29 minutes, 39 seconds answering the study (σ = 6.4). Once a decision was made, the participants received positive feedback (Sydow et al. 2009) in the form of a message on their savings in the respective round. This feedback message was followed by new

[2] Note: Participants who had no managerial position have been removed from the sample due to a lack of eligibility for the research purpose.

information required for the participants to make a decision in the respective decision round, and the participants then had to decide again. In sum, the participants went through 25 consecutive decisions. The following information was provided in each decision round:

- The cost structure of the four machines (Turbo, Heavy, Fast, Efficient) in the present and following four decision rounds, including basic fee, total production costs, total labor costs, and total energy costs
- The costs for placing a new contract with another machine ("switching costs") for the present and the following four decision rounds
- Information about savings in each round and total accumulated savings

Information was presented on one page in various tables on the computer screen. Figure 2 shows an example of the computer screen for decision round 4. Figure 3 depicts the switching costs incurred when participants switched machines. By providing information on the present and the next four decision rounds, we simulated a real-world setting in which the participants could come up with an optimal decision in each round with only limited foresight about the future development of the cost structures (cf. Levinthal and March 1993). Given that the participants had to calculate the total sum of costs to come to a decision in each round, they were encouraged to use a calculator or make notes if needed.

The manipulation for the two treatment groups was introduced in decision round 22 (see Figure 4). The manipulation addressed a change in the market environment, including a change in demand of manual steering wheels, allowing each participant to produce steering wheels for the boat industry and automatic steering wheels for autonomous-driving cars. The newly introduced options and the already existing Machine Heavy had the same cost structure (see Figure 4). Treatment groups A and B received the same manipulation. However, in treatment group B, Machine Turbo—the strategic option that a path-dependent decision-maker would prefer—was removed (see results from the control group). To make sure that both manipulations were equivalent in terms of attractiveness and complexity (e.g., Holbrook 1981; Amos and Spears, 2010), we also conducted a pretest in which we asked 50 participants to evaluate the information settings on a 7-point Likert scale in terms of attractiveness and complexity of the information displays. The participants evaluated the information settings as not significantly different in terms of attractiveness ($t = 1.189$; $p > 0.05$) and complexity ($t = 1.97$; $p > 0.05$). As an example, the information setting without removal of the path-dependent option was evaluated as less complex than the alternative information setting with removal of the path-dependent option. Yet, the difference between the two information settings was not significantly different in the degree of complexity, e.g., less or more complex. Thus, the analysis of the pretest with a conducted t-test confirmed that the given information situations were not the cause for difference in the participants' decision-making.

The information settings aimed to provide an optimal decision path as well as a possibility of a lock-in. In line with previous experimental research on path dependence (Koch et al. 2009), we identified path dependence when a decision that used to be optimal for many decision rounds due to positive feedback became suboptimal and could no longer be changed due to budget restrictions—a situation that Sydow et al. (2009) call a "rationality shift." By this, we conceptualized path dependence in its resource-based form (e.g., see Koch 2008, 2011; Sydow et al. 2009) based on production costs. We also defined an optimal decision by referring to the cost structure; i.e., an optimal decision is the one with the lowest overall costs. Taking all costs into consideration, a specific alternative was superior in every decision round during the course of the experiment (see Figure 5). In order to create a rationality shift, the superior alternative changed in the course of the experiment. The optimal change from one alternative to another alternative came in the 17th decision round. Thereafter, the participants could no longer shift to other alternatives as the switching costs became too high to pay with the provided budget of 100 money units per round.

Decision 4/25:

Overview of Machines:

Costs for Round 4

	Turbo	Heavy	Fast	Efficient
Basic fee	43	46	55	53
Total production costs	17,1	22,9	10,7	7,9
Total labour costs	5,8	7,4	4	7
Total energy costs	4,2	2	5	5

Switching Costs

Round 4	Round 5	Round 6	Round 7	Round 8
3	4	5	6	10

Future Predictions:

Costs for future rounds/Machine Turbo

	Round 5	Round 6	Round 7	Round 8
Basic fee	43	43	43	43
Total production costs	16,8	16,5	16,2	15,9
Total labour costs	5,7	5,6	5,5	5,4
Total energy costs	4,2	4,2	4,2	4,2

