**The Impact of Digitalization on the Insurance Value Chain and the Insurability of Risks**

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Abstract: Based on a dataset of 81 papers and industry studies, we analyze the impact of digital transformation on the insurance sector using Porter’s (1985) value chain and Berliner’s (1982) insurability criteria. We also present future research directions, from the academic and practitioner points of view. The results illustrate four major tasks the industry is facing: enhancing the customer experience, improving its business processes, offering new products, and preparing for competition with other industries. Moreover, we identify three key areas of change with respect to insurability: the effect of new and more information on information asymmetry and risk pooling, the implications of new technologies on loss frequency and severity, and the increasing dependencies of systems through connectivity.

Keywords: Digitalization, value chain, insurability, innovation, technology

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## 1. Motivation and aim of the paper

While digitalization – the integration of the analogue and digital worlds with new technologies – has already substantially transformed many other industries,[[1]](#footnote-2) industry commentators believe that the transformation of the insurance industry has come rather late (Müller et al., 2015) and that it has yet to exploit the full potential of digital technologies (Caitlin, Hartmann, Segev, & Tentis, 2015). Still, most market participants believe that digitalization will fundamentally change the value creation of this industry, with manifold new ways of customer interaction, new business processes, new risks and new products.[[2]](#footnote-3) Moreover, recent advances in insurtech have triggered an immense interest among practitioners worldwide. Given this transformation and the magnitude of the interest, it seems astonishing that the academic discussion on digitalization has been virtually nonexistent.

This paper is a comprehensive review of the impact of digitalization on the insurance industry. It establishes a database on studies, articles and working papers and systematically evaluates the impact of digitalization in light of Porter’s (1985) value chain and Berliner’s (1982) insurability criteria. Based on the review results, we derive potential future work from the perspectives of industry and research. We do this to provide insurance practitioners and academics a high-level overview on the main research topics and to encourage future academic work in this field. The focus of the analysis is on the business and economics literature in the risk and insurance domain. To structure our discussion, we organize the paper into three clusters and seven core topics (see Figure 1). The first step is to analyze the main technologies which influence the insurance sector. Based on the results, we describe the impact of those technologies on the insurers’ value chain and derive the consequences for the insurability of risks; here we also discuss whether insurance companies will lose substantial parts of their business to other industries or to insurtech companies.

The remainder of this paper is structured as follows. We begin with a short description of our research methodology (Section 2). Then, we review the literature on our five core research topics (Section 3). Finally, we discuss potential areas of work both practitioners’ and from researchers’ perspectives (Section 4).

**Section 4**

**Section 3**

## 2. Research approach

**Summary of existing knowledge on digitalization in the insurance industry**

1. What is digitalization and which technologies will influence the industry?
2. What is the impact of these technologies on the value chain?
3. Will the insurance industry lose parts of its value chain to other industries?
4. Can insurtechs significantly disrupt the industry?
5. How does the insurability of risks change?

**Derivation of potential future work (practical perspective)**

1. What should the insurance industry do in response to digitalization?

**Derivation of potential future research (academic perspective)**

1. What future research is needed?

**Figure 1:** Research approach with three clusters and seven key questions.

### 2.1. Literature review

Our literature review consists of a structured and standardized search and identification process that has been used in numerous academic papers (e.g., Biener & Eling, 2012; Biener, Eling & Wirfs, 2015; Eling & Schnell, 2016). We review the academic literature by searching the terms “digitalization & insurance,” “technology & insurance,” “big data & insurance,” “machine learning & insurance,”[[3]](#footnote-4) “internet of things & insurance,” “telematic & insurance,” “cloud computing & insurance,” “blockchain & insurance,” “smart contracts & insurance,” “robo advisor & insurance,” “value chain & insurance,” “insurtech,” and “digitalization & insurability,” in the journal databases EBSCOhost (Business Source Premier and EconLit) and ABI/INFORM Collection.[[4]](#footnote-5) We then review journal issues from January 2000 to May 2017 of a predefined list of journals related to insurance.[[5]](#footnote-6) Moreover, we review all working papers from the annual meetings of the American Risk and Insurance Association (ARIA) for 2011, 2012, 2013, 2014 and 2016, the 2010 and 2015 World Risk and Insurance Congress and the 2011, 2012, 2013 and 2016 European Group of Risk and Insurance Economists conferences. Finally, we review citations in the identified papers to explore additional relevant materials. In addition, we searched for the key words in the Social Science Research Network (SSRN) and via Google Scholar. We also identified numerous industry studies with these key words by performing a regular Google search. Based upon this selection process, a database of 81 papers (see Appendix A) is set up and the main results are extracted.

### 2.2. Conceptual frameworks: Value chain and insurability criteria

For the presentation of the results we use two conceptual frameworks. The value chain (Porter, 1985) distinguishes the primary and supporting activities a firm needs to deliver a product or service. Because Porter’s (1985) value chain was formulated for the general industry, we adapt it using the insurance-specific value chain by Rahlfs (2007) (see Figure 2).



Figure 2: Insurance-specific value chain based on Porter (1985) and Rahlfs (2007).

We also rely on Berliner’s (1982) insurability criteria, a frequently used and comprehensive approach for differentiating insurable and uninsurable risks. Nine insurability criteria cover five actuarial, two market-specific and two societal aspects of insurability (see Table 1). Biener et al. (2015) use this approach to determine the insurability of cyber risks. We refer to Berliner (1982) and Biener et al. (2015) for further details on the criteria.

Table 1: Insurability criteria and related requirement defined by Berliner (1982)

|  |  |  |  |
| --- | --- | --- | --- |
| *Insurability criteria* |  |  | *Requirements* |
| *Actuarial* | (1) | Randomness of loss occurrence | Independence and predictability of loss exposure |
|  | (2) | Maximum possible loss | Manageable |
|  | (3) | Average loss per event | Moderate |
|  | (4) | Loss exposure | Loss exposure must be large enough |
|  | (5) | Information asymmetry | Moral hazard and adverse selection not excessive |
| *Market* | (6) | Insurance premium | cost recovery (insurer) and affordable (policyholder) |
|  | (7) | Cover limits | Acceptable |
| *Society* | (8) | Public policy | Consistent with social values  |
|  | (9) | Legal restrictions | Allow the coverage |

## 3. Summary of existing knowledge on digitalization in insurance

### 3.1. What is digitalization and which technologies will influence the industry?

In a first step, we scan through all articles and studies for different definitions of “digitalization” and compare them (see Appendix A).[[6]](#footnote-7) Ingleton, Ozler, & Thomas (2011) describe digitalization in a narrow way and in technical terms such as the availability of digital data; every detail of life is stored in interconnected databases, resulting in a real-time exchange of information. With a broader focus on the business consequences, Tischhauser, Naumann, Candreia, Treier, & Senser (2016) characterize digitalization as the use of new technologies to industrialize and automatize processes, to change the communication between customer and insurer, and to generate and evaluate new data.[[7]](#footnote-8) Hiendlmeier & Hertting (2015), Müller et al. (2015) and Caitlin et al. (2015) describe digitalization as a combination of different components. Whereas Hiendlmeier & Hertting (2015) determine analytics, processes, business impact, technology, mobility and data as the six components of digitalization, Müller et al. (2015) and Caitlin et al. (2015) also consider a digital customer experience and customer centricity in their definition. Back et al. (2016) offer the broadest definition, comprising strategic and cultural elements: the digital transformation is characterized by the changes in corporate strategy, business model, processes and corporate culture caused by technologies with the aim of enhancing competitiveness.

We choose a middle way between the broad and narrow definitions and define digitalization for the purpose of this paper as “the integration of the analogue and digital world with new technologies that enhance customer interaction, data availability, and business processes.” This definition and the discussions in this paper focus on the economic consequences of digitalization, but digitalization goes beyond economics; for instance, the societal consequences such as the change in human behavior or the ethical frontiers of digital monitoring must be considered. We briefly discuss these topics, but they are beyond the scope of this paper.

In Table 2 we list all technologies which are discussed in the reviewed studies,[[8]](#footnote-9) define them and explain the extent of implementation in the insurance industry. In the Table we can identify three broad categories of change in the insurance industry: 1) new technologies change the way insurers and customers interact (e.g., social media and robo advisor); 2) new technologies can be used to automatize, standardize, and improve the effectiveness and efficiency of the business processes (e.g., online sales, digital claims settlement); and 3) new technologies create opportunities to modify existing products (e.g., telematic insurance) and to develop new ones (e.g., cyber insurance).

