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Technological adoptions and sector-specific innovations in a low-tech environment: key actors and sources of R&D in InsurTech

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Abstract
Following financial technologies' rapid growth, innovations and R&D are entering the insurance industry. The development of technologies such as smart sensors, artificial intelligence, and mobile technologies offers potential for disruptive innovations to revolutionise the industry. This paper identifies the key technological adoptions and R&D in the field of InsurTech considering the sources of innovations and actors through patentometrics. It analyses the main areas of granted patents and patent applications in this field. The present literature provides both quantitative and qualitative information about key areas, investments, and further financial data in the field, but a thorough patent analysis is not yet available. This study also contributes to the adoption and innovation theories. It outlines a new angle by examining the sources of innovations and technological adoptions through both academic and professional lenses. Patentometrics helps to identify the technological clusters and main actors globally. Patent applications can reveal potential future focus points. Hence, the analysis of patents can provide a more specific outlook than an extrapolation of historical financial data. In addition, interviews with experts are conducted to justify the results of the patentometrics and to collect further information. The results show how, in a low-tech environment, innovations occur with the support of third parties and industry-specific R&D and organisations. Interestingly, most adopters and innovators are within the insurance industry. Analysing InsurTech patent applications leads to the identification of R&D activities in the vehicle, health, and property insurance areas. These areas can represent the future trends of innovations in the InsurTech industry.

Keywords InsurTech · Low-tech industry · Technological adoptions · Innovation · Patentometrics

Introduction

The insurance industry, which is traditionally slow to respond to technological developments (Institute of International Finance, 2016; Pine Bridge Investments, 2016; PWC & Startbootcamp, 2016), is currently experiencing a possibly disruptive change triggered by newly implemented technologies. The relatively young field of insurance technologies

Extended author information available on the last page of the article

(InsurTech) is growing exponentially (Berthelmann & Mehta, 2017). Even though there is no specific definition of InsurTech, the following explanation serves as a description: the acronym *InsurTech* (insurance and technology) represents those new innovations in the insurance industry that are entirely focused and based on recent technological developments (Scott-Briggs, 2016; Sia Partners, 2017; Van Eck & Waltman, 2013). In a sector in which business models have mostly remained the same throughout the last 30 years, technology-driven start-ups (InsurTechs) are entering the playing field and the world's largest insurers are forming collaborations with them (Pine Bridge Investments, 2016).

Technologies such as the Internet of Things (IoT), Blockchain, and mobile and smart devices are used by InsurTechs and incumbents to create niches in the value chain of the traditional insurance business. Different factors, for instance expectations regarding customer service, technological change, and diminishing confidence in insurance enterprises, have changed the mind-set of insurance companies towards the way in which they have been working. Advances in sensor technologies and related services (Institute of International Finance, 2016) are acting as drivers for the technological change in the industry (Ernst & Scott-Briggs, 2016; Young, 2016).

Even though the number of InsurTechs is increasing steadily and the chances to earn profits in specific product segments are high, there are still several challenges in this field. Firstly, InsurTechs cannot exhibit the same level of knowledge about the market as the incumbents (Volosovic, 2016). Secondly, they cannot attain a similar-sized client base as the incumbents[1] (Institute of International Finance, 2016). However, InsurTechs might fill unserved gaps and act as new technology suppliers for large insurers. Incumbents have realised the necessity of investing in insurance technologies to stay competitive in the future. This is apparent from the amount of funding that is allocated to InsurTechs, which doubled from 2014 to 2015 and surpassed 200 million USD in Q1 and Q2 of 2015 (CBI Insights, 2017). Furthermore, both practitioners (Ernst & Young, 2016; PWC & Startbootcamp, 2016) and academics (Volosovic, 2016) have confirmed that traditional insurers are increasingly entering partnerships[2] with InsurTechs. Another indicator is the increasing mergers and acquisitions and financing activity in the InsurTech sector (CBI Insights, 2017).

Based on these facts, it can be concluded that the InsurTech momentum is growing. This development suggests an increasing number of patent filings [(Institute of International Finance, 2016; PWC & Startbootcamp, 2016] as "patents can be considered as indicators of inventions" (Leydesdorff & Bornmann, 2012; Porter & Cunningham, 2004). In contrast to analyses of publications, which rather reflect academic activity, patent analyses help to identify industrial and practical efforts in R&D.[3]

The patent analysis of specific sectors is a controversial topic among academics. Pavitt (1984) presented a taxonomy to explain sectoral patterns of technological development. A review of Pavitt's taxonomy (Archibugi, 2001) found that it was mainly created for manufacturing firms and has limited significance for patents in the financial sector. Further studies (Porter & Cunningham, 2004; Zhang et al., 2014) have attributed only minor relevance to patent analyses performed in the service industry. Yoon and Lee (2011) stated that Archibugi's

[1] At least in the short term.

[2] For example, the partnership of AXA with Google Nest (Sia Partners, 2016).

[3] Even though publications and patent records are similar to a certain extent, they are not identical. Patent documents are can be highly complex and the authors try not to reveal business intents in the abstracts what makes a patent analysis outstandingly challenging (Porter & Cunningham 2004).

(2001) re-edited ICIS taxonomy expanded the taxonomy by including service sector companies. In fact, the technological development has blurred the boundaries of different sectors. The approaches in InsurTech have moved the traditional insurance companies closer to data science approaches and advanced technologies (Berthelmann & Mehta, 2017). Hence, performing patent analysis in the insurance industry would be beneficial to examine the technological developments and to understand the shift from the traditional insurance environment to InsurTech implemented new business solutions and models. Accordingly, the aim of this study is to use patentometrics to examine technological adoptions versus innovations considering the sources of technologies and developments in InsurTech.