Costs for future rounds/Machine Heavy

	Round 5	Round 6	Round 7	Round 8
Basic fee	46	46	46	46
Total production costs	22,2	21,5	20,8	19,9
Total labour costs	7,2	7	6,8	6,6
Total energy costs	2	2	2	2

Costs for future rounds/Machine Fast

	Round 5	Round 6	Round 7	Round 8
Basic fee	55	55	55	55
Total production costs	10,6	10,5	10,4	10,3
Total labour costs	4	4	4	4
Total energy costs	5	5	5	5

Costs for future rounds/Machine Efficient

	Round 5	Round 6	Round 7	Round 8
Basic fee	53	53	53	53
Total production costs	7,7	7,5	7,3	7,1
Total labour costs	7	7	7	7
Total energy costs	5	5	5	5

Question 14:
Which machine do you choose?

Machine Turbo ○ Machine Heavy ○ Machine Fast ○ Machine Efficient ○

Continue

Figure 2. Information Displayed in Decision Round 4

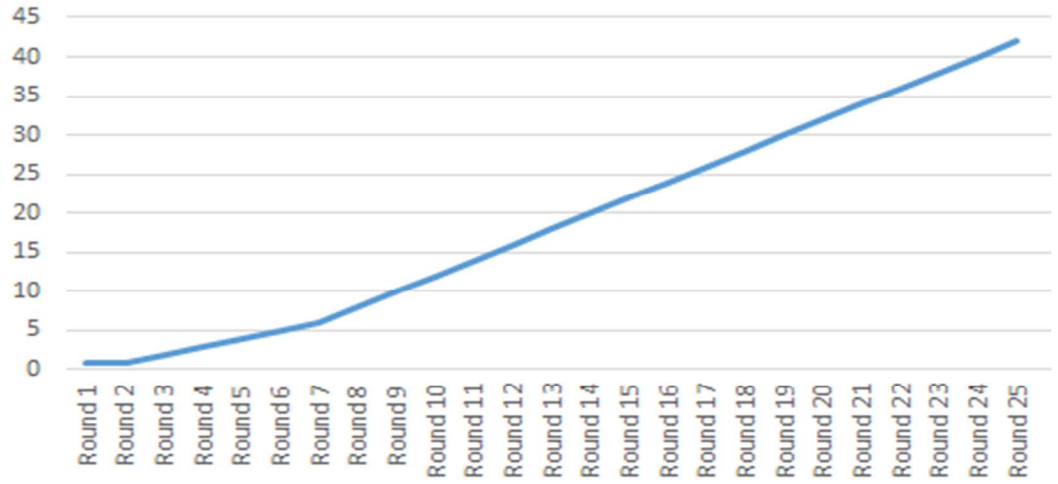

Figure 3. Switching Costs for the Decision Rounds

Decision 22/26: New Development and Notice from the Machine Supplier:

There has been a big decline in demand of steering wheels since a longer time. During a long meeting with the owners of the company, you are now tasked to make a decision concerning the future innovation strategy of the firm. The current market situation looks as follows: The international automotive market experiences a significant decrease in demand in (manual) steering wheel systems. However, a steady increase in demand in (automatic) steering wheel systems which is new invention where steering is taken over by the bordcomputer´s software. This shift can be explained by a steady growth in demand of autonomous cars on the international market.

Based on the current development on the automotive market, new opportunities have emerged for your company. The boat industry is interested in steering wheels. Based on the expertise in producing steering wheels over 80 years, your company would be able to shift from producing steering wheels for automotive to producing steering wheels for boats. Producing steering wheels for boats is relatively similar to producing steering wheels for the automotive industry. As described above, there is a big increase in demand in automatic steering wheel systems. Your machine supplier also offers you this option which means your companies would shift from producing manual steering wheels to produce automatic steering wheels.

Based on this development, your machine supplier offers you the known four machine alternatives as well as two new alternatives Machine Automatic to produce automatic steering wheel systems and Machine Water to produce steering wheels for the boat industry. For which option do you decide?