Table 2: List of digital technologies

| *Technologies* | *Explanation* | *Status quo in the insurance industry* |
| --- | --- | --- |
| Panel A: Technology for data acquisition and analysis |
| *Big data* | * Analysis of large (partly unstructured) data with the goal of improved decision making.
* Different data types (e.g., text, audio, video) from many data sources.
 | * Many insurers use text mining, e.g., for fraud detection.
* Japanese insurer Fukoku Mutual Life uses IBM’s Watson Explorer for automated payout calculation (still subject to human approval; McCurry, 2017).
* 26% of German insurers are using big data analytics and 46% have developed a big data strategy (Bitkom & KPMG, 2016).
 |
| *Internet of things* | * Connected world; every element is sending and receiving information through sensors.
* Sub-topics: telematic devices, smart home, smart factory.
 | * Telematic devices are starting to be more integrated in health insurance (e.g., vitality program from Generali) and motor insurance (e.g., Progressive, State Farm).
 |
| Panel B: Technology for data storage |
| *Blockchain* | * Decentralized database of all digital transactions among participants (Crosby, Nachiappan, Pattanayak, Verma, & Kalyanaraman, 2016).
* Contracts could be stored and automatically executed (smart contracts).
 | * Aegon, Allianz, Munich Re, Swiss Re and Zurich have founded the blockchain Insurance Industry Initiative B3i to analyze the potential (Swiss Re, 2016a).
* Allianz and Nephila piloted the blockchain technology for cat swap transactions (Allianz, 2016).
 |
| *Cloud computing* | * Files stored online and thus accessible everywhere and anytime.
 | * 87.5% of all financial institutions use cloud services, but with a limited range (Chalvatzi, Dupre, Liveri, & Naydenov, 2015).
 |
| Panel C: Technology for communication and sales |
| *Mobile devices with apps* | * Smartphones/tablets with their applications replace desktop computers.
* People are always online because of mobile internet access.
 | * Apps are used for claims reporting (e.g., Allianz, Debeka), sometimes for contract administration and customer service (e.g., Allstate).
* Insurtech Trov and Lemonade are solely using an app for their insurance products.
* Apps can be used for a more efficient sales process. Agents and brokers can be supported by a variety of tools (e.g., electronic signature, task and time management).
 |
| *Robo advisor* | * Software that uses artificial intelligence to advise customers.
* Communication usually via webpage or apps with built in chat programs.
 | * Chatbots are already used for service queries (Huckstep, 2017).
* Chatbot SPIXII takes user data for a tailored conversation to automatically sell insurance products (Huckstep, 2017).
* Moneypark uses robo advisor to consult in asset management (Cash, 2016).
 |

Table 2: List of digital technologies (continued)

| *Trend*  | *Explanation* | *Status-quo in the insurance industry* |
| --- | --- | --- |
| Panel C: Technology for communication (continued) |
| *Social network (Facebook)/ Messenger (WhatsApp) / internet forum* | * Platforms for private persons and organizations to share information (statements, pictures, videos).
* Messenger services have replaced text messages, starting to get more attention than social networks.
* Internet forums provide an easy way to get help for frequently asked topics.
 | * Facebook is often used by insurance companies.
* Some have also started to use messenger services, e.g., Ergo uses WhatsApp for customer service.
* Forums are used to screen feedback of customer, to intervene in case of queries and to communicate actively with (potential) customers.
 |
| *Video calls (Skype, Facetime)* | * Visual phone call, where you can see and interact with others and present sales material.
 | * Video calls are used in the sales process (e.g., Ergo Direkt).
* Also, insurer offer telemedicine via video (e.g., telehealth program by Anthem Blue Cross)
 |
| *Video platforms (YouTube, Vimeo)* | * Videos with a wide variety of topics (instruction manuals, entertainment, product testing, sports, etc.) shared on a platform in the internet.
 | * Most large insurance companies (e.g., Allianz, Axa, Allstate, Swiss Life) have their own YouTube channel, e.g., for advertisement and product explanations.
 |
| *Website* | * Insurers present various information on the company, the products etc.
* Insurers offer policies via websites.
 | * Used by all insurance companies in the life and non-life segment.
* Also, new players that focus on online sales only (e.g., CosmosDirect, smile.direct).
* First contact either via own websites or aggregators (e.g., Check 24, Comparis).
 |

### 3.2. What is the impact of these technologies on the value chain?

Table 3 analyzes the potential impact of the new technologies (see Table 2) on the value chain of insurance companies.[[9]](#footnote-10) Referring to the three principal categories of change discussed in Section 3.1., the first obvious impact on the value chain is the way insurance companies interact with their customers (e.g., sales, customer service) and how they adapt to their behavior.[[10]](#footnote-11) Whereas customers traditionally needed personal interaction (agent, broker, bank, etc.) for product information, today they get most information online and directly compare products and prices via aggregator platforms. Some products can be purchased online without any personal interaction.[[11]](#footnote-12) Also in later stages of the value chain, digital technologies such as apps offer assistance and support claims reporting.

The second obvious change concerns the digitalization of all processes along the value chain, leading to the automatization of business processes (e.g., automated processing of contracts, automated reporting of claims) and decisions (e.g., automated underwriting, claim settlement, product offerings). While transaction-intensive industries like health insurance are already widely using background processing,[[12]](#footnote-13) the use of big data will trigger a further automatization wave in the insurance industry.[[13]](#footnote-14) At least two challenges arise in using big data. First, insurance companies need workforce and tools to analyze large, often unstructured, datasets which are generated by telematic devices, social networks or other internet sources (e.g., customer feedback, pictures, videos).[[14]](#footnote-15) Second, the use of big data raises legal and ethical questions. Politicians are now discussing whether insurers are allowed to use all the generated data for decision making, how long they have to store the data and which actions insurers must take to protect the data (e.g. against cyber-crime; Hussain & Prieto, 2016).[[15]](#footnote-16)

Table 3: Impact of digitalization on the insurer’s value chain

|  |  |  |
| --- | --- | --- |
| *Value-chain process* | *Tasks* | *Impact on the value chain* |
| ***Primary activities*** |
| *Marketing* | * Market and customer research: researching ideas for product development.
* Analyzing target groups.
* Development of pricing strategy for product sale.
* Designing of advertisement and communication strategies.
 | **Big data:*** Usage of data for a better target customer segmentation.
* More precise calculation of the customer lifetime-value and cross selling-potential.

**Video platforms:*** Usage of videos for product explanations to (future) customer, company news, topics of asset management, regulations, etc.

**Website, social networks and messenger:*** Product information/advertisement reputation management.
 |
| *Product development* | * "Manufacturing" the products.
* Product pricing (actuarial methods).
* Check legal requirements.
 | **Big data:*** More and better data allows the insurer to reorganize the risk pools and apply a more risk-appropriate pricing.

**Internet of things:*** The insurer also could motivate prevention.
* Situational insurance, e.g., travel insurance offer during a hotel check-in in a foreign country.

**Blockchain:*** Smart contracts, i.e. development of contract which are stored in a central database and can be automatically executed.
 |
| *Sales* | * Customer acquisition, consultation.
* Product sale.
* After-Sales.
 | **Big data:*** Combination of manifold data sources (partly unstructured) to develop a complete picture of the client (CRM-system).

**Cloud computing:*** Contract information stored digital.

**Robo advisor:*** Sales for simple products (e.g., travel insurance) are purchased via this channel.

**Social networks and messenger:*** New acquisition channels: Messenger, Social Media.

**Video calls and mobile devices:*** Consultation with the help of the latest technology, if necessary location-independent by using tablet, video calls, etc.

**Website and apps:*** New information and sales channels.
* Some process steps done by the customer (e.g. data input).
* For simple products process fully automated.
 |
| *Underwriting* | * Application handling.
* Risk assessment.
* Assessment of the final contract details, if necessary ask for more information.
 | **Big data:*** More and better data allows the insurer to reassess the risk pools (better estimation of losses, reduction of information asymmetry, ex post and ex ante).

**Internet of things:*** Telematic devices are used to get customer’s data for risk and pricing calculation.

**Blockchain:*** All information for automated underwriting is stored.

**Cloud computing:*** Contract information stored digitally.
 |

Table 3: Impact of digitalization on the insurer’s value chain (continued)

|  |  |  |
| --- | --- | --- |
| *Value-chain process* | *Tasks* | *Impact on the value chain* |
| *Contract administration/ customer service* | * Change of contract data.
* Answering customer requests regarding the contract or other purposes.
 | **Internet of things:*** More responsibilities and tasks in the customer service process: Fitness coaching, etc.

**Cloud computing:*** Contract information stored digital and can be changed by the customer (shift of the process)

**Robo advisor:*** Automated answering of service queries.

**Video calls, social networks, messenger and chat:*** Video call or live chat for service questions - the customer chooses the way of contact.
 |
| *Claim management* | * Investigation of fraud.
* Claim settlement.
 | **Big data:*** Prevention of fraud through data analytics.
* Automated calculation and payout of the amount of damage.

**Blockchain:*** Storage of the information for the automated payout.

**Mobile devices with apps:*** Customers file their claims via smartphone
 |
| *Asset manage-ment* | * Asset allocation
* Asset liability management.
 | **Big data:*** Automated asset management.

**Blockchain:*** Because of one central database, transaction costs might decrease
 |
| *Risk management* | * Analysis and manage-ment of all risks.
 | **Big data:*** Automated decision making, e.g., for risk transfer or automated reporting.
 |
| ***Support activities*** |
| *General management* | * Strategic planning and implementation of company goals.
 | **Big data:*** Decision process supported by big data analytics.
* Internal processes are fully supported by digital possibilities (video calls, chats, cloud computing).
 |
| *IT* | * IT procurement (hard-/ software) and installation.
* IT service.
* IT support.
* IT development.
* Coordination of IT processes.
 | **Internet of things:*** IT systems automatically report trouble and give the employer support to fix the problem.