This study makes both theoretical and practical contributions. Rogers (2003) examined the technology adoption life cycle from a consumers' technology adoption perspective. Our study proposes a model to examine technological adoptions versus innovations from a sectoral perspective. Accordingly, we categorise the sources of innovations as 1) technologies and solutions that are developed for and specific to a particular sector (sector-specific technologies and innovations) and 2) technologies that are developed by third-party or R&D-intensive organisations and adopted by sectoral actors (technology adoption by sectors). Technology adoption is a more common approach to innovations in low-tech sectors (Ozcan et al., 2021; Stornelli et al., 2021). Considering the practical contribution of this study, we used our model to examine the InsurTech developments with an adoption vs. innovation approach. The majority of the analyses in the underlying field have focused on outlining past financial data or been based on qualitative reports. Considering these existing unilateral analyses, this study adds a new analytical perspective to the existing literature. It therefore contributes to the field with a novel approach to illuminate the topic in a more holistic way by identifying and visualising recent technological clusters and possible future trends in InsurTech through a patent analysis and expert interviews. This study can be used as supportive output in addition to other studies and reports, such as those by Berthelmann and Mehta (2017), Klapkiv and Klapkiv (2017) and Volosovic (2016). Other studies have examined the technologies and innovations in this field based on industry analysis, interviews, and reports, but the proposed patentometric approach offers a different angle to show technological diffusion, adoption, and innovations in a wide spectrum that is difficult to cover through other means of data analysis.

The subsequent parts of the study are organised as follows. First, the importance of scientometrics and patent analyses will be outlined to demonstrate their suitability for analyses in the underlying field along with a discussion of related work. This part is followed by the research gaps, the aim and objectives of the study, and the conceptual framework. Next, we provide an introduction to patentometrics and its spectrum of applications. The subsequent part presents the detailed methodology, from patent data retrieval to the visualisation and interpretation of the patent data. The last part outlines the outcomes of the analysis and its impact on the sector.

Table 1 Inventions in the field of InsurTech

Inventions	Purpose
Telematics	Telematics, which monitors driving behaviour and sends notifications to drivers, changes premiums, etc. (IIF, 2016; Klapkiv & Klapkiv, 2017)
Wearables	Sensors that monitor the health of customers (heart rate, oxygen, blood pressure, etc.) and send information to customers, change premiums, etc. (IIF, 2016)
On-demand insurance	New insurance products that can be taken out immediately (e.g. *pay as you drive*) to reduce costs and make the insurance more precise and usage based (using the IoT) (IIF, 2016)
Automated claims processing	The use of artificial intelligence (AI) and smart devices allows customers to file a claim online via an application on a smart device, such as a smartphone (Hall, 2017)
Chat bot	Systems that use mobile applications and messaging platforms to answer questions, give advice, perform transactions, and so on automatically (mainly used for automated claims management) (Hall, 2017)
Fraud detection	Use of AI to detect possible insurance fraud by automatically running anti-fraud algorithms after an insurance claim is submitted (IIF, 2016)
Property insurance devices	Devices and sensors, such as carbon monoxide meters, that help in monitoring the circumstances in a property (Klapkiv & Klapkiv, 2017)

Literature review and theoretical background

InsurTech

The insurance industry is growing rapidly, with investments in InsurTech start-ups reaching 1.7 billion US dollars in 2016.[4] Even though the rapid development of the FinTech sector has suggested similar impending changes in the insurance industry, the adoption of new technologies did not take place to the same extent until around 2012 (Ernst & Young, 2016). The IoT, Blockchain,[5] and artificial intelligence (AI) are the key drivers that enable the creation of innovative products and new business models in the insurance industry (Hall, 2017; Volosovic, 2016). Drawing on these technologies, InsurTechs are able to fulfil the desires for improved customer service and technological development. Moreover, traditional insurers have an indirect connection with their customers, whereas start-up companies show a direct connection (Gundlach, 2017; Volosovic, 2016). InsurTechs can take advantage of unsatisfactory user experience in the insurance industry and develop a competitive advantage (Institute of International Finance, 2016; Scott-Briggs, 2016). The direct connection of start-ups with customers is vital as relatively young companies are introducing entirely new products and disseminating product information in the market. To enhance customer service and efficiency, they use a mixture of technology, flexible

[4] Compared to 0.1 billion US dollar in 2011.

[5] "The IoT is a network of nodes, or devices, that collect, monitor, and share data through the Internet." (IIF, 2016) Blockchain is a new system which simplifies and speeds up transactions, enables a secured maintenance through cryptography and it removes the need for a centralised authority who was in charge for these processes so far (IIF, 2016).

Table 2 Purposes of analysed patent data (Abbas et al., 2013)

Determining novelty in patents
Analysing patent trends
Forecasting technological developments in a particular domain
Strategic technology planning
Extracting information from patents for identifying infringements
Determining patents quality analysis for R&D tasks
Identifying the promising patents
Technological road mapping
Identification of technological vacuums and hotspots
Identifying technological competitors

business processes, and user-oriented services[6] (Volosovic, 2016). Table 1 presents the most important inventions in the InsurTech industry in recent years based on previous studies and reports. However, a holistic approach and examination may be beneficial to see the technological adoptions and innovations in this sector.

Patentometrics

To analyse the developments of science and technologies, several research methods are used to perform quantitative analyses in specific research fields: *bibliometrics*, *scientometrics*, *informetrics*, *webometrics*, *patentometrics*, and *altmetrics* (Leysdesdorff & Mingers, 2015). The methods that relate most to the analysis of this paper are *scientometrics* and *patentometrics*, which have been defined as "the quantitative methods of the research on the development of science in an informational process" (Nalimov & Mulchenko, 1971). The purpose of patentometrics or patent mining is to reveal technological insights by analysing patent data with quantitative approaches.

Patentometrics reveals key insights for organisations and governments regarding the appropriate planning. Abraham and Moitra (2001) applied patentometrics to identify key technological innovations with the purpose of helping Indian organisations to increase their knowledge and competitiveness in strategic planning. Breitzman and Mogee (2002) asserted that patent analysis can be used for numerous purposes, such as company valuation, merger and acquisition targeting, the identification of key employees of an enterprise, technology assessment, research and development management, and analysing the inventory of an enterprise's patent portfolio. Moreover, Trappey et al. (2012) stated that intellectual property and patent quality are assessed by firms to identify current technological trends and innovative products. Hence, patentometrics can be used for several purposes, as shown in Table 2.