Overview of Machines:
Costs for Round 22

	Turbo	Heavy	Fast	Efficient	Automatic	Water
Basic fee	43	46	55	53	46	46
Total production costs	11,7	7,3	8,9	4,3	7,3	7,3
Total labour costs	4	3,8	4	7	3,8	3,8
Total energy costs	4,2	2	5	5	2	2

Switching Costs

Round 22	Round 23	Round 24	Round 25	Round 26
36	38	40	42	44

Future Predictions:

Costs for future rounds/Machine Turbo

	Round 23	Round 24	Round 25	Round 26
Basic fee	43	43	43	43
Total production costs	11,4	11,1	10,8	10,5
Total labour costs	3,9	3,8	3,7	3,6
Total energy costs	4,2	4,2	4,2	4,2

Costs for future rounds/Machine Heavy

	Round 23	Round 24	Round 25	Round 26
Basic fee	46	46	46	46
Total production costs	6,4	5,5	4,6	3,7
Total labour costs	3,6	3,4	3,2	3
Total energy costs	2	2	2	2

Costs for future rounds/Machine Fast

	Round 23	Round 24	Round 25	Round 26
Basic fee	55	55	55	55
Total production costs	8,8	8,7	8,6	8,5
Total labour costs	4	4	4	4
Total energy costs	5	5	5	5

Costs for future rounds/Machine Efficient

	Round 23	Round 24	Round 25	Round 26
Basic fee	53	53	53	53
Total production costs	4,1	3,9	3,7	3,5
Total labour costs	7	7	7	7
Total energy costs	5	5	5	5

Costs for future rounds/Machine Automatic

	Round 23	Round 24	Round 25	Round 26
Basic fee	46	46	46	46
Total production costs	6,4	5,5	4,6	3,7
Total labour costs	3,6	3,4	3,2	3
Total energy costs	2	2	2	2

Costs for future rounds/Machine Water

	Round 23	Round 24	Round 25	Round 26
Basic fee	46	46	46	46
Total production costs	6,4	5,5	4,6	3,7
Total labour costs	3,6	3,4	3,2	3
Total energy costs	2	2	2	2