**IT development:*** Processes have to be more flexible and the "time to market" has to be shorter.
* IT support via video calls and chats
 |
| *Human resources* | * Planning HR development.
* Job interviews.
* Job market advertisement.
* Job training.
 | * Usage of available media channels for recruitment.
* Automated search for employees instead of outsourcing to recruitment companies.
* Usage of cloud computing for handling of document of employees and applicants.
* Using of video calls for employee training.
 |
| *Controlling* | * Data capture and analysis.
* Reporting.
* Business-KPI measurement.
 | * With digitized data, it will be easy to get automated reports.
* Technology will enable interactive reporting (selection of reporting data), dynamic reporting and real-time planning.
 |
| *Legal department* | * Dealing with legal effects.
 | * New legal effects, e.g., data safety, privacy vs. transparency.
* Software checks contracts automatically which reduces basic and repetitive tasks.
 |
| *Public relations* | * Press/investor management.
 | * Shift from offline to online.
* New communication channel: social media, messenger, etc.
 |

A third obvious impact is that digitalization changes the existing products (e.g., telematic insurance) and allows new product offerings (e.g., cyber risk insurance). Telematic devices are used in life/health and motor insurance to build smaller and more accurate risk-pools and offer cheaper prices to good risks.[[16]](#footnote-17) The sharing economy, i.e., lending or borrowing personal items for a short period, creates on-demand insurance markets where a premium is paid for the renting period (PWC, 2015). With respect to new offerings the notification requirements for data breaches in the US have triggered the development of an insurance market for cyber risks, both in personal and commercial lines (Biener et al., 2015). The technological progress also makes it possible to underwrite risk, which could not have been insured so far.[[17]](#footnote-18) Furthermore, smart contracts – i.e. programs that automatically execute the claim payment under pre-defined conditions stored in the blockchain (Cant et al., 2016) – have the potential to be full digital and full automatic products.[[18]](#footnote-19)

There are material differences when it comes to the impact on the value chain comparing different lines of businesses. The lines of businesses which are today most affected by digitalization are health insurance, motor insurance and home insurance. It seems that health insurance is a little ahead of other types of insurance, because of the large number of interactions a company has with the customers. Standardization and automatization of processes is much more efficiency-enhancing for health insurance as, for example, compared to motor insurance where the claim frequency on average is much smaller. In motor insurance and home insurance we find manifold new technologies and innovative products (e.g., telematic insurance) that reduce the frequency of claims. The same also holds for health insurance with pay as you live tariffs and the increasing use of gadgets that track customer behavior.

### 3.3. Will the insurance industry lose parts of its value chain to other industries?

It has long been projected that like other industries, insurers will outsource major parts of their value chain to increase the process efficiency (e.g., Haller, 1997). Maas & Bühler (2015), however, show that insurance managers still prefer to offer the full range of activities and not to specialize on parts of the value chain. However, they note that many insurers do not see IT development and IT operations as their core competence, which might lead to more outsourcing – if not done already – in this area.[[19]](#footnote-20) Moreover, customers are increasingly integrated into the value creation process; selected activities (e.g., change of personal data, reporting of claims) are done by the customer online, which is convenient for the customer, saves resources for the insurer and thus could lower premiums.

There is, however, an ongoing debate whether (on top of these decisions made by insurers themselves) the industry will be forced to give away parts of the value creation and with this also parts of the profit margin to other industries. For example, the automobile industry might take over the sales and claim settlement processes. Given the high competition and decreasing margins in the automobile industry, automobile producers are looking for additional profit margins in neighbor areas of their value chain.[[20]](#footnote-21) Their key advantage is the access to the customer[[21]](#footnote-22) and thus to the respective data. One scenario is then that insurance products (e.g., product liability, car insurance, travel insurance) are offered during the sales process by the producer (e.g., automobile producer, technology provider) or retailer (e.g., Amazon), without any opportunities for insurers to intervene. Also at later stages of the value chain other industries might have the first access to information, for instance in the case of car accidents.

One question in this context is whether the producers and retailers are acting as brokers or as risk carriers. So far, most of these firms are acting as brokers, but if the margin of being a risk carrier is attractive enough and outweighs the broker margin, producers and retailers might also apply for a license and offer their own insurance products. This likelihood may be even higher for technology driven firms like Amazon, Apple, Facebook or Google, because they have huge amounts of relevant data and might profit from advantageous selection.[[22]](#footnote-23) It thus seems plausible that the company with the access to the customer will absorb the majority of the profit margin.[[23]](#footnote-24) There are, however, also reasons why technology firms or players from other industries might not be willing to enter the insurance market. It might for example be that a realistic return on equity for selling insurance is rather low and that technology firms like Apple have more attractive investment opportunities that offer higher returns.[[24]](#footnote-25) Another factor is the large number of regulations for insurance companies, which serve as an entry barrier for new market entrants and thus protect the established players. Another argument for not being a risk carrier might be the required expertise in different steps of the insurance value chain, which the players from other industries cannot build up without substantial upfront investments. Overall the risk of disruption from other industries seems rather low at the moment, but this might change when new technologies emerge (see Section 4.1. for more discussion on this aspect).

### 3.4. Can insurtechs significantly disrupt the industry?

After some technology start-ups have left their footprints in the banking sector (e.g., Funding Circle, Prosper, Number26, Robinhood),[[25]](#footnote-26) other start-ups now concentrate on the insurance sector (so called insurtechs). This can be seen by the amounts invested in insurtechs: the venture capital investments increased almost fivefold from 2014 to 2015, reaching 2.5 billion USD in 2015; the investment in the fintech market only doubled in the same interval (2014: 7.3 billion USD; 2015: 14.5 billion USD; KPMG & CBInsights, 2016). Comparing insurtechs to traditional insurers, Wiener & Theis (2017) argue that insurtechs might have systematic advantages by using the latest technology and being more flexible in their innovation processes. The existing insurtech start-ups can be structured in three categories: they offer specific services or products to target: 1) customer experience (e.g., GetSafe, Backbase, Oscar), 2) business processes (e.g., Getsurance, Check24) or 3) new products (e.g., Trov, Metromile, Guevera).[[26]](#footnote-27)

In the category of customer experience, insurtechs take advantage of today’s often analogue interactions between insurers and customers. For example, GetSafe offers an online administration tool for all contracts independent of the insurance company.[[27]](#footnote-28) Backbase offers software to insurers where customers can track their application, view their contracts or message with a service representative. In the second category, business processes, insurtechs are typically active as aggregator platforms or they support claims handling. Aggregators create more transparency for customers but to make profit, customers have to purchase the products through their website. However, as we have argued before, most customers still purchase the products offline (Barwitz et al., 2016). Regarding claim handling, some insurtechs support the customer (e.g., RightIndem, Unfallfuchs) or even offer the entire process of claim management to insurers (e.g., Claimable). In the third category of new products, insurtechs typically focus on single products and do not offer the full spectrum of insurable risks. Some companies fill the gap for on-demand and sharing economy insurance (e.g., Trov, SafeShare), others use telematic devices in existing products (e.g., Metromile). Some insurtechs offer digital peer-to-peer insurance (e.g., Guevera, Friendsurance); if claims are low, money is payed back to the insured risk pool. Lemonade offers digital home insurance for a fixed fee and if there is money leftover give it back to predefined charitable causes.

We see four arguments why it is rather unlikely that insurtechs will cause a disruption to the insurance industry. First, traditional insurance companies could easily copy the business model of insurtechs when it seems attractive. Second, instead of copying insurtechs, insurers could simply acquire them, because of their relative small scale. We have first seen this in the banking industry (e.g., BBVA acquired Simple and Holvi, Barclays acquired the LogicGroup), but in the meantime also insurers invested in insurtechs (e.g., Wüstenrot & Württembergische acquisition of the financial assistant platform treefin, Northwestern Mutual acquisition of the financial planning platform LearnVest; Helvetia’s acquisition of Moneypark). Third, it seems that insurtechs are more focused on cooperation than on rivalry with traditional insurers (Kottmann & Dördrechter, 2016). Especially partnerships with technology providers, such as big data analysis or blockchain technology usage could save the insurance industry’s resources. Fourth, the amount of regulation, unsolved legal questions (e.g., consultant liability in online sales, data security) and lack of expertise could be a problem when insurtechs want to expand their businesses.[[28]](#footnote-29)

### 3.5. How does the insurability of risks change?

In Table 4 we summarize the expected insurability changes structured along Berliner’s (1982) insurability criteria. We see three major effects: the effect of new information on information asymmetry and risk pooling, the implication of new technologies on loss frequency and severity, and the increasing dependence through connectivity. Moreover, several legal and ethical questions arise.