Patent analysis can be applied in almost any subject area: Alfranca et al. (2002) analysed food and beverage firms on the global level, the medical prostheses industry was examined by Lo Storto (2006), the collaboration policy of the Japanese university industry has been investigated (Motohashi & Muramatsu, 2012), and nanotechnology patent collaborations have been analysed using patent analysis techniques (Ozcan & Islam, 2017). Whether the

[6] And therefore, reduce costs through automated processes.

field is a high-tech or a low-tech environment, and whether there is a sectoral, national, or technological focus, this approach can be used for the previously mentioned purposes.

Although patentometrics and scientometrics have been used to analyse various areas, they have never been implemented in the InsurTech area. The InsurTech industry is experiencing large-scale growth. Most of the existing literature within the insurance technology industry has either applied quantitative analyses of past financial data or made use of qualitative methods, such as interviews.

Theoretical background

For this study, the most relevant theories to consider are innovation, adoption, and diffusion theories. These theories explain how new or different types of technologies or innovations are adopted and diffused over time within or across organisation, sectors, and nations. Roger's (2003) diffusion of innovation is a widely used theory to examine such environments. He proposed five steps for the innovation or adoption process: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. Roger also examined the adoption process based on the classification of members of a social system, categorising them as innovators, early adopters, early majority, late majority, and laggards. Using this theory and models, many studies have focused on the process or critical factors of technological adoption. Van Oorschot et al. (2018), in their bibliometric study, examined the innovation adoption literature and found four clusters: (1) institutional theory and the legitimisation of innovative behaviour, (2) the theory of reasoned action and the technology acceptance model, (3) determinants of innovation adoption and the econometric perspective, and (4) diffusion theory.

The previous studies have examined the adoption of technologies and their relation to innovations at either the individual level, focusing on the acceptance of the technology investigated, or at the organisational level, considering the adoption acceptance process and factors in a broader sense by modelling and studying the diffusion of innovations (diffusion rates and econometric perspectives). However, the distinct categorisation between adoption and innovation at the sectoral level is very weak. The adoption and innovation literature is studied in an integrated fashion, whereby adoptions lead to innovations or first adopters are accepted as innovators. However, the adoption and innovation theories, considering their unique characteristics and processes, should be examined as a whole in the context of sectoral progression and development. Considering the adoption and innovation characteristics at the sectoral level, there can be innovations that are based on sector-specific R&D and solutions for which the technologies and innovations are specific to the innovation sector or there can be technological adoptions for which the technologies are adopted for the sectoral needs and innovations occur. These distinct sources of innovations and their progressions may not be especially apparent in the high-tech environment as many are developed by R&D-intensive organisations in the low-tech environment, in which innovations occur mostly as a result of adoptions. However, there are organisations that invest in R&D as well for sector-specific innovations. It is important to examine the dynamics and differences between innovations and adoptions to understand the sources of innovations and technological trajectories in different sectors. The literature providing such an illustrative perspective and a model at this point is limited.

Research gaps, aim, and conceptual framework

The research on the underlying topic has revealed several gaps. The field is relatively young, and most of the studies conducted have been based on similar approaches. Quantitative studies have used historical financial data both to explain the status quo and to try to predict the future trends (CBI Insights, 2017). Even though past financial data, such as the percentage increase of investments in InsurTechs and collaborations, have formed the basis for a prediction, they have not focused on specific areas. There are also several qualitative studies in the field of insurance technologies, such as Ernst & Young (2016), Klapkiv and Klapkiv (2017, Pine Bridge Investments (2016). These players have provided information based on experience in the field and developments that they have observed. Although all these studies are representative, no study has tackled the prediction of future trends through a patent analysis.

Considering the theoretical gap, the academic literature can benefit from a model and an illustrative example examining technological adoptions and innovations together. This distinct categorisation can be performed at the sectoral level based on the sources and providers of innovations. Hence, the aim of this research is to examine technological adoptions versus innovations at the sectoral level to identify the technological sources and developments in the InsurTech field. The specific objectives of the study are:

1. To analyse the InsurTech landscape and identify the key players and technologies;
2. To examine the sources of technologies from an innovation and adoption perspective;
3. To identify possible future trends and make recommendations for investments for the InsurTech industry.

This study developed the conceptual framework shown in Fig. 1 considering the theoretical base and application area. The conceptual framework was created based on the adoption and innovation theories as discussed in "Theoretical background" section and in the objectives of the study.