Figure 4. Manipulation in Decision Round 22 for Treatment Group A

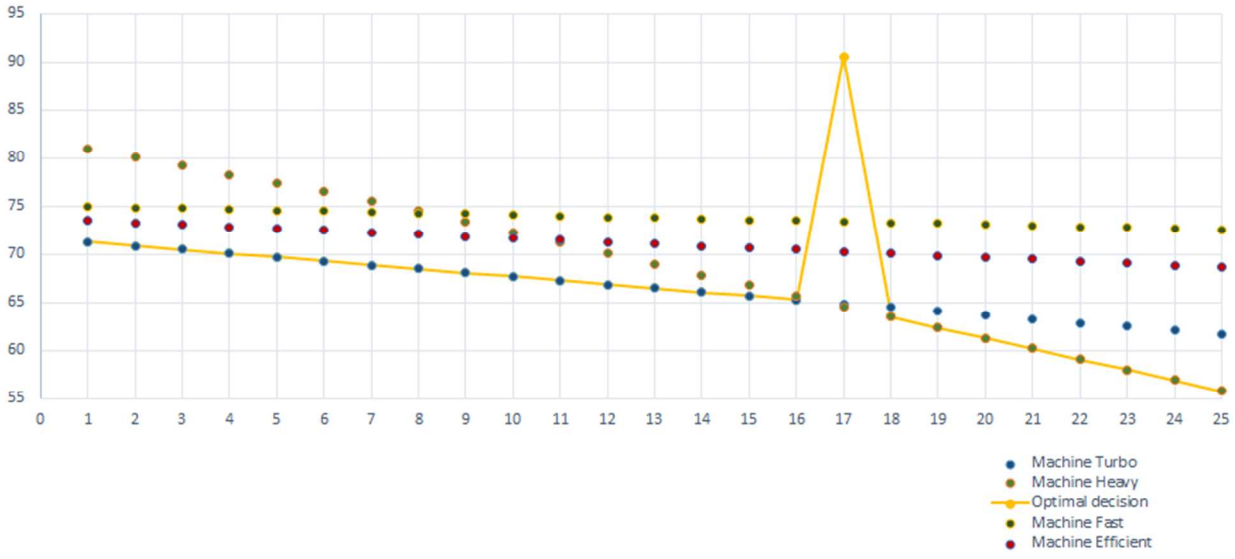

Figure 5. Overall Costs

The dependent variable was path dependence. We measured path dependence with a dummy variable that distinguished between choosing the optimal alternative in the last round versus choosing a non-optimal alternative. Participants who ended up with a choice for a non-optimal alternative in the last round were path dependent since the switching costs were higher than the available budget; i.e., they were locked in (Koch et al. 2009). To reward the participant with superior decision-making performance, we additionally included decision quality as a dependent variable and measured it with dummy variables, indicating whether participants were choosing the single best alternative in a decision round. For each participant and for decision rounds 1 to 20 (in which participants were still able to choose without being locked in), we assigned either 0 (non-optimal alternative chosen) or 1 (optimal alternative chosen) as the value for the variable. We used the sum of the values of each round (i.e., the number of choices for the single best alternative in rounds 1 to 20) as a measure of decision quality.

Results

To ensure the random assignment of subjects to the different experimental conditions and to rule out alternative explanations, we performed several one-way ANOVAs. There were no significant differences in gender ($F = 0.393$, $p > 0.05$), marital status ($F = 1.559$, $p > 0.05$), working experience ($F = 1.918$, $p > 0.05$), managerial experience ($F = 1.13$, $p > 0.05$), leadership experience ($F = 0.74$, $p > 0.05$), annual salary ($F = 0.761$, $p > 0.05$), team size ($F = 0.63$, $p > 0.05$), age ($F = 0.59$, $p > 0.05$), size of company ($F = 1.333$, $p > 0.05$), position ($F = 0.30$, $p > 0.05$), industry ($F = 0.73$, $p > 0.05$), education ($F = 2.125$, $p > 0.05$), and time spent for answering the study ($F = 1.565$, $p > 0.05$), thus indicating that these factors were not the cause of difference in responses.

We began our analysis by conducting manipulation checks (Cozby 2009); i.e., we determined whether the manipulation of the independent variable had its intended effect on the decision-making of participants and generated further evidence for construct validity of the manipulation. Descriptive statistical analysis of the applied manipulation checks within the three groups revealed that participants that were subject to treatment group A clearly recognized the introduction of manipulation in decision round 22 (except for two persons) and participants in treatment group B clearly recognized the introduction of the manipulation in decision round 22 as well as the removal of the preferred strategic option (except one person). In contrast, participants in the control group clearly stated that no apparent change happened during the course of their decisions (expect two persons). In addition, the descriptive statistical analysis of the applied manipulation checks also reveals that participants in all three groups clearly recognized the positive feedback on savings in each decision round and total cumulative savings concerning their individual choices (except one person). One-way ANOVAs additionally confirmed these findings (all $p < 0.05$). These results provided strong evidence that the manipulations were successful.

H1 argued that the non-emergence of digitization increases the probability that firms become path dependent. In our data, 57 of 73 participants, more than 78 percent of the control group, did not recognize and thus missed the possibility to switch to the favorable alternative within 25 decision rounds, while only 16 participants (21.9 percent) succeeded in switching to the optimal decision and were not locked in (see Figure 6 for a graphical overview). A significant chi-square test revealed that the probability of lock-in differs significantly between the groups ($\chi_2 = 28.286$, $p < .001$), thus supporting H1. This result demonstrates a significant relationship between the non-emergence of digitization as an external event that broadens the available scope of action and the probability that firms become path dependent. In all, these results verify the existence of path dependence in our experiment (Koch et al., 2009). As such, we could support the main effect hypothesized in H1 and the direct effect of non-emergence of digitization on path dependence.

H2a argued that the emergence of digital technologies leads to a market shift, whereas H2b argued that the emergence of digital technologies leads to a technological shift, in comparison to the control group. Our results show that the emergence of digital technologies leads to a significant technological shift. Thus, we can support H2b ($x^2 = 11.583$, $p < 0.001$). The results reveal that the emergence of digital technologies does not lead to a significant market shift of the business model; therefore, H2a is rejected ($x^2 = 3.46$, $p > 0.05$). Our results suggest that path-dependent decision-makers are inclined to pursue a technological shift, rather than a market shift, after the emergence of digital technologies. As illustrated in Figure 6, results from treatment group A with a sample of 74 participants demonstrate that 20 participants (27.6 percent), namely, participants who chose Machine Heavy and Machine Turbo, did not recognize the sub-

optimality of their decision despite the presented information about changes in the market environment in decision round 22; i.e., these participants stayed with their preferred strategic option and became locked in. Despite the introduction of new strategic alternatives, 14.7 percent stayed with the strategic option of producing manual steering wheels by using Machine Heavy. Interestingly, 13.2 percent chose Machine Fast or Machine Efficient, which represented the other two possible options that were, however, less favorable from the start.