Table 4: Impact of digitalization on insurability of risks (Berliner, 1982)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Insurability criteria* |  |  | *Valuation* | *Assessment* |
| *Actuarial* | (1) | Randomness of loss occurrence | * Because of the IoT and big data smaller risk pools can be created, which will lead to a more distinguished separation risks. Still, the loss occurrence in each risk pool is random.
 | Does not contradict insurability. |
|  | (2) | Maximum possible loss | * The “connected world” could lead to higher losses if one component fails. As data storage becomes an important asset, losses form cybercrime may rise.
 | Identification of maximum loss more problematic. |
|  | (3) | Average loss per event | * On the one side the digitalization will reduce administration and production costs for insurers. On the other side insured objects are getting more expensive with all built in technology (higher loss amount).
* Prevention could help to reduce the average costs.
 | Hard to verify if the average will de- or increase |
|  | (4) | Loss exposure | * The size of the risk pools has to be adequate that the insurer can calculate the loss probability.
* Loss probability might be reduced through technical assistance systems or internet of things, e.g. in motor or theft insurance.
 | Does not contradict insurability. |
|  | (5) | Information asymmetry | * Depending on regulation and willingness to share personal information, asymmetries can become smaller or larger.
 | Depends on the regulation. |
| *Market* | (6) | Insurance premium | * Through smart data and IoT insurers can make their pricing more precise. Good risks might get a premium reduction. Bad risks might pay more.
 | Overall, costs and thus premiums might decrease. |
|  | (7) | Cover limits | * Because of big data methods the loss amount can be better predicted which might affect the choose of cover limits.
 | Does not contradict insurability. |
| *Society* | (8) | Public policy | * The rising ethical questions are similar to the ongoing debate about genetic tests.
* If individuals have the chance to emerge from bad risk classes by changing their behavior and/or taking prevention measures, the new measures might be beneficial. If not, ethical questions might arise.
* Increased transparency might affect the solidarity of people; with more visibility of costs and benefits the willingness of good risks to subsidize bad risks might be reduced.
* Willingness to share information and to use telematic devices needs to be discussed.[[29]](#footnote-30)
 | Does not contradict insurability, but ethical aspects have to be discussed.  |
|  | (9) | Legal restrictions | * The increasing transparency raises legal questions, e.g., can individuals be discriminated because of their health conditions (e.g. in social insurance)?
* Regarding the usage of data, other legal questions exist: Is collecting data in line with current freedom and equal rights?[[30]](#footnote-31) Who is allowed to use the data? What has to be done for data quality and security?
* Also, in the area of autonomous driving – next to the ongoing debate on ethical questions (e.g., should an algorithm decide if the driver gets hurt or another person)[[31]](#footnote-32) – legal questions arise for regarding liability (manufacturer vs. software developer vs. driver).
 | Does not contradict insurability, but legal questions have to be discussed.  |

The first influential effect on the insurability of risks could be access to information on customers through online texts, pictures, videos, via mobile phones and via other devices (e.g., telematic devices). However, it is not clear if insurers will have access to this data. If individuals keep their personal risk assessment this could increase adverse selection and especially in the case of telematic insurance it cannot prevent moral hazard. If insurers are allowed to use the information on the individuals,[[32]](#footnote-33) they will be able to form smaller homogenous risk pools.[[33]](#footnote-34) As a consequence, good risks might pay a lower and bad risks a higher premium. In the health insurance segment, this debate is similar to the ongoing discussion about the usage of genetic information for risk calculation. Hoy & Ruse (2005) argue that the reduction of adverse selection and therefore the increasing efficiency is accompanied by the effect that people who are in poor health are punished twice (higher premium and health problems) and that some people will refuse to take a genetic test because they are afraid that it will increase their insurance premium instead of seeing the test as a diagnostic instrument. Moreover, the authors argue, some people do not want to know their health condition either because it might be hard to keep that information confidential or they do not want to worry about their future health. Doherty & Posey (1998) find that for uninformed individuals a genetic test has a positive private value if prevention is sufficiently effective in lowering the premium, even though the information must be shared with the insurer.

Following this argument, we think that better data analysis methods and telematic insurance can be beneficial in all insurance segments, if individuals have the chance to emerge from bad risk classes by changing their behavior and/or taking preventive measures. For example, young drivers who are typically high-risk can reduce their insurance premiums if they drive carefully and their behavior is tracked by a telematic device. People who are overweight could get a discount when they reach a certain level of activity level per day, which is also tracked by the insurer. These tracking devices make efficient prevention measurable and risk insurable. For example, it can be determined if mold in a house has been caused by the tenants, because they avoid regular airing, or if it is a more general issue with the construction material. This access to more information and increasing transparency might also affect the solidarity of people; with more visibility of costs and benefits the willingness of good risks to subsidize the bad risks – especially in the social insurance – might be reduced. The latter aspect and also the use of telematic devices in cases where people cannot change their behavior (e.g., genetic diseases) lead to open ethical questions which need to be answered in a societal dialogue.

Second, digitalization creates new machines and devices that influence loss frequency and severity. It is difficult to say if new innovations increase or decrease the average and maximum possible losses. On the one side, automatization reduces production costs of insured devices, such as medical instruments or automobiles. On the other side, these devices could become more expensive because of all the new built-in technology. When looking at the health sector, one can see that technological innovations are one of the main cost drivers (Erixon & van der Marel, 2011). Considering their internal processes, insurance companies can save administrative and production costs; moreover, by using technological devices they can reduce the loss probability and loss amount by incentivizing and controlling prevention measures.

A third effect is that an increasingly connected world could increase the maximum possible losses if risks cease to be independent, thus reducing the insurability of risks. For example, Biener et al. (2015) analyze the insurability of cyber risks and show that one major hurdle is the accumulation risk. Given that all individuals and companies are using the same software and systems, increasing the diversity of software products and IT systems might be beneficial from an insurability perspective.

## 4. Derivation of potential future work

Table 5 summarizes the results for the five core topics discussed in Section 3. Based on these results, we now derive potential areas of future work from both an academic and a practical perspective.

Table 5: Summary of results

|  |
| --- |
| 1. **What is digitalization and which technologies will influence the industry?**
 |
| * Digitalization is the integration of the analogue and digital world with new technologies that enhance customer interaction, data availability and business processes.
* The relevant technologies are in the fields of data acquisition and analysis (big data, internet of things), data storage (blockchain, cloud computing) and communication (apps, robo advisor, webpages, social networks, messenger, video calls, video platforms).
 |
| 1. **What is the impact of these technologies on the value chain?**
 |
| * Digitalization changes the way insurers and customer interact (e.g., sales, customer service).
* Digitalization and automatization of all business processes (e.g., automated processing of contracts), automatization of decisions (e.g., automated underwriting).
* Digitalization changes existing products (e.g., telematic insurance) and allows new product offerings (e.g., cyber risk insurance).
 |
| 1. **Will the insurance industry lose parts of their value chain to other industries?**
 |
| * Companies from other industries might have a better access to the customer or the respective data, but the risk taking over substantial parts of the insurance value chain is limited at the moment; a realistic return on equity is too small to justify investments, also because more attractive alternatives exist (invest in other businesses, cooperate with insurers); moreover, regulation and lack of expertise serve as entry barriers.
* Statement only holds for today, but maybe not in the future (see Section 4.1.).
 |
| 1. **Can insurtechs significantly disrupt the industry?**
 |
| * It seems rather unlikely that insurtechs will cause a major change or disruption to the insurance industry (today and in the future).
* Reasons: Business model of insurtechs can be easily copied, insurers could easily acquire small insurtechs, insurtechs are rather focused on cooperation than rivalry with traditional insurers, regulation and lack of expertise serve as entry barriers when insurtechs want to expand their businesses.
 |
| 1. **How does the insurability of risks change?**
 |
| * New information impacts information asymmetry (depending on who has access to the customer data) and risk pools, which will become smaller and more homogeneous.
* New technologies change loss frequency and severity (production and administrations costs might decrease, but insured values might increase due to costlier built-in technology); new technologies also might increase dependences through connectivity (cyber risks).
* Manifold legal and ethical questions arise (Which information should be used? Who is liable?).
 |

### 4.1. What should the insurance industry do in response to digitalization?

If we consider all the above discussions from a customer point of view, it seems that the digitalization has big potential to increase customer value by offering better products at lower prices. It is also obvious that the traditional insurance idea is not in question, given that the pooling of risks and the realization of diversification in that pooling is not affected by the digital transformation. The relevant question is more how to optimally organize this risk pooling. Should they do this as integrated service companies that do the major part of the value creation by themselves, or in another, maybe less centralized way? At the time this article is written the risk of losing major parts of the value chain to other industries, seems rather low. But this might change quickly when new technologies arise. For example, when mobile devices pervade every aspect of daily life, users seeking convenience might allow companies like Apple to use this information to optimize their life. In such a scenario, the mobile device might offer relevant data to third parties to identify optimized offerings, for example, for insurance. Such an endeavor might greatly benefit customer value, but the implications for product variety and competition are highly unclear. It thus seems imperative for insurance companies to follow the technology development closely and to seek collaboration to learn from technology companies and build up the requisite skills. One example is the ability to adapt to the digital change which must be further developed. This is relevant, because most insurance companies are working partly with old IT systems and need further investments to prepare people and systems for the digital world. Moreover, insurers have to define the future work environment for their employees and sales representatives (sales process, sales tools, etc.). But the core idea of insurance – a risk adequate calculation and the pooling of risk – remains.

There are several questions that insurance practitioners need to answer about digitalization. Regulators must define how and where they have to intervene. For example, to what extent should insurtechs be regulated? Which data should insurance companies be allowed to use (which raises the ethical questions outlined in Section 3.5)? Another question is how insurers should set priorities because they cannot concentrate on all digitalization topics equally. In this context, Maas & Bühler (2015) identify – based on the concept from Treacy & Wiersema (1995) – three strategic pathways: customer intimacy, operational excellence, or product leadership, exactly reflecting these categories of impact.[[34]](#footnote-35) A related question is how to organize the integration of new technologies and innovative models in an organization (e.g., Burgelman, Christensen, & Wheelwright, 2008, present the latest research on technology management); many insurance companies operate their own incubators (e.g., Lumenlab, Allianz X, Werk 1) or cooperate with insurtechs, but empirically it is not clear which model works better.