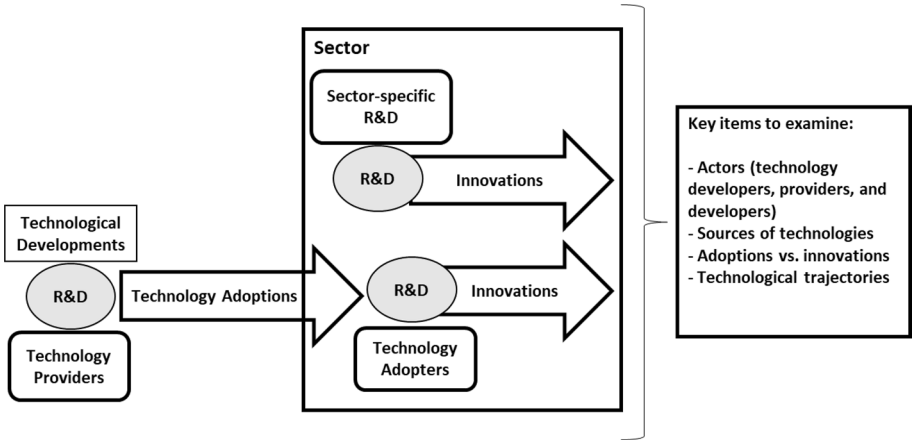

Fig. 1 Conceptual framework

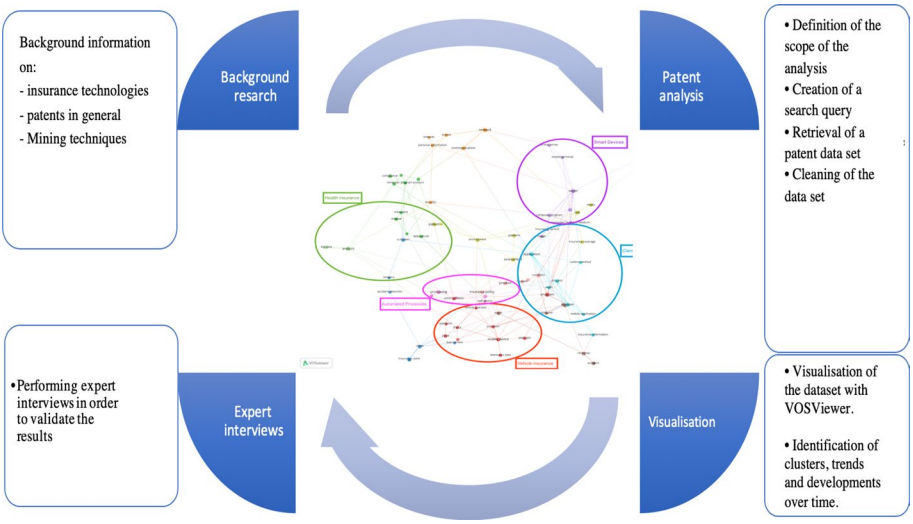

Fig. 2 Explorative methodological framework

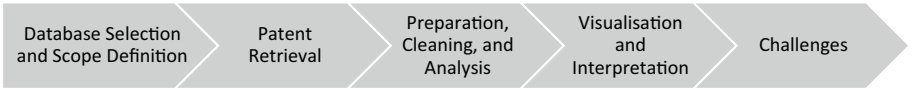

Fig. 3 Steps of the patentometrics

Methodology

In this study, we implemented patentometrics in an explorative way to analyse the focus areas of the insurance industry and to understand the technological adoptions and innovations in this field. Afterwards, interviews were conducted to examine the results in depth.

Figure 2 shows the overall process and method. The starting point of background research and the technical approach of patentometrics will be explained in the following subsections.

Patentometrics

Figure 3 represents the individual steps that we undertook in the course of the patentometrics. For this study, both primary and secondary data were collected. Secondary data were gathered and evaluated by applying the patentometric technique. Primary data were collected by conducting two interviews with experts in the field to improve, verify, and interpret the outcomes of the study. The following sections outline the detailed steps of the method.

For this study, the *Google Patents database* was used to retrieve the required dataset. The database includes all the patent authorities, such as the USPTO, WIPO, and EPO.

Table 3 Leading organisations and their sectors

Organisations	Sectors	%
Ping an insurance	Insurance	7.50
State farm mutual automobile insurance company	Insurance	7.00
Allstate insurance company	Insurance	3.60
Taikang life insurance	Insurance	3.20
Hartford fire insurance company	Insurance	2.90
Samsung life insurance	Insurance	1.70
International business machines corporation (IBM)	Software	1.20
Guidewire software	Software	0.90
United services automobile association	Insurance	0.90
The travelers indemnity company	Insurance	0.80
Alipay information technology	Financial services	0.80
Qomplx	Software	
Mitchell international	Software	0.70
Metropolitan life insurance	Insurance	0.60
Fubon insurance	Insurance	0.50
National health insurance corporation	Insurance	0.50
Liberty mutual insurance company	Insurance	0.50
	Total	33.30

Only English patent documents from the period from 2008 to 2018 were included in this study. Regarding the patent status, granted and application were both used as part of the analysis.

The search query was created by adding topic-related terms in the search bar. To refine the query, we included terms that had to appear in either the abstract, the title, or the claims section of each patent document. The preliminary query for this action was the following: TI = (insuranc*) OR AB = (insuranc*) OR CL = (insuranc*). The result contained documents that were not related to the field of InsurTech. Ozcan and Islam (2017) stated that the combination of a lexical query with a code retrieval technique provides ideal results. Therefore, the query was further refined by adding InsurTech-related patent codes.

The dataset was further cleaned in two ways: (1) duplicates were removed and (2) irrelevant patents were removed by looking through the patent titles (if the title was not meaningful enough, the abstracts were examined further). The data were further processed based on the categorisation, pre-processing (i.e. generic stopword removal process), threshold selection, and dimensionality reduction with PCA. Finally, *VOSViewer* was used to visualise the results. Using *VOSViewer* with binary counting, the minimum number of occurrences was selected (a minimum of four occurrences was chosen). Generic or descriptive terms were removed as part of the final stopword removal step. When the final set of terms had been established, the results were clustered using the visualisation tools of the software. After the visualisation step, each result was checked once again with the database and, if there was an irrelevant term or set of terms, the steps were repeated from the beginning.

When the final visual was created, the interpretation of the clusters was performed with the support of the interviews, which were conducted with two experts in the InsurTech field. The aim was to improve, verify, and interpret the outcomes of the study. Based on the identified clusters, each set of terms was examined by searching for the items in the

database to label clusters and interpret them. For each cluster and set of terms, patent documents were identified and examined in depth to understand the sources of technologies, the relevant R&D, and the purpose of these technologies in the insurance sector.

Results and discussion

Upon the completion of the process, it was apparent that the results from the patent analysis were strengthened by the interviews. The responses of the interviewees correlated with the outcomes of the analysis and therefore substantiated them. We first present the results of the descriptive analysis in the next section.

