Digital Agendas in the Insurance Industry: The Importance of Comprehensive Approaches

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EXECUTIVE SUMMARY

Mobile, interconnected digital technology opens up many new possibilities for innovation in the insurance industry. Companies can access huge amounts of information which have previously not been available; they can connect data sources from different origins to gain a more comprehensive and accurate basis for their calculations, and they can monitor natural phenomena and human behavior in real-time. Furthermore, they can connect to clients frequently and flexibly to negotiate and sell contracts, monitor behavior and mitigate risks or provide additional services which have so far not been considered. In the years to come, it will be one of the most challenging tasks for companies to develop digital agendas which allow them to make best use of these possibilities.

Extant research in the field of information systems has already explored the implications of digital technology for innovation in much detail. During the last years, the notion of digital innovation has become popular to describe a new type of innovation which is not limited to the generation of new products or service offerings. Digital innovation refers instead to a larger transformation process which concerns the whole company, its position in the market as well as its internal value streams, its culture, assets and relations to business partners, suppliers and customers. Drawing on the notion of digital innovation, we hypothesize that insurance companies benefit not only from having a digital agenda, but that they will benefit most from digital technology by if they take a comprehensive approach which includes internal as well as external innovation activities.

In order to test our hypotheses, we study the business performance of 39 publicly-traded European insurance companies for the time period from 2007 to 2015. We use the annual reports of the companies to find out in what way the companies have put together a digital agenda in these years. Using state-of-the-art text-mining techniques, we analyze references to digital technology in the reports, as well as the context in which the references appear. We distinguish between the internal context, where digital technology is applied for data management, risk calculation, process optimization, etc. and external contexts, where it supports interaction with clients, marketing etc.

With our analysis, we can show that over time, references to digital technology have continuously increased, with the exception of the crisis-year 2008. However, there are notable differences between companies in terms of the time at which they start to adopt a digital agenda and the intensity in which they pursue it.

In line with prior research, we use Tobin's *Q* as the basis for measuring firm value. Excluding effects of size, ROA, leverage, dividends, and sales growth, we detect a positive relationship

between the existence of a digital agenda and firm value for all companies and years. Moreover, we find that this effect is stronger for companies which address digitalization in external as well as internal contexts: they exhibit a firm value almost 8% higher than the other companies. This finding holds true when taking relevant covariates into account and when controlling for endogeneity.

The results of our study have strong implications for insurance companies regarding the treatment of digital technologies. It is not enough to adopt them for specific application cases. Instead, companies need to think more strategically about digitization and acknowledge its transformative effect on their overall business activities. From a theoretical point of view, our study shows how the concept of digital innovation can be applied to the insurance industry and which subcategories of digital innovation need to be further outlined. Furthermore, we believe that our paper also contributes to the development for research methodology in the field with an application of text mining techniques which has so far received comparably little attention, but can be expected to play an increasingly important role in the years to come.

DIGITAL AGENDAS IN THE INSURANCE INDUSTRY: THE IMPORTANCE OF COMPREHENSIVE APPROACHES

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ABSTRACT

With a growing awareness of the potential of innovation provided by digital technology, insurance companies have increasingly adopted digital agendas in their business activities. Our paper studies the relationship between the expression of a digital agenda in annual reports and the business performance of 39 publicly-traded European insurance companies for the time period from 2007 to 2015. Our findings show a positive relationship, which is particularly strong in cases where companies take a comprehensive approach by addressing digital technology both in the context of internal activities within their own organization and external activities in connection with customers and business partners.

Keywords: Digitalization; firm characteristics; shareholder value

1. INTRODUCTION

Insurance business is coupled to socio-economic change in many different ways. On the one hand, new developments in society and economy affect the demand for insurance. Megatrends such as urbanization, individualization, and the ageing society create dynamics in the client markets of insurance companies. Climate change, economic instability, and political unrest require alterations to the way how risk is calculated. On the other hand, insurance companies are themselves part of larger socio-economic structures which affect their daily performance. They require qualified personnel, use modern information and communication technologies, and depend on financial products to generate savings. Socio-economic change therefore also has an effect on the way insurance companies perform. In this sense, one can talk about external couplings and internal couplings of insurance business to socio-economic change. While the former concerns markets, customers and offerings, the latter concerns business operations, management and control.

Among the many drivers of socio-economic change, digital technology plays a particularly important role. In recent times, mobile, interconnected devices equipped with powerful, miniaturized processors, sensors and actuators have become ubiquitous in daily life. In the years to come, they will permeate human life even more, creating enormous potential for new ways to inform actors, support decision making and collect data to analyse and predict patterns of behaviour (see, e.g., Lee, 2008; Porter and Heppelmann, 2014; McAfee and Brynjolfsson, 2012). At the same time, existing IT infrastructures such as the Internet enable new forms of commerce, which can lead to innovation through platform-based interaction and systemic value creation (see Lusch and Nambisan, 2015). These changes create opportunities for insurance companies to enter into a new phase of digital insurance (see, e.g., Nicoletti, 2016).