H3a argued that the emergence of digital technologies and the removal of the preferred strategic option (Machine Turbo) leads to shifting the established product to new markets, whereas H3b argued for a shift of the technological foundation of this product. Our results show that the emergence of digital technologies and the removal of the preferred strategic option lead to a technological shift, thus supporting H3b (x^2= 14.983, p. < .023). The results reveal that the emergence of digital technologies and the removal of the preferred strategic option do not lead to a significant market shift; therefore, H3a (x^2 = 3.062, p > 0.05) is rejected. As illustrated in Figure 6, results from treatment group B with a sample of 78 participants demonstrate that, despite the introduction of new strategic alternatives, 14.7 percent stayed with the strategic option of producing manual steering wheels. Despite the introduction of new options provided by digitization, 21.7 percent of the participants stayed with the preferred strategic option of producing manual steering wheels. Furthermore, Figure 6 illustrates the direct comparison of treatment groups A and B. For the analysis of the third set of hypotheses, we compared treatment group A against treatment group B. While we used the control group as the benchmark for treatment group A in the second set of hypotheses, this would have not worked equally well for the third set of hypotheses because the control group did not receive the other treatments. The third set of hypotheses were especially focused on the slight difference of whether the removal of the path-dependent option is of relevance, as well as whether there are slight differences in decision patterns. Therefore, previous treatments could confound the results if we compared treatment group A and the control group. Participants in group B, who did not have the ability to reproduce the preferred strategic option, were more inclined to stay with this option (21.7 percent) than participants in group A (14.7 percent). Thus, a technological shift in response to the emergence of new digital technologies is more likely when reproduction of the preferred strategic option is no longer possible. Furthermore, we can state that 17 percent of group B participants chose Machine Fast or Machine Efficient, in comparison to group A with 13.2 percent and the control group with 32.8 percent. In general, we can conclude that the degree to which decision-makers tend to choose a non-optimal decision decreases with the introduction of digitization.

After completing the 25 consecutive decision rounds, all participants in our study completed a survey that contained open and closed questions regarding the chosen strategy, the rationale of their decisions, demographical questions, manipulation checks, and an additional check of their eligibility. The post-hoc analysis of the gathered answers on the chosen strategy and rationale of decision-making support the presented results. For example, one participant stated, "Now, reflecting on my choices, I am not sure if sticking to Machine Turbo [the preferred strategic option of path-dependent decision-makers] despite changes on the market was the best choice but on [sic!] some point, I just stuck with it and at the end switching was just so difficult because of the costs." Further statements support our research design and experimental setting, such as functionality of positive feedback. For instance, participants stated that "[i]t was never worth switching as I was constantly saving the company" or that "there was no incentive to change to another machine as long as it was saving me money."

Additionally, we controlled for several factors, such as motivation for participation and related questions with open and closed questions about participation in our research setting, in a post-hoc questionnaire in order to re-ensure the eligibility of the participants and the sample as a whole. In line with prior research on the motivation of MTurk participants, in which payment was found to be an important, though not essential, factor for participation (e.g., Paolacci et al. 2010; Sheehan and Pittman, 2016), the results demonstrate that the majority of participants stated factors such as gaming, interest in research, and fun as the primary drivers for participation (e.g., "I love to aid research," "possibility to give my opinion on important matters," "tasks are fun"). From the total sample, only four participants stated that they participate in MTurk studies solely for monetary reasons. Overall, participants indicate that they are driven by both extrinsic and intrinsic motives, which suggests that rewards on MTurk are not merely monetary. The post-hoc analysis supports the eligibility of the chosen sample. As Table 2 depicts, participants had an annual salary of $123,500 on average (SD = 45.500) and can, therefore, be assumed

to participate for reasons other than monetary ones. One-way ANOVAs also confirmed these findings (all $p < 0.05$).