Descriptive results

Table 3 shows the top companies that acquired patents related to the insurance sector. Considering the actor- and sector-based involvements, even though the insurance sector is accepted to be a low-tech environment, the table indicates that the majority of the patents are acquired by some of the top companies in the field. Interestingly, however, some of the top insurance companies, for instance Berkshire Hathaway (with the highest market capitalisation globally—$714 billion), do not appear to invest in patents. Some companies, such as IBM, Guidewire Software, and Mitchell International, provide technological solutions to the insurance sector. In relation to the conceptual framework, the majority of the R&D appears to be generated within the sector and dominated by some of the top actors. However, the insurance sector has many InsurTech-related startups, and it is evident only about 30% of the patents are covered by the top organisations.

Patentometrics in InsurTech

In this section, two types of analysis are presented. Firstly, all granted patents were identified to show the overall R&D in this field. Finally, applied patents were examined to highlight the recent R&D investments. As shown in Fig. 4, there are five clusters, covering claims processing, health insurance, vehicle insurance, automated processes, and smart devices. These clusters are explained in detail in the following sections.

Claims processing

Patents in this cluster tackle claims initiation and identification. Automatic claims initiation occurs in conjunction with the provision of audio signals, images (photographs), or personal information about the persons involved in an incident. Other patents focus on computer-based identification of matching claims to determine damage amounts in similar claims. Further inventions facilitate the reporting of injury claims through the use of a mobile device and the provision of feedback after an accident (first aid, organising a rental car or towing service, etc.). Patents in this area also focus on claims data coming from smart homes. This information is evaluated automatically and used to recommend intelligent smart home systems by comparing specific user data and claims data. Eliminating the need for an on-site assessment of an insured party (person, vehicle, property, etc.) is the main reason for these systems. A small portion of patents introduces computers or systems