On the technical side, an open question about digitalization is whether the benefits outweigh the investments in IT and people (e.g., when specific investments for better risk calculation, fraud detection, or new insurance products are evaluated). Also, the blockchain technology seems attractive given that it might fully automatize the insurance offerings, but the barriers to and limitations of implementing such models still need to be explored. It is worth mentioning that not every question needs to be answered by each company; some can be addressed collaboratively. The analysis of the general implications of new technologies (e.g., blockchain or the internet of things) on insurers might be good examples.

If an insurance company wants to sustain for the next decades, not to invest in new technology might not seem a realistic option; but in principal it might also be an option to send (parts of) the existing company in a controlled run-off and let the future digital business be done by new divisions that are developed from scratch without legacy systems. We believe that especially from a regulatory perspective such a scenario should be discussed, because digitalization might trigger a lot of consolidation within the industry.

### 4.2. What future research is needed?

So far there has been little research on digitalization in the insurance segment. This seems surprising, given that digitalization and big data offer enormous potential for empirical research. One example is the increasing use of telematic devices in motor insurance. How does telematic insurance affect driving behavior? If a risk reduction can be observed empirically, is it a result of less moral hazard or of adverse selection? How can we separate the two? To our knowledge, the few studies that exist have not analyzed empirically the impact of telematic insurance on both moral hazard and adverse selection.[[35]](#footnote-36)

The identification and evaluation of big data techniques opens a new research field, e.g., from the perspective of actuarial science (pricing telematic contracts). The use of such information creates a space for legal and ethical questions that have not been answered yet. If in the future large technology firms like Apple or Google gain access to a lot of information, how will they use it? What is the role of insurance companies in such a world? We refer to the discussion on how mobile devices might track every aspect of daily life and the implications for product variety and competition. In general, more research is needed to analyze how privacy and data protection laws interact with big data applications.

Regarding future research, the role of the insurance industry in insuring the risks from the digital world is noteworthy. For example, can the availability of cyber risk insurance facilitate investments in cyber risk management? How can modeling and pricing of cyber risk be improved given lack of data, dynamic changes in risk characteristics, and complex correlation structures? Are transfer schemes to the capital market (alternative risk transfer instruments such as insurance linked securities) a viable solution to provide risk-bearing capacity for cyber risk to develop the cyber risk insurance market?

In general, the link between new technologies and insurance will raise many new research questions. For example, what should liability insurance look like in the context of self-driving cars? What does “pay as you live” mean for the insurance idea to provide solidarity? What if the risk profile is fully known to the insurance company? These questions seem a little away, but researchers might want to think about such scenarios and their consequences for economy and society today. We believe that also the academic community should be part of the discussion on how to use digital technologies in economy and society.

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## Appendix A: Dataset of papers and industry studies