The potential of digital technology for innovation in the insurance industry is significant (see Eling and Lehmann, 2017). It includes the implementation of new forms of online marketing and sales activities (see Seitz, 2011), the generation of new business models and value creation processes (see Desyllas and Sako, 2013; Schmidt et al., 2017), and the overall transformation of insurance companies into more agile organizations (see Barkur, Varambally, and Rodrigues, 2007). Given this variety, insurance companies can choose different strategies to approach digital technology. Our research interest in this paper is directed at the question of which strategies are most likely to lead to success. In line with the aforementioned considerations, we hypothesize that companies benefit most from digital technology if they use them for a comprehensive approach to innovation which addresses internal as well as external aspects of change.

The remainder of the paper is structured as follows. Section 2 provides a literature overview leading to the hypotheses development. In Section 3, we describe our data set and outline the approach to the empirical analysis using a treatment effects model. Section 4 provides the study results and robustness tests, while Section 5 summarizes and gives concluding remarks.

2. Literature and Hypotheses

Digital technologies and innovation

Understanding the contribution of digital technology to the success of business operations is a central topic in information systems research (see Agarwal and Lucas, 2005; Schryen, 2013). The body of literature in the field is large and covers a variety of different approaches with respect to the key constructs, dependent variables and data sources used (see, e.g., Melville, Kraemer, and Gurbaxani, 2004; Kohli and Devaraj, 2003). Recent contributions have emphasized the importance of a broader look at different manifestations of value and its mediating factors (see Kohli and Grover, 2008). Digital technology has to be considered not only as means of cost reduction, but also as an investment for revenue growth in supporting different functions in the company (see Mithas et al., 2012). Information systems can have a strong impact on organizational agility (see, e.g., Lu and Ramamurty, 2011; Sambamurthy, Bharadwaj, and Grover, 2003). Furthermore, they involve numerous different intangible assets related to the implementation and operation of the systems, which affect organizational capabilities in different ways (see, e.g., Saunders and Brynjolfsson, 2016; Mithas, Ramasubbu, and Sambamurthy, 2011).

On a more general level, information systems can be considered as a driver for organization change, as they affect the concepts and operational structures of business practice (see Markus, 2004). While technological determinism is hard to uphold (see Markus and Robey, 1988), as the decisions about how technology is adopted in an organization result from complex social dynamics (see Boudreau and Robey, 2005; Venkatesh et al., 2003), technical devices and systemic structures still provide an important point of reference for reflection on organizational practice and options for further development (see Orlikowski, 2009). This perspective becomes even more apparent in highly dynamic socio-economic environments where organizational routines and instrumental action is constantly re-negotiated (see Pentland et al., 2012; Leonardi, 2011). This transformative power of digital technology (see Lucas et al., 2013; Dhar and Sundararajan, 2007) has recently been documented in various different industries, such as healthcare (see Agarwal et al., 2010), manufacturing (see Brettel et al., 2014), and robotics (see Brynjolfsson and McAfee, 2012).

The notion of digital innovation expands this line of thought towards a new understanding of innovation, following the digitization of physical artefacts (see Svahn, Henfridsson, and Yoo, 2009). Drawing on the study of multimedia devices, Yoo, Henfridsson, and Lyytinen (2010, p. 725) consider digital innovation as carrying out "new combinations of digital and physical components to produce novel products". New architectural paradigms such as the Internet of things (see Atzori, Iera, and Morabito, 2010) and cyber-physical systems (see Lee, 2008) support this process by a stronger association of physical processes with computational events, such that they can be referred to interchangeably (see Gölzer and Fritzsche, 2017). Common examples can be found in the automotive industry, where innovation is increasingly around new combinations of physical products and data services in cars and mobility services related to them (see, e.g., Hildebrandt et al., 2015; Hylving and Schultze, 2013). Fichman, Dos Santos, and Zheng (2014, p. 330) take a broader approach to digital innovation, which is associated with any "product, process, or business model that is perceived as new, requires some significant changes on the part of the adopters, and is embodied in or enabled by IT". In a similar way, Nambisan et al. (2017, p. 224) expand the notion of digital innovation to "the creation of (and consequent change in) market offerings, business processes, or models that result from the use of digital technology". Fichman et al. (2014) as well as Nambisan et al. (2017) thus turn the focus towards the added value for customers resulting from the application of digital technology to make new kinds of offerings available to them. Any innovation which relies in one way or another on the availability of digital technology can accordingly be considered as a digital innovation. It does not matter how digital technology exerts its influence, as long as it provides a necessary condition for the possibility of the innovation. In this sense, digital innovation results not only from the application of digital technology, but also relies on its availability, since the innovation could otherwise not be achieved and sustained. Engagement in digital innovation has strategic significance for an organization, because it accompanies decisions to put business operations on a new foundation, rather than just replacing an old tool by another one.