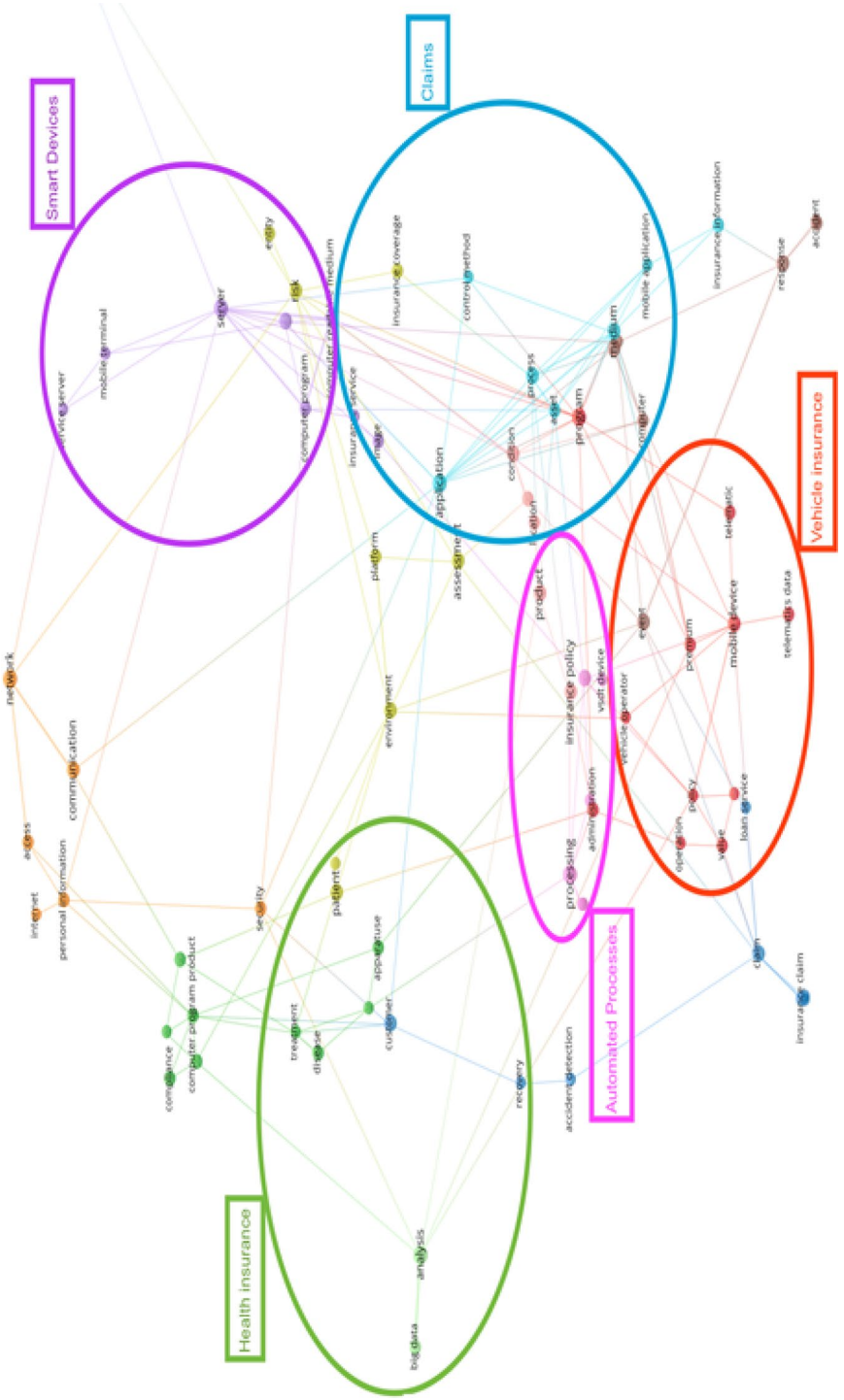

Fig. 4 Clustering results for the granted InsurTech patents

Table 4 Summary of granted InsurTech patents

Clusters	Technologies	Sources of innovations
Claims processing	Automated claims	Sector specific R&D
	Simplified claims initiation	Sector specific R&D
	Simplified claims identification	Sector specific R&D
	Claims evaluation (smart homes)	Sector specific R&D
	Claims processing (smart homes)	Sector specific R&D
	Claims feedback	Sector specific R&D
Health insurance	Online applications for health insurances	Sector specific R&D
	Chat bots	Technology adoption
	Automated processes (e.g. reimbursement payments)	Sector specific R&D
	Online applications for health insurances	Sector specific R&D
	Automatic claims assistance	Sector specific R&D
	Claims settlement and processing	Sector specific R&D
Vehicle insurance	Telematics	Technology adoption
	Automated accident tracking	Technology adoption
	Monitoring driving behaviour (accelerometer)	Technology adoption
	Insurance premium calculations	Sector specific R&D
Automated processes	Automated insurance policy pricing	Sector specific R&D
	Insurance policy payment deferral plans	Sector specific R&D
	Spotting qualified insurance customers	Sector specific R&D
	Classify customers into risk categories	Sector specific R&D
Smart devices	Damage inspection with drones	Technology adoption
	Location tracking	Technology adoption
	Insurance integrated security systems	Technology adoption

through which insurance companies can receive customer feedback and automatically improve the claims process through the evaluation of pre-set questionnaires.

Health insurance

Chat bots (accessible through the IoT) through which health insurance takers ask questions and receive automated information about personal health and give instructions to undergo medical examination are the key focus within this cluster. Moreover, automated processes, such as systems that recognise documents for reimbursements and automatically initiate the payment, are some of the important inventions. Other patent documents within this cluster focus on health insurance claim settlement through apps and online claims processing. This cluster also contains patents that are mainly related to the automatic processing of data. Online applications for health insurance via smart devices and computers using the IoT account for the largest part of the patents.

Vehicle insurance

Most inventions include the monitoring of driving behaviour. Accelerometers, which monitor the acceleration of a vehicle, and other measuring instruments, which gather information about the driving behaviour of an insured person, are of major importance. The insurance premiums of insured persons can either decrease or increase. Moreover, automatic tracking of accidents is important in this cluster. Furthermore, there are patents for systems that recognise electronic devices, for example smartphones and laptops, and their usage

inside a vehicle. When detected, these systems send security alerts to the device to reduce "text-while-driving" (accident prevention). In addition to amendments to granted patents, there are patents for systems that recognise the facial expression of the driver and send alerts when drowsiness or distraction is detected by the system (accident prevention).

Automated processes

Underlying patents focus on automated systems that calculate insurance policy pricing models based on telematics route-tracking devices. Moreover, computer-based systems that automatically create insurance policy payment deferral plans are introduced. Devices that provide information about life insurance applicants to speed the spotting of qualified insurance customers were also detected. Finally, systems are introduced that classify insured customers into different risk categories to allocate the cost of the insurance.

A summary of these clusters and technologies is provided in Table 4. Following the theoretical foundations, we also examined the sources of these innovations to determine whether they are sector-specific developments or whether these innovations occurred as a result of the technology adoption process.

To identify future trends in the field of InsurTech, patent applications were examined separately. In this category, similar clusters were apparent, but progress is apparent in the application of smart devices, usage-based insurance products, and automated processes. These appear to be the result of advanced approaches in the data science applications and usage of advanced sensors (please see Fig. 5). Each category is examined in the following sections, describing the technological progression.

Property insurance

Smart homes are properties that are equipped with smart meters or a security system. These newly invented smart meters are installed at properties to reduce several risks and send notifications to the insurance carrier when the status of any measured unit is alarming. The following areas are tackled by the meters: ice formation on rooftops, pipe breaks, gas development, and fire alarms (damage prevention).

Usage-based insurance products and smart contracts

These are specific insurance products, enabling customers to take out insurance for motorised vehicles for short periods (e.g. one day, a weekend, a specific season, etc.). Insurance takers can also insure their sports equipment on specific occasions (e.g. a skiing holiday). Smart contracts represent the use of the IoT or smart devices to simplify the process of entering into an insurance contract.

Automated processes

These mainly involve the computer programs that gather information on claims events. Based on this information, the system calculates claim requirement recommendations based on an event. When similar claims occur, the system can compare them and send recommendations automatically. Other systems can transmit customer information from a customer terminal to a management server, which enables and simplifies the monitoring of customer information.