Table A: Dataset of papers and industry studies

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Computational methods*** |
| 1 | A Review of Computational Intelligence Algorithms in Insurance Applications.  | Sancho Salcedo-SanzLucas CuadraPortilla-Figueras, ASilvia Jiménez-FernándezEnrique Alexandre | 2013 | Statistical and Soft Computing Approaches in Insurance Problems |  |  |  | no specific |
| ***Customer survey*** |
| 2 | Aggregation metrics: Consumer approaches to insurance comparison sites in Europe | unknown | 2013 | Press release (Finaccord) |   |   |   | Europe |
| 3 | Capturing hearts, minds and market share: How connected insurers are improving customer retention | Christian BieckLee-Han Tjioe | 2015 | Industry study (IBM) |   |   |   | no specific |
| 4 | Die Customer Journey in einer multioptionalen Welt | Niklas BarwitzPeter MaasDennis BlockChristoph Nützenadel | 2016 | Industry study (I.VW-HSG and Synpulse) |   |   |   | Germany, Switzerland, Austria |
| 5 | ROPO Studie für Versicherungsprodukte in Deutschland – Kernergebnisse | unknown | 2016 | Industry study (Zurich, GfK and Google) |   |   |   | Germany |
| 6 | Trust, transparency and technology: European customers’ perspectives on insurance and innovation | Peter MaasAlbert GrafChristian Bieck | 2008 | Industry study (I.VW-HSG and IBM) |   |   |   | Denmark, the Netherlands, France, UK, Germany, Switzerland |
| 7 | Winning share and customer loyalty in auto insurance | Tanguy CaitlinDevin McGranahanSharmila Ray | 2013 | Industry study (McKinsey & Company) |   |   |   | US |
| ***Insurability*** |
| 8 | Digitales Monitoring: Fluch oder Segen? | Hato SchmeiserLukas Reichel | 2016 | *I.VW HSG Trendmonitor*  |   | 3 | 3-5 | Germany, Switzerland, Austria |
| 9 | Insurability in microinsurance markets: An analysis of problems and potential solutions | Christian BienerMartin Eling | 2012 | *The Geneva Papers on Risk and Insurance* | 37 | 1 | 77-107 | no specific |
| 10 | Insurability of cyber risk: An empirical analysis | Christian BienerMartin ElingJan-Hendrik Wirfs | 2015 | *The Geneva Papers on Risk and Insurance* | 40 | 1 | 131-158 | no specific |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Insurability (continued)*** |
| 11 | On the value of a checkup: Adverse selection, moral hazard and the value of information | Neil DohertyLisa Posey | 1998 | *The Journal of Risk and Insurance* | 65 | 2 | 189-211 |   |
| 12 | Prädikative Gesundheitsinformationen bei Einstellungsuntersuchungen | unknown | 2007 | *Stellungnahme Nationaler Ethikrat Deutschland* |   |   |   | Germany |
| 13 | Reconciling privacy and speech in the era of big data: A comparative legal analysis | Ronald Krotosynski | 2015 | *William & Mary Law Review* | 56 | 4 | 1279-1338 | no specific |
| 14 | Reducing asymmetric information in insurance markets: Cars with black boxes | Lilia Filipova-NeumannPeter Welzel | 2010 | *Telematics and Informatics* | 27 | 4 | 394-403 | no specific |
| 15 | Regulating genetic information in insurance markets | Michael HoyMichael Ruse | 2005 | *Risk Management and Insurance Review* | 8 | 2 | 211-237 | no specific |
| 16 | What do we know about cyber risk and cyber risk insurance?  | Martin ElingWerner Schnell | 2016 | *The Journal of Risk Finance* | 17 | 5 | 474-491 | no specific |
| ***Insurtech*** |
| 17 | The current insurtechs landscape: Business models and disruptive potential | Alexander BraunFlorian Schreiber | 2017 | *I.VW-HSG Schriftenreihe* | 62 |   |   | no specific |
| 18 | 101 insurtech startups revolutionizing the $4.5-trillion-dollar insurance industry | Elena Mesropyan | 2016 | *Let's Talk Payments* |   |   |   | no specific |
| 19 | Fintech 100: Leading global fintech innovators report 2015 | unknown | 2015 | Industry study (KPMG and H2 Ventures) |   |   |   | no specific |
| 20 | Insurtech Übersicht DACH | Sascha Noack | 2016 | Industry study (New Players Network) |   |   |   | Germany, Switzerland, Austria |
| 21 | InsurTech(s): Zwischen Konkurrenz und Partnerschaft | Klaus WienerAnja Theis | 2017 | GDV - Makro und Märkte | 9 |   |   | Germany |
| 22 | Insurtech: assembled for takeoff? The German insurtech universe and its disruptive potential | Christopher SchmitzOlaf JohannsenDanilo RaponiBastian Hengstler | 2016 | Industry study (EY) |   |   |   | Germany |
| 23 | The pulse of fintech Q2 2016: Global analysis of fintech venture funding | unknown | 2016 | Industry study (KPMG and CBInsights) |   |   |   | no specific |
| 24 | Zukunft von Insurtech in Deutschland. Der Insurtech-Radar | Dietmar KottmannNikolai Dördrechter | 2016 | Industry study (Oliver Wyman and Policen Direkt) |   |   |   | Germany |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Management survey*** |
| 25 | Assekuranz 2015 - Eine Standortbestimmung. Neue Koordinaten im deutschsprachigen Versicherungsmarkt | Hato SchmeiserAngela ZeierAndrea FürnthalerVania BättigBenjamin BurrCynthia StampfliAndré Schlieker | 2010 | Industry study (I.VW-HSG and Accenture) |   |   |   | Germany, Switzerland, Austria |
| 26 | Die digitale Transformation in der Versicherungsbranche | Peter RoßbachWalter KuhlmannMarc Laszlo | 2015 | Industry study (Q\_Perior) |   |   |   | Germany, Switzerland, Austria |
| 27 | Digital maturity and transformation report | Sabine BerghausAndrea BackBramwell Kaltenrieder | 2016 | Industry study (I.WI-HSG and Crosswalk) |   |   |   | Germany, Switzerland |
| 28 | Digital transformation report 2015 | Andrea BackSabine BerghausBramwell Kaltenrieder | 2015 | Industry study (I.WI-HSG and Crosswalk) |   |   |   | Germany, Switzerland |
| 29 | Evolution of strategic levers in insurance claims management: An industry survey | Nils MahlowJoël Wagner | 2016 | *Risk Management and Insurance Review* | 19 | 2 | 197-223 | Germany, Switzerland |
| 30 | Global digital insurance benchmarking report 2015 | Florian MuellerHenrik NaujoksHarshveer SinghGunther SchwarzAndrew SchwedelKirsten Thomson | 2015 | Industry study (Bain & Company) |   |   |   | no specific |
| 31 | Industrialisierung der Assekuranz in einer digitalen Welt | Peter MaasPascal Bühler | 2015 | Industry study (I.VW-HSG and Adcubum) |   |   |   | Germany, Switzerland, Austria |
| 32 | Insurance in a digital world: The time is now | unknown | 2013 | Industry study (EY) |   |   |   | no specific |
| 33 | Mit Daten Werte schaffen | unknown | 2016 | Industry study (KPMG and Bitkom) |   |   |   | Germany |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Regulation*** |
| 34 | Expanding innovation law, information technology and insurance | Alexander Traum | 2016 | *Journal of Internet Law* | July |   |   | no specific |
| ***Strategic outlook*** |
| 35 | Auf dem Weg zum Omni-Kanal | Gero MatouschekBodo von Hülsen | 2015 | *Change Management in Versicherungsunternehmen: Die Zukunft der Assekuranz erfolgreich gestalten* |   |   | 335-352 | Germany, Switzerland, Austria |
| 36 | Digital distribution in insurance: A quiet revolution | Darren PainKülli TammGinger Turner | 2014 | Industry study (Swiss Re) |   |   |   | no specific |
| 37 | Digital reinvention: Trust, transparency and technology in the insurance world of tomorrow | Christian BieckAnthony Marshall Sandip Patel | 2014 | Industry study (IBM) |   |   |   | no specific |
| 38 | Digital transformation and insurance | Dr. Fabian Sommerrock | 2016 | Presentation during the 16th Asia CEO Insurance Summit |   |   |   | no specific |
| 39 | Digitalisierung: Der Schweizer Versicherungssektor im Umbruch | Pia TischhauserMatthias NaumannAngelo CandreiaStephan TreierJulia Senser | 2016 | Industry study (The Boston Consulting Group & Google) |   |   |   | Switzerland |
| 40 | Digitization in life insurance: A prerequisite for success in spite of low interest rates | Daniel BergerPatrick BroerDavid Pankoke | 2016 | *I.VW HSG Trendmonitor*  |   | 1 | 15-19 | no specific |
| 41 | Dying, surviving or thriving. Strategic analysis of the future Swiss insurance market | Achim BauerYamin GröningerJulius ScheidtRicardo GarciaEdvin Rimpo | 2016 | Industry study (EY) |   |   |   | Switzerland |
| 42 | Insurance on the threshold of digitization: Implications for the life and P&C workforce | Sylvain JohanssonUlrike Vogelgesang | 2015 | Industry study (McKinsey & Company) |   |   |   | no specific |
| 43 | Insurance technology strategy: Time to re-evaluate | Ronald Pressman | 2003 | *The Geneva Papers on Risk and Insurance* | 28 | 1 | 39-64 | no specific |
| 44 | Leading a digital transformation in insurance | Harshveer SinghGunther SchwarzHenrik NaujoksAndrew Schwedel | 2014 | Industry study (Bain & Company) |   |   |   | no specific |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Strategic outlook (continued)*** |
| 45 | Life insurance in the digital age: Fundamental transformation ahead | Jonathan AnchenAstrid FreyMilka Kirova | 2015 | Industry study (Swiss Re) |   |   |   | no specific |
| 46 | Raising your Digital Quotient | Tanguy CatlinJay ScanlanPaul Willmott | 2015 | Industry study (McKinsey & Company) |   |   |   | no specific |
| 47 | Strategy, not technology, drives digital transformation – becoming a digitally mature enterprise | Gerald KaneDoug PalmerAnh Nguyen PhillipsDavid KironNatasha Buckley | 2015 | *MIT Sloan Management Review* |   |   |   | no specific |
| 48 | Telematics strategy for automobile insurers | Johannes PaefgenElgar FleischLukas AckermannThorsten StaakeJonas BestLukas Egli | 2013 | Whitepaper (I-LAB) |   |   |   | Austria, Germany, Switzerland |
| 49 | The Customer-centric insurer in the digital era | Andrea Moneta | 2014 | Industry study (Accenture) |   |   |   | no specific |
| 50 | The debate on the insurance value chain | Anton van RossumRobert MendelsohnHenri de Castries | 2002 | *The Geneva Papers on Risk and Insurance* | 27 | 1 | 89-101 | no specific |
| 51 | The digitization of everything: How organizations must adapt to changing consumer behavior | Richard IngletonYunus OzlerPippa Thomas | 2011 | Industry study (EY) |   |   |   | no specific |
| 52 | The hallmarks of digital leadership in P&C insurance | Tanguy CatlinIdo SegevHolger Wilms | 2016 | Industry study (McKinsey & Company) |   |   |   | US |
| 53 | The impacts of digitization on the management of insurance companies: Steering business in a digital world | Stefan HiendlmeierMark Hertting | 2015 | Industry study (Horváth & Partners) |   |   |   | no specific |
| 54 | The making of a digital insurer: The path to enhanced profitability, lower costs and stronger customer loyalty | Tanguy CatlinRob HartmannIdo SegevRuxandra Tentis | 2015 | Industry study (McKinsey & Company) |   |   |   | no specific |
| 55 | The new division of labor: How computers are creating the next job market | Frank LevyRichard Murnane | 2005 |   |   |   |   | no specific |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Strategic outlook (continued)*** |
| 56 | Versicherungen: Die digitale Herausforderung | Gero MatouschekHenrik NaujoksGunther SchwarzBodo von Hülsen | 2013 | Industry study (Bain & Company) |   |   |   | Germany, Switzerland, Austria |
| ***Technology*** |
| 57 | 7 big data techniques that create business value | Debbie Stephenson | 2013 | Firmex |   |   |   | no specific |
| 58 | Analysis of Fraud Detection in Insurance Claim | Neelam TakShalini Rajawat | 2016 | *International Journal of Recent Trends in Engineering & Research* | 2 | 7 | 136-140 | no specific |
| 59 | Anything you can do, AI can do better: Machine learning and artificial intelligence in insurance | Morag Cuddeford Jones | 2016 | White paper (Insurance Nexus) |   |   |   | no specific |
| 60 | Beyond the hype: Big data concepts, methods, and analytics | Amir GandomiMurtaza Haider | 2015 | *International Journal of Information Management* | 35 | 2 | 137-144 | no specific |
| 61 | Big data in the finance and insurance sectors | Kazim HussainElsa Prieto | 2016 | *New Horizons for a Data-Driven Economy* |   |   | 209-223 | no specific |
| 62 | Blockchain applications in insurance  | Alexander Shelkovnikov | 2016 | Industry study (Deloitte) |   |   |   | UK |
| 63 | Blockchain in insurance – opportunity or threat? | Johannes-Tobias Lorenz et al. | 2016 | Industry study (McKinsey & Company) |   |   |   | no specific |
| 64 | Blockchain technology: Beyond bitcoin | Michael CrosbyNachiappanPradan PattanayakSanjeev VermaVignesh Kalyanaraman | 2016 | *Applied Innovation Review* | 2 |   |   | no specific |
| 65 | Bringing big data to life: Four opportunities for insurers | Eric BratPaul ClarkPranay MehrotraAstrid StangeCéline Boyer-Chammard | 2014 | Industry study (The Boston Consulting Group) |   |   |   | no specific |
| 66 | Chatbot and the rise of the automated insurance agent | Rick Huckstep | 2017 | *The Digital Insurer* |   |   |   | no specific |
| 67 | Data mining – What it is and why it matters | unknown | 2017 | Industry study (SAS) |   |   |   | no specific |