Digital innovation and the insurance industry

Early work on the implications of advanced digital technology for the insurance industry was mainly concerned with new online distribution channels (see Garven, 2002; Dumm and Hoyt, 2003), particularly with respect to their consequences for insurance agents (see Eastman et al. 2002), customer orientation (see Kaiser 2002) and regulation (see Meyer and Krohm 1999). While older data processing systems in the companies were seen chiefly as a means to increase efficiency, new generations of digital technology are expected to increase market dynamics and competition, due to more transparency and comparability, lesser transaction costs and a wider reach of online platforms (see Schulte-Noelle, 2001; Taylor, 2001). As a consequence of these developments, possibilities for convergence in financial services are discussed (see Beltratti and Corvino, 2008), as well as implications of formal models of insurance business (see, e.g., Seog, 2009).

Barkur, Varambally, and Rodrigues (2007) emphasize the need for organizational change in the insurance industry to cope with the aforementioned dynamics. The ubiquitous presence of mobile, interconnected devices adds further momentum to this argument, as it enables insurance companies to adopt new business models (see Desyllas and Sako, 2013) and change the types of risks that can be insured against (see Gehrke, 2014). Big data analytics allow individual and adaptive calculations of premiums based on information about the insurance holder's behavior (see McAffee and Brynjolfson 2012), and risks which have previously not be calculable can now be estimated in ways that make it possible to address them with new types of insurance (see Eling and Schell, 2016). Furthermore, platform-based interactions can complement centralized insurance offerings for specific interest groups (see, e.g., Cole 2015; Salman 2014).

Eling and Lehmann (2017) give an overview of current literature related to digital transformation in the insurance industry. Subtopics include artificial intelligence, big data, the Internet of things, blockchain, cloud computing, mobile devices, and various online applications. They show that the effects of digital technology for insurance companies cannot be considered in isolated subcategories (see also Nicoletti, 2016; ACORD, 2017). Opportunities for digital innovation span different steps of the value chain and at the same time influence the structure of insurance offerings and their objects of reference. A distinction between internally oriented technical solutions to support business operations and externally oriented solutions for customer interaction can no longer be upheld. To capture the full potential of digital technology for innovation in the insurance industry, companies must take a comprehensive approach which includes all their internal and external operations.

The combination of the aforementioned streams of literature in the fields of information systems and insurance research highlights the importance of digital technology for innovation in the insurance industry. It also emphasizes the importance of an inclusive strategy to address all the different implications of digital technologies for insurance companies. We express these findings in the following two hypotheses:

H_1: *The business performance of insurance companies with a digital agenda is better than the business performance of insurance companies without a digital agenda.*

H_2: *The business performance of insurance companies with a comprehensive digital agenda is better than the business performance of insurance companies with a selective digital agenda which considers internal or external applications in isolation.*

In following sections, we will use the annual reports of insurance companies as source material to assess their digital agendas. It is assumed that companies with a digital agenda address these agendas in their reports by mentioning the word digital or some of its derivatives. It is also assumed that the context in which words pertaining to a digital agenda are mentioned allows conclusions about the field of application for digital technology.

3. Data, Variables, and Methodology

In the following we present the composition of our sample of major European insurance companies, which we use to assess the impact of innovation transformation in the form of digitalization activities on an insurance company's firm value. Overall, our sample contains 39 publicly-traded European insurance companies for the time period from 2007 to 2015, for which we retrieved financial data from the Thomson Reuters Datastream. Information on the firms' digitalization activities was derived from their disclosed annual reports.[1] The sample covers a

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[1] In order to be able to calculate Tobin's Q, we restrict the data set to publicly-traded insurance companies and consider companies that disclose their full annual reports in English for the respective years.

sizeable proportion of the insurance market in Europe, representing approximately 60% of gross premiums in the year 2015 (see Insurance Europe, 2016; Bohnert et al., 2017).

Measuring firm value (dependent variable)

We use Tobin's *Q* as a proxy for an insurance company's value following prior practice (see, e.g., Bardhan, Crishnan and Lin, 2013; Masli et al. 2011; Hoyt and Liebenberg, 2011; Bohnert et al., 2017). As stated in Table 1, Tobin's *Q* is calculated as the ratio of the market value of equity plus the book value of liabilities divided by the book value of assets, or equivalently as the ratio of the market value of assets divided by their replacement costs (see, e.g., Hoyt and Liebenberg, 2011). It is held in the finance literature that Tobin's *Q* has several advantages compared to other performance and value measures (see, e.g., Lindenberg and Ross, 1981; Hoyt and Liebenberg, 2011; Lin, Wen, and Yu, 2012).