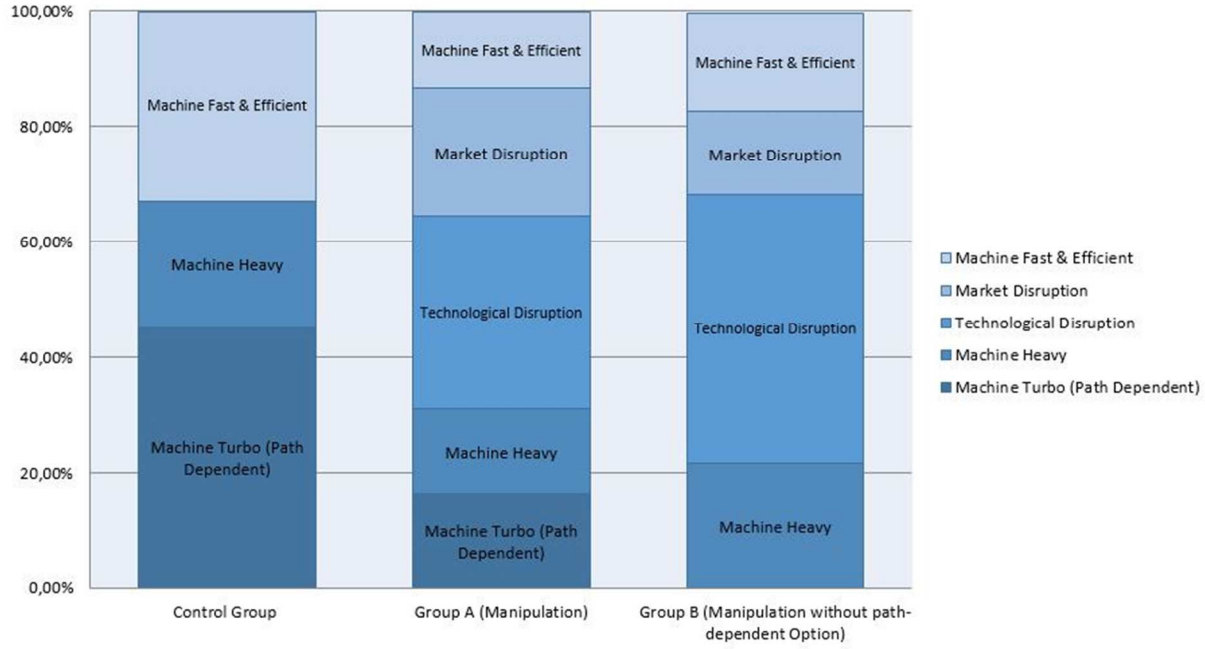

Figure 6. Graphical Overview of Results across the Treatment Groups

Discussion and Conclusion

Our research question was: *How do path-dependent firms respond to digital disruption?* To examine this research question, we drew on the literatures on path dependence (e.g., Rothmann and Koch 2014; Sydow et al. 2009; Vergne and Durand 2010) and disruptive innovation (e.g., Christensen and Raynor 2003; Tushman and Anderson 1986; Yu and Hang 2010) to develop and formulate our hypotheses. Then, we tested these hypotheses in an experimental setting. Our results suggest that path-dependent firms are particularly inclined to renew the technological foundation of their products and services when digital technologies emerge (i.e., a technological shift) and focus less on repositioning their existing products and services in new market segments (i.e., a market shift). Thus, our findings indicate that digitization causes a technological shift rather than a market shift. Our findings also indicate that a technological shift is more likely when path-dependent firms can no longer reselect the previously preferred strategic option; i.e., under this condition, a technological renewal is more attractive than repositioning the established product or service in a new market segment.

Our findings offer several contributions to the previous literature. First, we complement the literature on digitization with its preponderance of the business opportunities of digitization by offering insights into the challenges that digitization imposes on established firms, i.e., its disruptive potential that has remained less explored so far (Besson and Rowe 2012; Lucas et al. 2013; Sørensen and Landau 2015). In particular, we shed further light on the responses of path-dependent firms to digital disruption. While previous works have holistically emphasized the disruptive impact of digitization on established businesses (e.g., Karimi and Walter 2015; Lyytinen and Rose 2003), our study develops a more nuanced understanding of the disruptive nature of digitization. Our study points to the preponderance of technological shifts that lead path-dependent firms to renew the technological foundation on which their products and services are based and less to shifts to new market segments. Here, it is interesting to note that the renewal of the technological foundation of businesses does not necessarily lead to a new product/market concept as such; i.e., news publishers continue to rely heavily on ad-based revenues in the digital sphere (Rothmann et al. 2014), funeral homes still insist on enacting their counseling competence and generating an expensive coffin in digitized firm-consumer interactions (Wenzel 2015), manufacturers of formerly mechanic steering systems still focus on (now digitized) steering systems, and