Table A: Dataset of papers and industry studies (continued)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | Title | Author(s) | Year | Journal/Book | Volume | Issue/No. | Pages | Country |
| ***Technology (continued)*** |
| 68 | Ethereum dapps showcase: Peer to peer insurance applications | unknown | 2016 | *Digital Insurance Observer* |   |   |   |   |
| 69 | From data mining to knowledge discovery in databases | Usama FayyadGregory Piatetsky-ShapiroPadhraic Smyth | 1996 | *AI Magazine* | 17 | 3 | 37-54 | no specific |
| 70 | How insurers can invest in big data analytics to improve decision making | Henrik NaujoksLori Sherer | 2015 | Industry study (Bain & Company) |   |   |   |   |
| 71 | Insurance technology '2.0:' An interactive process for 2013 | Richard Weber | 2013 | *Journal of Financial Service Professionals* | March |   |   | no specific |
| 72 | Smart contracts in financial services: Getting from hype to reality | Bart CantAmol KhadikarAntal RuiterJakob Bolgen BronebakkJean CoumarosJerome BuvatAbhishek Gupta | 2016 | Industry study (Capgemini Consulting) |   |   |   | no specific |
| 73 | Technology's effect on property-casualty insurance operations | Robert Puelz | 2010 | *Risk Management and Insurance Review* | 13 | 1 | 85-109 | no specific |
| 74 | Telematics: Connecting the dots | Andrea KellerFabian Transchel | 2016 | Industry study (Swiss Re) |   |   |   | no specific |
| 75 | The drive to digitization in insurance. Turning “big paper” into big profit | Mark Breading | 2012 | Industry study (SMA - Strategy Meets Action) |   |   |   | no specific |
| 76 | The evolution of analytics: Opportunities and challenges for machine learning in business | Patrick HallWen PhanKatie Whitson | 2016 | Sebastopol, CA: O’Reilly Media and SAS |   |   |   | no specific |
| 77 | The sharing economy | unknown | 2015 | Industry study (PWC) |   |   |   | no specific |
| 78 | The sharing economy: Your business model’s friend or foe?  | Wolfgang KathanKurt MatzlerViktoria Veider | 2016 | *Business Horizons* | 59 |   | 663-672 | no specific |
| 79 | Transforming into an analytics-driven insurance carrier | Ari ChesterRichard ClarkeAri Libarikian | 2016 | Industry study (McKinsey & Company) |  |  |  | no specific |
| 80 | Trends in der Technologie sowie Erkenntnisse des Behavioural Pricings vereinbaren | Michael HartmannChristoph Nützenadel | 2015 | *I.VW HSG Trendmonitor*  |   | 1 | 3-9 | no specific |
| 81 | What “digital” really means | Karel DörnerDavid Edelman | 2015 | Industry study (McKinsey & Company) |   |   |   | no specific |

## Appendix B: Definitions of digitalization

Table B: Definitions of digitalization

| **Source** | **Definition digitalization** |
| --- | --- |
| Back et al. (2016) (Translated from German) | “Digital transformation” is the combination of change in strategy, the business model, organization/processes and culture in companies by using digital technologies to enhance the competitiveness. |
| Caitlin et al. (2015) | Six areas to succeed in a digital era:1. *Digital analytics and decision making*: Data from both internal and external sources is gathered in real time and mined for actionable insights.
2. *Strategy*: A digital strategy adapts to rapid industry change while supporting overall business aspirations.
3. *Customer centricity*: Digital tools improve the customer experience at every step in the decision journey, and beyond.
4. *Digitize business processes*: Processes are reimagined from a zero base, reducing costs and errors, and boosting customer satisfaction.
5. *Organize for digital*: The corporate culture, approach to talent and organizational model all support digital excellence.
6. *Technology*: Two-speed IT allows for rapid digital development and ensures that transactional systems are safely maintained.
 |
| Dörner and Edelman (2015) | […] we believe that digital should be seen less as a thing and more a way of doing things. To help make this definition more concrete, we’ve broken it down into three attributes: creating value at the new frontiers of the business world, creating value in the processes that execute a vision of customer experiences, and building foundational capabilities that support the entire structure. |
| Hiendlmeier and Hertting (2015) | In other words, it is only when the six components technology, data, processes/use cases, analytics, business impact and mobility come together that there is any meaningful contribution […] it is more appropriate to use the term digitization as this brings together all the instruments and possibilities resulting from linking together technology, data, analytics and concrete business processes.  |
| Ingleton et al. (2011) | Defining “digital.” Digitization at its simplest means the conversion of analogue information into digital information. As digitization capabilities extend, virtually every aspect of life is captured and stored in some digital form, and we move closer towards the networked interconnection of everyday objects. The impact of this is a real-time global exchange of information between multiple connected devices (fixed and mobile). |
| Müller et al. (2015) | Six dimensions of digital transformation:1. *Digitally enhanced customer experience*: Insurers need to understand customers’ digital behaviors and priorities in order to design the appropriate offerings and experience. The leaders are reengineering moments of truth, such as lodging a claim, to integrate digital components.
2. *An omnichannel sales and distribution model*: Customers increasingly expect their insurers to have robust online and mobile channels, with technology integrated seamlessly into activities such as contact center conversations.
3. *Optimized operations using digital technologies*: Digital can play a big role in simplifying operations by trimming redundant and manual processes while speeding up turnaround times and reducing error rates.
4. *Advanced analytics and big data applied throughout the business*: Big data holds the potential for step change improvements in customer segmentation, risk calculation, fraud identification and other areas. But it takes time to develop an advanced analytics capability staffed by the right people and then to focus them on the highest-priority issues.
5. *Technology activated to enable a digital transformation*: The challenge is to cost-effectively enhance IT infrastructure and capabilities, either internally or through off-the-shelf systems.
6. *An innovation-ready organization*: Becoming a digital innovator requires creating an environment that fosters rather than stifles innovation, and encouraging active collaboration across functions and business units
 |
| Tischhauser et al. (2016)(Translated from German) | Digitalization is the integration of new technologies with the aim of:1. Industrialization and automation of business processes to enhance the efficiency, quality and throughput speed and to reduce costs at the same time
2. Transformation of the interaction between customer and insurer along the customer journey by adapting the frontend interfaces (e.g., mobile, apps, websites) to the changing customer requirements
 |

## Appendix C: Value-chain and technology matrix

Table C: Value-chain and technology matrix – Summary of technology impact

|  |  |  |
| --- | --- | --- |
|  |  | **Technology** |
|  |  | Big data | Internet of things | Robo advisor | Blockchain | Cloud computing | Mobile devices with Apps | Website | Social network / Messenger / internet forum | Video calls | Video platforms |
| **Value-chain process** | ***Primary activities*** |  |  |  |  |  |  |  |  |  |  |
| Marketing | More precise calculations (segmentation, cross-selling) | --- | --- | --- | --- | --- | Information platform | Advertisement and product information | --- | Information platform |
| Product development | Better calculation of product prices | New situational product and pre-vention offers | --- | New offerings of smart contracts | --- | --- | --- | --- | --- | --- |
| Sales | Combining all data sources to get a complete analysis of the customer | --- | Sales without a human agent | --- | Digital document processing | New sales channel, partly fully automated | New acquisition channel | Location-independent consultation and acquisition | --- |
| Underwriting | Better risk calculation | Data generated by telematic devices are used for pricing | --- | Automated underwriting | --- | --- | --- | --- | --- |
| Contract adminis-tration/customer service | --- | Preventative support for clients | Answering service queries | --- | --- | --- | Location-independent customer service | --- |
| Claim management | Fraud analysis and payout calculation | --- | --- | Automated payout | --- | Claims are filed via App | --- | --- | --- | --- |
| Asset management | Advanced asset analysis | --- | --- | Decreasing transaction costs | --- | --- | --- | --- | --- | --- |
| Risk management | Advanced risk analysis | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Support activities*** |  |  |  |  |  |  |  |  |  |  |
| General management | Analytics are used to support the decision process | --- | --- | --- | Digital document processing | --- | --- | More efficient internal communication | --- |
| IT | --- | Automated trouble reports | --- | --- | --- | --- | --- | --- |
| Human resources | Employee analysis | --- | --- | --- | Digital document processing | --- | Recruitment channels, usage of video calls for training of employees |
| Controlling | Automated auditing of contracts and data | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Legal department | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Public relations | --- | --- | --- | --- | --- | --- | --- | New communication channels |