Assessing digitalization activities

In order to empirically assess the impact of digital innovation transformation on Tobin's *Q*, we had to develop a measure for digital agendas in insurance companies, since companies are not required to report their agendas. We base our approach on the firms' disclosed annual reports and text mining techniques to search for evidence of engagement in digitalization activities.[2] The firms' annual reports are manually retrieved as PDF documents from the companies' websites and further processed to extract the plain text of the reports, followed by a quantitative text analysis.[3]

Table 1 provides an overview of the variables used in analysis, with the upper part showing the digitalization variables.

2 To conduct a survey as done in, e.g., Kleffner, Lee, and McGannon (2003) and Altuntas, Berry-Stoelzle, and Hoyt (2011) with respect to enterprise risk management engagement would be an alternative.

3 Several approaches were conducted and evaluated, The most suitable results in our case were provided by pre-processing with Ghostscript, plain text extraction via Xpdf, and quantitative text analysis using the programming language R (considered alternatives include, amongst others, PDFBox, RapidMiner, and Tika).

Table 1: Definition of variables

Variable	Measurement
$d_{i,t}^{absolute}$	Absolute number of occurrences of words containing the strings "digita" or "digiti" (keyword strings *d*) for company *i* in year *t*[4]
$w_{i,t}^{absolute}$	Total number of words in the annual report for company *i* in year *t* (without punctuation and numbers)
$d_{i,t}^{relative}$	$d_{i,t}^{absolute} / w_{i,t}^{absolute} \cdot 100{,}000$, i.e. number of occurrences of words containing the keyword strings *d* for company *i* in year *t* relative to the total number of words in the respective annual report times one hundred thousand
$d_{i,t}^{binary}$	1 if $d_{i,t}^{absolute} \geq 1$, i.e. at least one occurrence of the keyword strings *d*. 0 otherwise
$d_{i,t}^{c20,e,binary}$	1 if at least one occurrence of keyword stems *e* indicating digital external activities focusing on products and sales[5] 0 otherwise
$d_{i,t}^{c20,i,binary}$	1 if at least one occurrence of keyword stems *i* indicating digital internal activities including modeling and management[6] 0 otherwise
$d_{i,t}^{c20,ei,binary}$	1 if $d_{i,t}^{c20,e,binary} = 1$ and $d_{i,t}^{c20,i,binary} = 1$ 0 otherwise
Q	(Market value of equity + book value of liabilities) / book value of assets
Size	Natural logarithm of book value of assets
ROA	Net income / book value of assets
Leverage	Book value of liabilities / market value of equity
Dividends	1 = Insurer paid dividends (i.e. dividend payments > 0) in the respective year 0 = Otherwise
SalesGrowth	(Sales(t) – sales(t–1)) / sales(t–1)

Notes: Quantitative text mining variables are calculated based on the companies' annual reports; financial variables are based on Bohnert et al. (2017) and retrieved from Thomson Reuters Datastream: Market value of equity = market capitalization (WC08001), book value of liabilities = total assets (WC02999) – total shareholders' equity (WC03995), book value of assets = total assets (WC02999), net income = net income available to common (WC01751), sales = net sales or revenue (WC01001), dividend payments = cash dividends paid total (WC04551), all calculations are done in Euros and converted to Euros if necessary.

We first count the number of occurrences of words containing the strings "digita" or "digiti" (keyword strings *d* hereafter) for company *i* in year *t* denoted as $d_{i,t}^{absolute}$ comprising any

[4] Comprising words such as digital, digitalisation, digitalise, digitalised, digitalising, digitalization, digitalize, digitalized, digitalizing, digitally, digitisation, digitise, digitised, digitising, digitization, and digitize.

[5] Word stems include channel, client, custom, distribut, market, onlin, product, sale, service.

[6] Word stems include board, employe, group, manag, model.

grammatical forms of "digitalization" and "digitization".[7] We next calculate $d_{i,t}^{relative}$ as the ratio of occurrence of these words relative to the overall number of words (without punctuation and numbers) for company i in year t. In addition to this, we also determine a binary variable $d_{i,t}^{binary}$ that is equal to one in case of $d_{i,t}^{absolute} \geq 1$ and zero otherwise. While the occurrence of the keyword strings d (measured by the figures $d_{i,t}^{k}$, k = absolute, binary, or relative) might be interpreted as a sign for the general awareness and relevance of digitalization for the respective company for a given year, however, it does not reveal the specific area of digitalization and digitalization activities that is sufficiently relevant to be discussed in an annual report and might play a role for the company.