so on. Thus, our study essentially highlights that, although digitization may infuse new "digital options" (Sambamurthy et al. 2003), path-dependent firms may not conduct *strategic* change per se but rather reinforce their existing *strategic* path through technological shifts that allow them to retain their product/market concept even in the digital sphere. Thus, our findings draw a more defensive picture of the (strategically) innovative power of digitization than the previous literature suggests.

Second, our findings also add to the literature on disruptive innovation by offering an integrative view of different perspectives. While the literature on disruptive innovation has distinctly approached the disruption of strategic paths from both the technological and market sides (e.g., Christensen and Raynor 2003; Tushman and Anderson 1986; Yu and Hang 2010), our study tested both approaches simultaneously in an experimental setting. Our study lends support to the idea that punctuated disruptions may lead incumbent firms to renovate their processes and competences for producing new products and services (Tushman and Anderson 1986) and that finding new market segments for their products and services is one of the key challenges of incumbents in the face of disruptions (Christensen and Raynor 2003). Taking both views on disruptive innovation into perspective simultaneously echoes past calls for an integrative view of disruptive innovation (Danneels 2004; Yu and Hang 2010). Therefore, our study provides a potential cornerstone for future research that may continue to examine these two approaches simultaneously.

Third, our findings extend the literature on path dependence. While previous works have focused on path emergence and path persistence rather than path disruption (see Rothmann and Koch 2014; Wenzel 2015), our study focuses specifically on the disruption of strategic paths. In particular, we provide insights into the responses of path-dependent firms in the moment of path disruption. Our results point to a decision-making pattern in the face of digitization that favors renovation of the underlying technology of the established products and services and focuses far less on shifts toward new market segments. Thus, experimentally testing path-dependent decision-making in response to digital disruption draws a more nuanced picture of the specific responses to path disruption by highlighting the preponderance of technological shifts that do not result in strategic change per se.

Our paper also has several practical implications. In particular, in fast-paced environments, managers face an overflow of information from different sources and develop decision routines to cope with the complex reality. This may result in accumulating a path-dependent decision history. Our results shed light on this decision process and help increase managers' awareness of their decision path. In that respect, our results indicate that managers should consciously consider whether their strategic actions favor following their history of decisions or a strategic change in response to digital disruption. Managers also should be aware of the distinct influence of shifts in demand and technological upheavals on their decision-making behavior. In sum, managers will benefit from awareness regarding the path dependence of their decision-making behavior by deciding in a more informed way and will eventually achieve better results.

Although the results provide several insights into the responses of path-dependent firms to digital disruption, the study has several limitations and is bound by the empirical setting. In our experiment, we neglect factors such as innovation expenditures, performance outcomes (e.g., profits), environmental dynamism (e.g., Eisenhardt and Martin 2000), and individual characteristics of participants such as managers that may influence strategic decision-making (e.g., willingness to take risks). Future research is needed to examine these aspects and their influence on our findings in the current study. Furthermore, our study focuses on the resource-based form of path dependence and does not include cognitive and normative forms (Koch 2008, 2011; Rothmann et al. 2014; Sydow et al. 2009). Although our study takes into focus the form of path dependence that can be overcome less easily (Sydow et al. 2009), future research may also test the disruptive impact of digitization on these alternative forms of path dependence. Another interesting future direction would be to explore situations in which path dependence yields positive performance outcomes despite digital disruption. In this case, newly emerging strategic alternatives would not immediately be as attractive as established strategic options and, thus, would likely intensify the inertial forces of path dependence that we have discovered in our experiment. In terms of future directions, we call for further empirical and conceptual work with a variety of methodological approaches, such as biographical (Wenzel et al. 2015), discursive (Koch 2011), and reconstructive (Wenzel et al. 2016) approaches, to investigate and enhance the debate on digitization and digital disruption. In particular, it would be a promising avenue for further research to investigate the explanatory mechanisms

through which digital disruption impacts path-dependent decision-making in more detail and the underlying causal relationships in which this phenomenon is embedded.

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