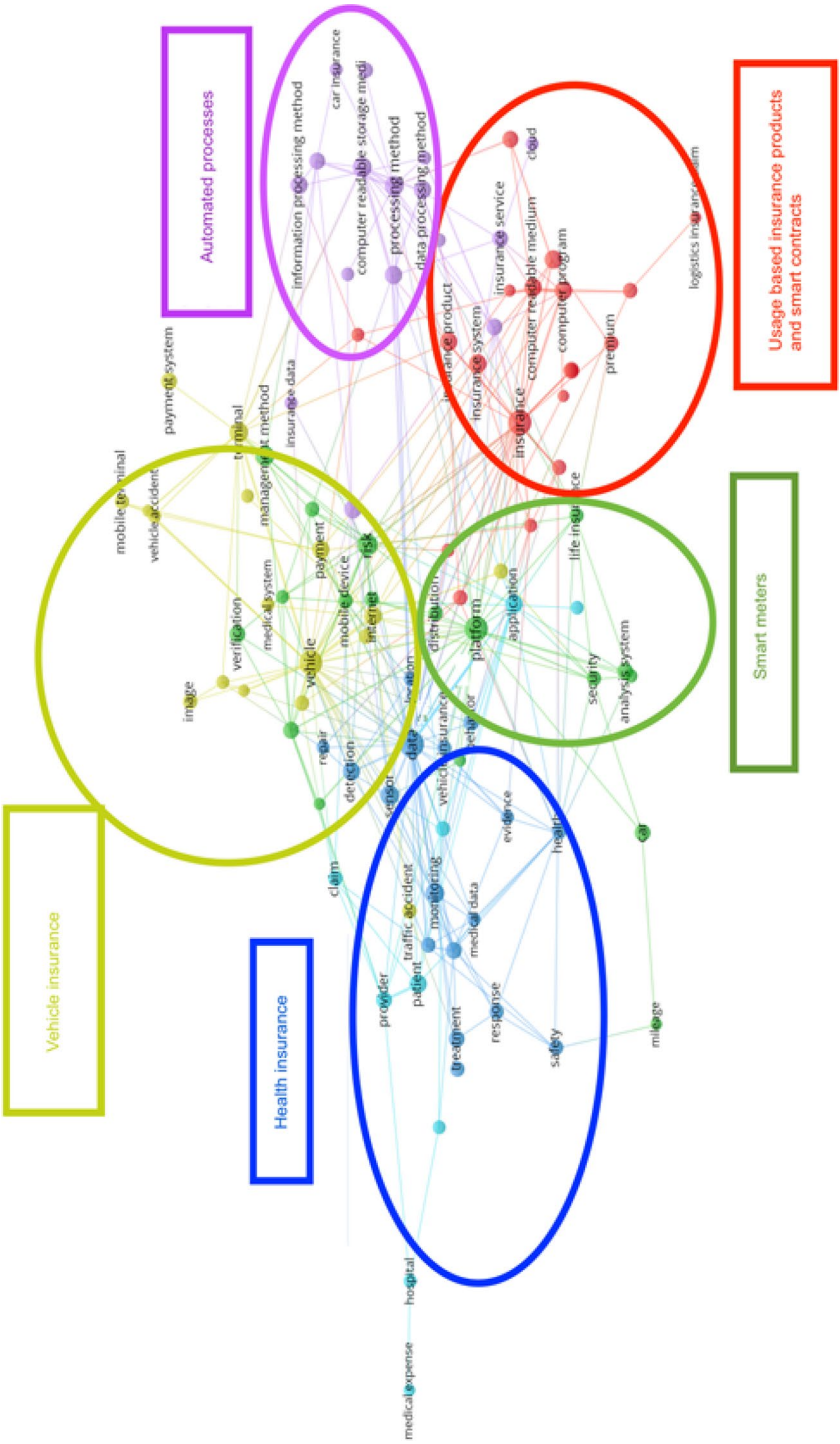

Fig. 5 Clustering results for InsurTech patent applications

Vehicle insurance

The most important topic concerns the behaviour of drivers (accelerometers, updated technologies about texting-while-driving, and chat bots that provide after-accident services). Additionally, face recognition technologies identify the main driver of a car. If the insured drivers are not driving the car, the status will be updated and stored and the insurer can compare the data (fraud detection). Moreover, several patents have been filed that concern the maintenance of a vehicle. Smart meters and telematics services provide information about the condition of a vehicle to reduce the risk of damage and possible accidents.

Health insurance

Major inventions under this topic are the cover applications on which patient records are stored. Among these inventions are smart devices that help in monitoring the health of insured persons. Via smart watches, for example, a person's heart rate and other fitness-relevant indicators can be measured. Automated notifications about the status quo and relevant tips to live a healthy life are then provided via an application (reducing the risk of becoming ill and undergoing medical examination and therefore reducing the cost of the insurer and the insurance fee). Big data are used to search and associate disease dates and historical weather information. According to the data, patients can then be classified according to the analysis and age groups. Due to such extrapolations, the calculation of health insurance premiums for the previously defined classes is simplified. Other key topics are anti-fraud systems, which analyse matching health insurance claims and related fraud components.

A summary of these clusters and technologies is provided in Table 5.

Based on the previous assessments and the theoretical foundations, Fig. 6 was designed to illustrate the innovations that are based on the technological adoptions and the sector-specific R&D activities. It represents the technologies that are adopted for FinTech or the sector-specific R&D activities in this field.

Table 5 Summary of InsurTech patent applications

Clusters	Technologies	Sources of innovations
Property insurance	Insurance integrated smart home security systems	Technology adoption
	Sensors for preventing and informing damages such as; pipe breaks, leakage and detect carbon monoxide	Technology adoption
Usage based insurance products and smart contracts	"On-the-go" insurance products	Sector specific R&D
	Usage based insurance products	Sector specific R&D
	Smart contracts	Sector specific R&D
Automated processes	Calculating claims requirements	Sector specific R&D
	Monitoring and tracking customer information	Technology adoption
	AI based claims processing	Sector specific R&D
Vehicle insurance	Face recognition (fraud detection)	Technology adoption
	Texting-while-driving alerts	Technology adoption
	Automated vehicle maintenance checks	Technology adoption
Health insurance	Wearable technologies for health monitoring	Technology adoption
	Anti-fraud systems	Sector specific R&D
	Predictive cost analytics	Sector specific R&D