We thus make use of the key word in context (KWIC) concordance as "the most common corpus-linguistic tool currently used" (Gries and Newman, 2013, p. 277). Here, a predefined number of words to the left and to the right of a word of interest (which we define, e.g., as $c20$ as 20 words to both sides of a keyword expression) is extracted from the entire text to further assess the use of the word and get an impression of this word's immediate context. Since a manual inspection of all concordances is hardly feasible and would further induce a source of subjectivity, we proceed as follows.

For each concordance, i.e. a certain number of words (e.g. 20 words in case of $c20$) around a word of interest containing our keyword string d, we transform these words into word stems.[8] We next determine the most frequent word stems across all concordances and attempt to assign relevant word stems to distinct groups. We build two categories for digitalization activities with respect to (1) external stakeholders (denoted by e hereafter) including word stems such as "channel", "client", "custom", "distribut", "market", "online", "product", "sale", "service" and (2) for internal stakeholders (denoted by i hereafter) including word stems such as "board", "employe", "group", "manag", "model".[9]

While the previous figures $d_{i,t}^{k}$ (k = absolute, binary, or relative) allow the general assessment of activities with respect to digitalization, we now can further categorize the digitalization engagement as follows. We interpret the occurrence of any word stem of the class "e" ("i") in the concordance of digitalization words "d" as digitalization activities with respect to external (internal) stakeholders and set the variable $d_{i,t}^{c20,e,binary}$ ($d_{i,t}^{c20,i,binary}$) to 1 and 0 otherwise. The variable $d_{i,t}^{c20,ei,binary}$ (note the "ei" in the superscript) is equal to 1 in case of $d_{i,t}^{c20,e,binary} = 1$ and

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7 Note that we explicitly do not use the common word stem "digit" at this point, since it could be misleading.

8 This is done by Porter's word stemming algorithm via SnowballC (see Bouchet-Valat, 2014).

9 Any attempts to further classify digitalization activities beyond these two categories are subjective and thus omitted here.

$d_{i,t}^{c20,i,binary} = 1$ (0 otherwise), i.e. in case a company addresses digitalization in the context of both, external and internal stakeholders, in its annual report.

It is important to keep in mind that this process should be seen as a first objective and reproducible attempt to assess and categorize a firm's engagement with respect to digitalization based on the annual reports, which, to the best of our knowledge, has not been done so far.

Further covariates

In addition to the variables measuring digitalization engagement, there are further variables that can have an impact on firm value and thus have to be included as covariates in the regression analysis. We use the variables stated in Table 1 (lower part), which are based on Hoyt and Liebenberg (2011) and Bohnert et al. (2017).

Methodology

We apply a treatment-effects model to estimate the impact of a company's engagement in digitalization (binary and endogenous treatment) on its firm value (continuous and dependent variable), which is given by a system of two equations, i.e. the regression equation (denoted as *Q* Equation),

$$Q = f\left(Digital \mid Size,\ ROA,\ Leverage,\ Dividends,\ SalesGrowth\right), \tag{1}$$

and the selection equation (denoted as *Digital* Equation)

$$Digital = f\left(Size\right), \tag{2}$$

where the covariates are based on the literature (see, e.g., Bohnert et al., 2017). Since there are firm characteristics that can have an impact on the activities with respect to digitalization as well as on the firm value directly, we have to deal with endogeneity. In our base case, we set

$$Digital = d_{i,t}^{c20,ei,binary},$$

while we also use $d_{i,t}^{k}$, amongst others, k = "*c*20,*e*,*binary*", "*c*50,*e*,*binary*", "*c*20,*i*,*binary*", "*c*50,*i*,*binary*", "c50,*ei*,*binary*", and "*binary*" in the robustness analysis.

For further details on the treatment-effects model, we refer the reader to the literature (see, e.g., Lee, 1978; Heckman, 1978, 1979; Maddala, 1983; Guo and Fraser, 2009; Hoyt and

Liebenberg, 2011; Bohnert et al., 2017) and for more technical specifications in our setting see Appendix A.1. See Imbens and Wooldridge (2009) for a comprehensive overview on the statistical analysis of causal effects.

4. EMPIRICAL RESULTS

Descriptive statistics

We now show descriptive statistics for our full sample set (unbalanced panel) of European insurance companies comprising a total of 304 firm-year observations for the years 2007 to 2015 covering a considerable proportion of the insurance market in Europe.[10] The descriptive summary statistics for all firm-year observations are given in Table 2.