1. See for example Moreau (2013) on the music industry or Chathoth (2007) on the travel industry; we also refer to Back, Berghaus, & Kaltenrieder (2016) and Kane, Palmer, Phillips, Kiron, & Buckley (2015) for cross-industry comparisons on the importance of digitalization. [↑](#footnote-ref-2)
2. Dozens of media articles and studies analyze the impact of new technologies on customer satisfaction and loyalty (e.g., Maas & Bühler, 2015; Moneta, 2014), on the improvement of cost structure and business processes (e.g., Berger, Broer, & Pankoke, 2016; Caitlin et al., 2016; Chester, Clarke, & Libarikian, 2016), on the future workforce (e.g., Johansson & Vogelgesang, 2015), and on the insurability of new risks (e.g., Biener, Eling, & Wirfs, 2015, for cyber risk). These industry studies focus on specific digitalization trends and their strategic implications; none of them offer an overview of the knowledge on digitalization. [↑](#footnote-ref-3)
3. In our paper, we do not focus on literature on algorithms and computational methods. Regarding these topics, we refer for example to Salcedo-Sanz, Cuadra, Portilla-Figueras, Jiménez-Fernández, & Alexandre (2013). [↑](#footnote-ref-4)
4. We also searched “digitization” instead of “digitalization.” The results were often the same, even though the words are typically defined differently. See Section 3.1. [↑](#footnote-ref-5)
5. Journal of Finance, American Economic Review, Journal of Risk and Insurance, Insurance: Mathematics and Economics, Geneva Papers on Risk and Insurance – Issues and Practice, The Geneva Risk and Insurance Review, Journal of Insurance Regulation, and Risk Management & Insurance Review. [↑](#footnote-ref-6)
6. The terms “digitization” and “digitalization” are sometimes used synonymously and sometimes not. “Digitization” is often defined in the technical context of making analogue data digital available
(e.g. Ingleton et al., 2011; Breading, 2012) – for example, scanning of paper contracts. In contrast, “digitalization” is a broader description of the transformation of the economy and the society. [↑](#footnote-ref-7)
7. Also, focusing on the business, but in a more abstract way, Dörner & Edelman (2015) describe “digitalization” as a process of “creating value in a new business environment,” “creating value in the customer experience” and “building capabilities to support this structure.” [↑](#footnote-ref-8)
8. We do not discuss virtual reality which has been mentioned by some studies, but whose applications to insurance have not yet been developed. [↑](#footnote-ref-9)
9. A high-level summary of the technology impact on the value chain is also presented in Appendix C (the so called “value-chain and technology matrix”). [↑](#footnote-ref-10)
10. Bieck & Tjioe (2015) find that people under the age of 30 are more open to non-traditional insurance providers (e.g. auto dealers, retailers). Bieck, Marshall, & Patel (2014) find that future customers will be less price sensitive, are advice seeking, want personal multi-channel interaction and are open for new products. Concentrating on the motor insurance segment, Barwitz, Block, Maas, & Nützenadel (2016) define four customer segments based on the interaction between customers and insurers, independent of socio-demographics: utilitarians change the interaction frequently, depending on their personal benefit; hedonists prefer a high-quality and personal interaction; cost-minimizers want to reduce money and time investments; relationalists prefer personal interaction and stay loyal with their agent. Catlin, McGranahan, & Ray (2013) define nine customer segments depending on the preferences for price, brand, loyalty, convenience and personal advice. [↑](#footnote-ref-11)
11. One important aspect in this context is that customers research online, but then purchase offline via traditional channels (ROPO). For example, 84% of German consumers gather information online to buy insurance products but the majority purchases them offline (59% research online and purchase offline – ROPO); only 25% are pure online customers (Zurich, GfK, & Google, 2016). The ROPO behavior also depends on the product type: whereas 77% of pension plans are researched online and purchased offline, this only holds for 50% of motor insurance plans. One resulting challenge for insurance companies is the need to create a uniform customer journey, i.e. the customer expects to get the same information in the same quality anytime and in any channel (Pain, Tamm, & Turner, 2014). Also noteworthy are the large differences across countries when it comes to aggregators. While e.g. in Germany 41% of insurance customers use aggregators for the evaluation of motor insurance policies, only 27% of Swiss and 23% of Austrians use them (Barwitz et al., 2016). [↑](#footnote-ref-12)
12. Maas & Bühler (2015) find that today on average 41% of processes are automated in the German, Swiss and Austrian insurance industry and health insurers have already automatized 47% of processes; they estimate automatization to increase by 28%, leading to average cost saving of 14%. Caitlin et al. (2015) note in their global study that 70% of processes are done mostly manual, 25% are partially automated and only 5% are fully automated today; through digitization only 15% of processes will be still done mostly manual and 50%/35% will be semi-/automated; it is possible to save 30% to 50% in non-commission costs through automatization. Note, both studies do not mention a time period until when the full potential is tapped. [↑](#footnote-ref-13)
13. The annual spending on big data analytics will in the next three to five years globally increase by 24% in the life- and by 27% in P&C-segment (Müller et al., 2015). [↑](#footnote-ref-14)
14. For more detailed information on the tools, see, e.g., SAS (2017) and Fayyad, Piatetsky-Shapiro, & Smyth (1996). Additionally, to traditional statistical methods, data mining uses machine learning algorithms, which iteratively learn from past computations, for more efficient analyses. Usually, machine learning algorithms are trained on existing data and then automatically analyze new data sets (Hall, Phan, & Whitson, 2016). Most commonly, for the analysis classification, clustering or regression algorithms are used (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). Machine learning algorithms are also used for applications which cannot be programmed by hand (e.g. handwriting recognition) or self-customizing problems (Amazon, Netflix product recommendations). The new generated information can be used for applications such as risk allocation, customer segmentation, exploiting cross selling potential and fraud detection (Jones, 2016). [↑](#footnote-ref-15)
15. For example, the EU has reformed its data protection rules to simplify the use of big data for businesses and to set high standards of data protection (European Commission Justice, 2016). Furthermore, see Krotoszynski (2015) for a detailed comparison between the US and EU legal systems regarding privacy rights. [↑](#footnote-ref-16)
16. For the discussion in motor insurance, we refer, e.g., to Paefgen et al. (2013), Filipova-Neumann & Welzel (2010) or Keller & Transchel (2016). Anchen, Frey, & Kirova (2015) present some thoughts on wearables for the life insurance market. [↑](#footnote-ref-17)
17. One example is the use of big data techniques for risk underwriting and analysis; Climate Corporation (US) uses climate and soil data to offer farmers insurance against losses from weather events (Müller et al., 2015). AllLife (South Africa) offers life and disability insurance to policyholders, who suffer from HIV or diabetes; in their monthly health checks every client gets a personalized analysis and advice in managing their conditions. For assessing their clients’ conditions, the insurer has direct access to medical data form medical providers. If clients do not follow the checkup plan, coverage can be lowered or cancelled (Brat, Clark, Mehrotra, Stange, & Boyer-Chammard, 2014). [↑](#footnote-ref-18)
18. For example, the start-up InsurETH is developing a peer-to-peer flight insurance based on the blockchain technology which pays automatically a specific amount to the customer if the flight is too late, without any claim filing (Digital Technology Observer, 2016). [↑](#footnote-ref-19)
19. Maas & Bühler (2015) find that 42% of IT development and 51% of IT operations will be outsourced by 2020. [↑](#footnote-ref-20)
20. We also can observe the same behavior in the other direction, i.e., the increasing efforts of insurers to grow outside their core business. For example, Allianz recently bought the auto sales platform Instamotion Retail (Hegmann, 2016). [↑](#footnote-ref-21)
21. The same arguments can be made for other industries, e.g., mobile phone providers. [↑](#footnote-ref-22)
22. For example, technology firms offer payment solutions (e.g., Apple or Samsung Pay). Another example is Telefonica which offers a telematic motor insurance (O2 drive) in the UK. However, it seems that Telefonica is not carrying the risk, but is rather an intermediary to other insurers. They are providing the customer with a telematic device. [↑](#footnote-ref-23)
23. We also refer to valuation of companies like Google or Facebook, whose most valuable asset is the data of their customers. [↑](#footnote-ref-24)
24. Note that the return on equity consideration does not only mean investing in other industries, but also working with the insurance industry with alternative business models. For example, Google even retained in the US and UK from acting as an insurance broker (Google Compare). One might suspect that the profit from pure advertisement on Google are higher than the potential profit from acting as a broker or risk carrier all of which requires substantial expertise and up-front investments (Jergler, 2016). Another example in this context is that both Amazon and Apple are working with insurance companies (London General Insurance Company Limited and AIG respectively) for their warranty programs Amazon protect and AppleCare+. [↑](#footnote-ref-25)
25. For more examples, see KPMG & H2 Ventures (2015). [↑](#footnote-ref-26)
26. We refer to Mesropyan (2016), Noack (2016), Kottmann & Dördrechter (2016) and Braun & Schreiber (2017) for more examples. We also refer to Braun & Schreiber (2017) for a more detailed discussion on the role of insurtechs, their business model and how they might affect the insurance industry. [↑](#footnote-ref-27)
27. We note by using GetSafe the company is also contracted as the customer’s broker. As a consequence, it is getting the trailer commission. [↑](#footnote-ref-28)
28. We emphasize that the reasons are out of today’s industry perspective. Examples from other industries (e.g., low cost carriers in the airline industry) have shown the impact of a possible disruption that also was not envisioned before. [↑](#footnote-ref-29)
29. There are differences in the willingness to share private information depending on the area of life (car, housing or health) and country. The majority of people would use a GPS-transmitter to locate a stolen car or sensors in the house for fire detection, but would not want to share health conditions (Maas, Graf, & Bieck, 2008). [↑](#footnote-ref-30)
30. Also, see Nationaler Ethikrat Germany (2007). [↑](#footnote-ref-31)
31. For example, see Kolmar & Booms (2016). [↑](#footnote-ref-32)
32. For example, health and life insurers could not only separate people by age and be whether they are smokers or non-smokers but for instance by how physically active they are. Another example is in motor insurance, where data is enriched with information about driving behavior (acceleration, braking behavior, speed, etc.). [↑](#footnote-ref-33)
33. There is also a possibility that the customers share their information only with a technology provider (e.g. Apple tracks the usage behavior of their iPhone customers). In this constellation, the technology provider supplies the risk calculation and prevention. In exchange for carrying the risk, the insures get a minimum margin. [↑](#footnote-ref-34)
34. Müller et al. (2015) argue in the same direction by introducing four strategic pathways: advanced analyzer, digital distributer, customer-centric insurer and effective operator. Johansson & Vogelgesang (2015) predict that the digital transformation will also impact the workforce of insurance companies; insurance companies have to attract new employees with knowledge in data science, analytics and/or IT-development. Moreover, there will be a significant number of layoffs in the operations department. [↑](#footnote-ref-35)
35. Filipova-Neumann & Welzel (2010) develop a model for telematic motor insurance demand. Other studies focus on the impact of assistance systems or financial incentives on driving behavior, e.g., Bende, Hummel, Kühn, & Lang (2011) or Bolderdijk, Knockaert, Steg, & Verhoef (2011). [↑](#footnote-ref-36)