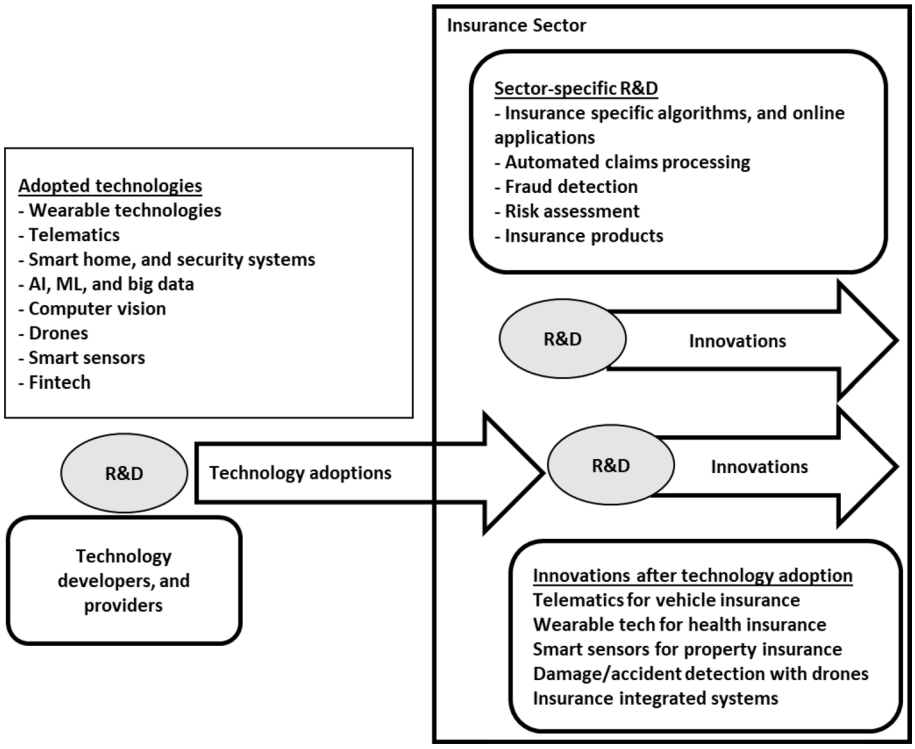

Fig. 6 Technological adoptions and innovations for FinTech

Current landscape and future trends

The current landscape of inventions in the InsurTech industry was outlined in the summary of patents granted in the period 2008–2018. The aggregated information was complemented by an analysis of previous studies and the key players in the analysed period. Our study also contributes to the technological adoption and innovation theories focusing on the sources and development of innovations at the sectoral level. Furthermore, our findings are helpful for the low-tech industry. Contrary to the previously accepted knowledge about the R&D or sources of innovations in low-tech sectors (Potters, 2009), our study shows that many InsurTech innovations originate from firms in the insurance sector. Certainly, there are technologies that have been developed outside the insurance sector and adopted as InsurTech innovations, but that is also the process for various high-tech industries. The interesting fact here is that some of the top insurance companies have not been involved in patenting activities. Moreover, this study did not analyse, improve, or compare mining techniques but solely applied the most suitable technique to gather results for a specific industry. In the current state, comparing the results of this study one by one with those of other analyses would not be adequate as the scopes are very different and the InsurTech industry is still young and has not previously been analysed using patentometrics. However, technologies that have been identified in previous studies, as shown in Table 1, validate our findings, and our results provide new insights for InsurTech.

Comparing the outcomes of the analysis (clusters in the table and visual) with the identified focus areas generated overlapping results. This qualitative information about the most important inventions can therefore be justified from a quantitative perspective through the underlying analysis. Moreover, the analysis detected additional areas that complement the landscape and recent trends. Accident assistance, automatic classification of customers into risk categories, and claims identification (health insurance) are topics that were not detected during the course of the literature research for this study. Generally, key clusters were related to vehicle, health, and property insurance and were mostly based on the applications of smart sensors and AI. Interviews with InsurTech experts confirmed the results and enhanced some of the technology-oriented interpretations. The patent analysis revealed that telematics is being continually developed and smart meters are important new focus areas, which have great potential. Experts agree that future trends are hard to identify as the related technologies are developing rapidly and possible regulations cannot be anticipated. However, it is worth mentioning that the developments, especially in smart devices and AI, are the key to the technological acceleration of InsurTech.

Conclusions

This study complements the existing research in the field of insurance technologies by outlining the current landscape and identifying future trends through a patent analysis. The current literature about InsurTech has reviewed and described various areas, such as telematics, wearables, and fraud detection approaches. However, our study extended the current findings with regard to the InsurTech application areas and developments using patent data. As the underlying quantitative analysis complements the existing research, a comparison with currently identified key areas was undertaken. The major trends identified in recent years match the statements from the examined research and expert opinions, collected through the interviews. With regard to this, the following trends were identified: claims processing, health insurance technologies, vehicle insurance technologies, automated processes, and smart devices. An examination of the patent applications in this field showed rapid redevelopments with regard to the applications of smart devices and AI. These are mainly being employed in relation to security systems of smart homes, location tracking, and object recognition applications.

Identifying the key players during the patentometrics analysis and interviewing experts revealed that large insurance enterprises located in the US are the main actors in the field, led by the Hartford Fire Insurance Company (US). However, a separate analysis showed that companies from other countries (Korea in this case) can rise to the top three countries with regard to the number of filed and granted patents. As can be seen in our results, even though the insurance sector is a low-tech environment, the majority of the innovations and R&D activities resides within the insurance sector and is based on insurance firms.

To detect possible future trends, patent applications were analysed, generating five main trends. Based on the patentometrics results and the expert views, we identified future directions especially in property insurance, usage-based insurance products, smart contracts, the usage of insurance integrated smart sensors, and the advanced application of artificial intelligence. Some major developments should be pointed out as they represent not further developments of existing patents but rather new topic areas. These are face recognition (vehicle insurance), health monitoring through mobile devices (health insurance), and the calculation of claims requirements (automated processes). According to the experts

interviewed, chat bots are currently a highly relevant topic and are therefore worth investigating as well.

Generally, there are some limitations of the underlying study, which should be discussed. Firstly, the necessary knowledge for patentometrics is not on an expert level as this would extend beyond the scope of this study. Therefore, the quality of this data set could be enhanced when the knowledge base is larger. Furthermore, abstracts were not included in the patent analysis, which introduced the danger of overlooking related patents or including unrelated patents, even though the data set was cleaned thoroughly. Moreover, there are no specific patent codes related to InsurTech. This fact complicated the creation of the search query and might have affected the quality of the data set negatively. Another limitation is related to the sample size, which is rather small due to the very time-consuming creation of the search query.

Finally, the underlying study might motivate authors to perform additional research in the field of InsurTech. Including cross-language mining could result in a more holistic analysis. Moreover, increasing the sample size and the knowledge base might present further smaller focus areas in the field. Analysing start-up enterprises and possible collaborations might add another perspective on the topic as well. Recapitulating the findings from this technology-specific analysis, the results indicate that the InsurTech industry is a rapidly growing, steadily developing, and possibly disrupting young market with several promising inventions that go hand in hand with the rapid technological development.

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