Table 2: Summary statistics

Variable	Mean	Std. Dev.	1st Quartile	Median	3rd Quartile
$d_{i,t}^{absolute}$	5.2664	16.1990	0.0000	1.0000	3.0000
$d_{i,t}^{relative}$	5.2239	17.1661	0.0000	0.4850	2.8214
$d_{i,t}^{binary}$	0.5033	0.5008	0.0000	1.0000	1.0000
$d_{i,t}^{c20,e,binary}$	0.3750	0.4849	0.0000	0.0000	1.0000
$d_{i,t}^{c20,i,binary}$	0.3322	0.4718	0.0000	0.0000	1.0000
$d_{i,t}^{c20,ei,binary}$	0.2796	0.4495	0.0000	0.0000	1.0000
Q	1.0228	0.0769	0.9862	1.0064	1.0336
Size	17.7246	1.8148	16.8842	17.7758	19.3237
ROA	0.0134	0.0183	0.0030	0.0073	0.0179
Leverage	14.3584	12.7570	4.8526	10.9404	19.8795
Dividends	0.9638	0.1871	1.0000	1.0000	1.0000
SalesGrowth	0.0194	0.4809	-0.0452	0.0300	0.0893

Notes: Total number of firm-year observations is 304 for a period of 9 years with 30 to 40 yearly observations.

Table 2 (upper part) shows descriptive statistics for the measures of digitalization activities. It can be seen that digitalization is addressed about 5 times on average in every annual report (case for a simple total count $d_{i,t}^{absolute}$). The relatively large standard deviation indicates large differences between the individual firm-year observations that are due to considerable differences in time of the topic of innovation transformation in the form of digitalization and also with respect to variations for different insurance companies (see Figure 1). The variable $d_{i,t}^{binary}$ shows that in about only half of the individual firm-year observations is digitalization

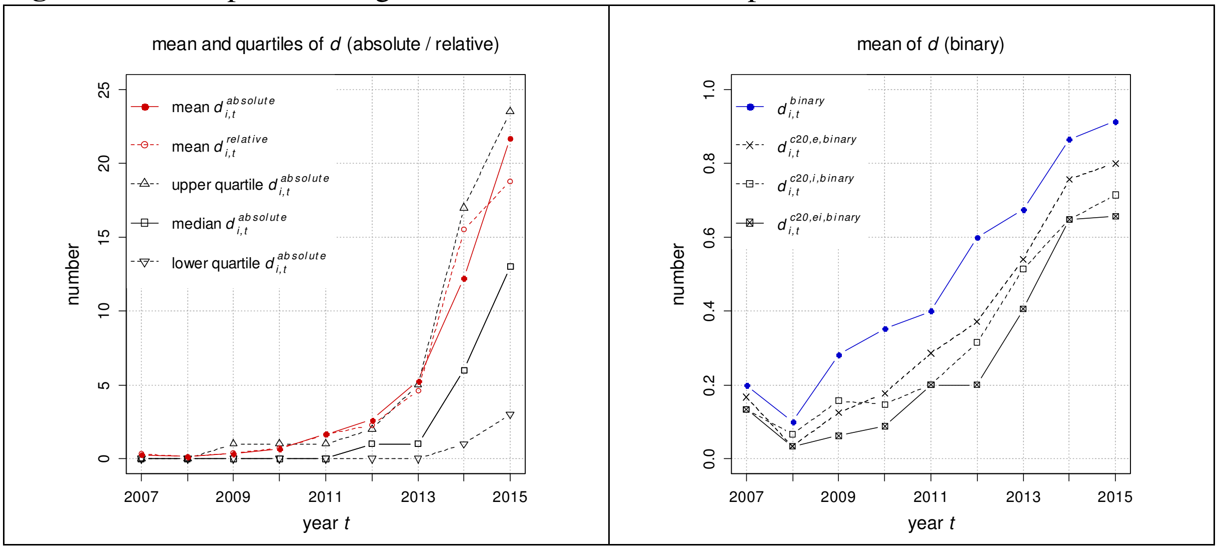
[10] By focusing on the European market, we refrain from dealing with market specifics.

addressed at least once on average. This finding is notable, in particular against the background of the considerably increasing importance and omnipresent discussion of digitalization. Note that the discussion of digitalization in an annual report might not reflect actual procedures within a company. However, it can be assumed that a topic that is attracting a not negligible amount of attention at the board level should be mentioned at least once in a firm's annual (comprehensive) report. Apart from the general discussion of digitalization, we further focus on $d_{i,t}^{c20,ei,binary}$, which measures (binary) whether a firm discusses digitalization in the context of external issues and stakeholders ("*e*") such as customers, market, or sales, and / or with respect to internal issues and stakeholders ("*i*") including the board, group, or model(ing). The results show that $d_{i,t}^{c20,ei,binary}$ is equal to 1 in a little fewer than 30% of the firm-year observations (85 firm-year observations with $d_{i,t}^{c20,ei,binary} = 1$ and 219 firm-year observations with $d_{i,t}^{c20,ei,binary} = 0$).

Table 2 (lower part) exhibits the summary statistics for the financial variables, i.e. the dependent (Tobin's *Q*) and the other explanatory variables. It can be seen that the insurers in our sample have *Q*-values that are larger than 1 on average indicating the creation of value (on average) (see, e.g., Lindenberg and Ross, 1981; Bohnert et al., 2017).

We next consider the digitalization activities of European insurers over time in Figure 1. Figure 1 (left graph) exhibits the developments of the absolute and relative measures over time (for the general case without taking the area of digitalization activities into account).

Figure 1: Development of digitalization activities of European insurers over time



First, it can be seen that all variables considerably increase over time showing that digitalization is addressed in more detail in the firms' annual reports and becoming increasingly relevant to insurers. But the graph further shows that this development does not occur for all insurers to the same extent, which can be seen by taking a look at the quartiles of $d_{i,t}^{absolute}$ (arrow upwards for the upper or 3rd quartile; box for the median or 2nd quartile; and arrow downwards for the lower or 1st quartile), and also in comparison to the mean of $d_{i,t}^{absolute}$ (line with solid red dots). The comparison of the development of the means $d_{i,t}^{absolute}$ (solid red dots) to $d_{i,t}^{relative}$ (red circle) does show a similar development indicating no need for relative measures here.

Figure 1 (right graph) shows the development of the mean of the binary versions of the digitalization measures. All show a considerable increase over time in general. The only exception is the year 2008, where we can observe a one-year drop in the otherwise clearly increasing trend, which might stem from the financial crisis forcing the financial industry to focus on its core activities. The variable $d_{i,t}^{binary}$ (blue line with solid dots) measuring whether an insurer addresses digitalization at least once in its annual report (1, and 0 otherwise) shows that only about 20% of the main European insurance companies did so in 2007, whereas in 2015 with about 90%, the situation has changed substantially. The two black dashed lines below show that activities with respect to digitalization in the context of external issues and stakeholders ("*e*") such as customers, market, or sales ($d_{i,t}^{c20,e,binary}$, black crosses) are a little more often discussed than topics with respect to internal issues and stakeholders ("*i*") including the board, group, or model(ing) ($d_{i,t}^{c20,i,binary}$, black circles), however, both developments are fairly similar.

We focus on the combined variable $d_{i,t}^{c20,ei,binary}$ in the regression analysis. The variable $d_{i,t}^{c20,ei,binary}$ (black crossed circles) depicts the intersection of these two, i.e. it shows insurers that address digitalization in both, the external and internal context representing the most important areas of innovation transformation. Hence, $d_{i,t}^{c20,ei,binary}$ is the main variable of interest in the subsequent regression analysis (besides Tobin's Q for value measurement).

Regression analysis

The aim is to statistically assess the impact of digitalization engagement in an insurance company (by means of the disclosure in an annual report) on its firm value and we now thus perform a treatment-effects regression analysis with the main results given in Table 3.

We consider $Digital = d_{i,t}^{c20,ei,binary}$ as binary and endogenous treatment for Equations (1) and (2) with the dependent (observed and continuous) variable Tobin's Q and obtain the regression estimates via full maximum-likelihood using firm-level clustering. The main finding reveals that the variable $Digital$ ($d_{i,t}^{c20,ei,binary}$) has a positive and statistically significant (at the 1% level) impact on Tobin's Q, i.e. companies that address digitalization in the context of external issues / stakeholders (such as customers, market, or sales) in addition to internal issues / stakeholders (including the board, group, or model(ing)) exhibit a firm value that is almost 8% higher than for companies that do not (and that are most likely engaged in digitalization activities to a lower extent) when controlling for relevant covariates and the endogeneity bias.[11]

It can also be seen that the variable *Size* has a positive and statistically significant (at the 1% level) impact on the digitalization activities (see *Digital* Equation in Table 3), i.e. the larger the insurer (by means of the book value of assets), the more likely is $d_{i,t}^{c20,ei,binary}$ to be equal to 1 meaning that an insurer is more likely to be active in digitalization with respect to external and internal issues / stakeholders. In addition to this, *Size* has also a positive (but not significant) impact on Tobin's *Q* (see *Q* Equation in Table 3).

Table 3: Treatment-effects estimates for the value relevance of digitalization

Variable	*Digital* Equation (2)	*Q* Equation (1)
*Digital**		0.078391 (0.022240)***
Size	0.180243 (0.064711)***	0.000709 (0.004685)
ROA		2.282048 (0.662007)
Leverage		-0.000787 (0.000420)*
Dividends		0.019452 (0.012941)
SalesGrowth		-0.004120 (0.004667)
Constant	-3.795445 (1.192362)***	0.950375 (0.079916)***
Observations	304	
Number of clusters (firms)	39	
Likelihood-ratio test	6.83***	
Wald test	82.34***	

Notes: The treatment-effects model is fitted via full maximum-likelihood using firm-level clustering; standard errors are given in parentheses with '' and '***' indicating the level of statistical significance at the 10% and 1% level, respectively.*

Several robustness checks confirm the main result that European insurance companies with $d_{i,t}^{c20,ei,binary}$ = 1 have a higher firm value than companies with $d_{i,t}^{c20,ei,binary}$ = 0. This result can also be confirmed for the variables $d_{i,t}^{c20,e,binary}$ ($d_{i,t}^{c20,i,binary}$) with a coefficient 0.08167 (0.07470) and standard error 0.02505 (0.02648), with both at a 1% level of statistical significance. We further calculate different values for the concordances and also the digitalization variables with lags of one and two years, which overall reinforce our previous findings.[12]

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11 For $d_{i,t}^{binary}$, the effect seems to be positive as well, but could not be statistically confirmed.

12 In particular, we also calculate $d_{i,t}^{c50,ei,binary}$, $d_{i,t}^{c50,e,binary}$, $d_{i,t}^{c50,i,binary}$, $d_{i,t}^{c100,ei,binary}$, $d_{i,t}^{c100,e,binary}$, and $d_{i,t}^{c100,i,binary}$.

5. SUMMARY

In this paper, we contribute to the discussion on the innovation transformation in insurance companies and to the literature by assessing the impact of digitalization activities on the firm value of insurance companies for the case of the European market. We draw on extant work in the field of insurance studies as well as information systems research, which allows us to take an interdisciplinary look at digital technology and insurance business. In line with current discussions about digital innovation in the field of information systems research, we identify the need for a comprehensive digital agenda to make use of the full potential of digital technology for new directions of growth and development in the insurance industry.

Digital technologies have already found many applications in the context of insurance. Although the current state of development can only be considered as a first step towards a full digitalization of the insurance industry, it still seems justified to use it as a basis for the analysis of the effects that digital technology have on insurance business and the role of explicit digital agendas in the companies.

Our findings reveal that the expression of digital agendas is positively related to business success. Moreover, they show that insurance companies which indicate activities with respect to digitalization in their core business areas in addition to activities externally exhibit a firm value measured by Tobin's Q that is almost 8% higher than for companies that do not and this holds true when taking relevant covariates into account and when controlling for endogeneity.

The results of our study have strong implications for insurance companies regarding the treatment of digital technologies. It is not enough to adopt them for specific application cases. Instead, companies need to think more strategically about digitization and acknowledge its transformative effect on their overall business activities. From a theoretical point of view, our study shows how the concept of digital innovation can be applied to the insurance industry and which subcategories of digital innovation need to be further outlined. Furthermore, we believe that our paper also contributes to the development for research methodology in the field with an application of text mining techniques which have so far received comparably little attention, but can be expected to play an increasingly important role in the years to come.

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Appendix

A.1. Treatment-effects model

The treatment-effects model is given by the following two regression equations that are simultaneously estimated via maximum-likelihood. We assume $d_{i,t}^{k} = d_{i,t}^{c20,ei,binary}$ in our base case.[13] The regression equation ("*Q* Equation") is given by

$$Q_{i,t} = x_{i,t}\beta + d_{i,t}^{k}\delta + \varepsilon_{i,t} \quad (3)$$

and the selection equation ("*Digital* Equation") is defined as

$$^{*}d_{i,t}^{k} = z_{i,t}\gamma + u_{i,t}, \quad (4)$$

where

$$d_{i,t}^{k} = \begin{cases} 1 & \text{if } ^{*}d_{i,t}^{k} > 0 \\ 0 & \text{otherwise} \end{cases}$$

and error terms $\varepsilon_{i,t}$ and $u_{i,t}$ that are assumed to be normally distributed with a mean vector of zero, variances of σ_{ε} and 1, and a covariance of ρ (see, e.g., Maddala, 1983; Guo and Fraser, 2009; Hoyt and Liebenberg, 2011; Bohnert et al., 2017).

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[13] In addition to this, we also use, amongst others, k = "*c*20,*e*,*binary*", "*c*50,*e*,*binary*", "*c*20,*i*,*binary*", "*c*50,*i*,*binary*", "*c*50,*ei*,*binary*", and "*binary*" in the robustness analysis.