

How Advanced Technologies Shape the Insurance Market: Statistical Insights at the European Union Level

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Abstract. *Considering the changes caused by new technologies and the significance of insurance field for the economy, the objective of this research is to highlight how advanced technologies and innovations influence the insurance market, through econometric analysis at the European Union level. The research methodology consists of applying Bayesian network analysis, through Gaussian Graphical Models, based on data collected for the period 2013-2022. The variables include indicators both from the insurance market and from the field of new technologies, digital transformation and innovation. The research suggests that that there is a connection between digital transformations, new technologies and the insurance market, and the relationship between these variables is complex, with both favorable and unfavorable connections between the analyzed variables.*

Keywords: digital transformation, European Union, innovations, advanced technologies, insurance development.

Introduction

Advanced technologies have reshaped various industries, including the insurance market. How technological evolution can revolutionize traditional activities can also be seen within the insurance industry. Artificial intelligence, data analytics and blockchain have reshaped various aspects of insurance, such as better risk assessment, customer price personalization, improved underwriting processes, and easier communication between stakeholders (Şendrea, 2022).

Improvement in insurance companies' practices, based on advanced technologies, has facilitated the collection and analysis of large amounts of data, allowing insurers to better assess risks and personalize services for individual customers in real time (Wang, 2019). This has led to the development of innovative technologies for the global insurance industry, such as those implemented by Applied Systems, which provide cloud-based insurance software techniques and agency management systems (Tunnecliff, Hayer, 2023).

In the context of the insurance market in the European Union, the digital transformation of the insurance industry is evident as technological innovations influence the way insurance products and services are offered. The insurance market, an important player in the European Union (EU) financial market, is characterized by a high degree of concentration and use of digital technologies (Barinov, 2020) that have revolutionized the way insurance products are sold and delivered. Insurtech companies, which use innovation and technology to deliver customer-centric solutions, have emerged as new entrants to the market and are forcing established insurance companies and brokers to compete in this digital ecosystem (Sosa, Montes, 2022).

Overall, advanced technologies have the potential to dramatically change the insurance market by increasing accessibility and personalization for both insurers and customers (Revathi, 2020).

The general objective of this article is to highlight the need for digitalization and innovation for insurance sector, examining how technology has been implemented and how it influences processes within the insurance sector, at the level of the EU Member States between 2013 and 2022. Overall, through an in-depth review of existing literature and analysis of data, the aim of this research is to uncover the complexity of technological progress, obstacles and perspectives that characterize the European insurance sector. By applying graphical models in data analysis, the research aims to identify connections and interdependencies between different indicators of interest of advanced technologies and insurance, providing complex information about the progress of the insurance sector in EU Member States and how technologies are revolutionizing this sector. Thus, the hypothesis of the research is the following: digital transformation, new technologies and innovation impact the social insurance sector, influencing their trend and evolution, with both types of connections, favorable and unfavorable.

While the analysis highlights the potential of technology to shape the insurance sector and how these changes affect member countries, it aims to highlight the existence of challenges that can hinder technological progress within the EU.

The structure of the paper comprises a brief literature review, presenting ideas about the insurance market, digitalization, digital transformation and innovation, synthesizing evolutionary perspectives of the adoption of these technologies. This section summarizes current trends in the field, existing challenges and opportunities, providing a basis for the analysis within this article. Also, a systematic presentation of the methodology is provided by presenting the indicators used in the study, highlighting the importance of the models applied in clarifying the relationships within the analysis.

Afterward, a presentation of the results obtained from the analysis of data on which Gaussian graphic models were applied is made in order to investigate the dynamics of the evolution of advanced technologies in the insurance sector. This analysis will reveal complex graphical models and interdependencies that underline the digital transformation of the industry.

Finally, the results obtained from the literature and data analysis are concluded, highlighting the importance of the evolving relationship between advanced technologies and the insurance sector within the European Union, but also the impact of these relationships on society. For a clear understanding, at the end of the paper we have inserted additional information as an appendix.

Literature review

In order to understand the evolution of advanced technologies in the EU insurance sector, a critical review of existing literature is necessary. This facilitates the understanding of how modern technologies are essential for smooth operation and at the highest level of the entire insurance sector.

The insurance sector is a very important part of the economy of any country, whether we are talking about the income it brings, referring to gross insurance premiums or about the coverage of risks affecting both individuals and legal entities. According to the opinion of the authors, insurance enhances the economic growth and sustainable development through the contribution at

Gross Domestic Product (GDP) creation, supporting capital markets, with manifold implications in people's social life (Cristea et al., 2014; Cristea et al., 2022).

In order to measure and analyze the insurance market, it is used the following indicators: penetration degree and density insurance. Insurance penetration degree presents the share of gross written premiums in Gross Domestic Product (GDP), over a year and the density of insurance for the total market is calculated by reporting the value of gross written premiums to the number of inhabitants of a country (Cristea et al., 2014).

According to Johansson and Vogelgesang (2016), by 2025, it is estimated that 25% of insurance activities will be automated with the help of artificial intelligence, thus the entire insurance sector will change significantly. This transformation addresses existing challenges, from shortening terms and conditions for customers to collecting real-time data. Therefore, technological advances will automate the entire insurance sector in the European Union in the coming years.

As far as the insurance sector within the EU is concerned, it has witnessed the development and integration of different technologies.

According to Cummins and Rubio-Misas (2022) the insurance sector has become more efficient and digitally advanced, with a reduction in the technological gap between countries within the EU. It notes that reducing the technological gap between EU countries suggests a more uniform adoption of technological solutions. The study provides an in-depth insight into the beneficial impact of advanced technologies, but critical analysis is needed on efficiency progress, potential disparities between member countries in adoption rates and competitiveness in the insurance sector.

The implementation of ethics and uniform adoption of advanced technologies signifies a critical stage of change in the EU insurance sector, with a major impact on the dynamics of member countries and reshaping the structure of the market. Barinov (2020) contributes to the understanding of the EU insurance market by highlighting the high degree of concentration within the industry.

Privacy and discrimination concerns emerge as significant challenges, requiring a delicate balance between reaping the benefits of big data and protecting consumer rights (Simon et al., 2023). Porrini (2017) realized a review of the EU insurance sector focused on the use of Big Data, a key aspect of digitalization that has redefined risk profiling and competitiveness. While the integration of Big Data analytics has undeniably improved industry practices, Porrini (2017) raises a crucial concern about the need for regulatory action. This study highlights the dual nature of Big Data – both a catalyst for innovation and a source of regulatory complexity.

The EU insurance sector is therefore significantly evolving, driven by the incorporation of modern technologies. The use of artificial intelligence, digital platforms and applications is significantly reshaping the insurance sector in the EU. These advanced technologies have profound influence on operational processes, analyzing data, assessing risk, and streamlining risk management, as Mullins et al. (2021) noted. Also, the rapid deployment of advanced technologies raises concerns over the entire sector. Kelley et al. (2018) warns of potential negative consequences, including the prospect of job elimination and an increased risk of social inequality, stresses the need for introspective policies and strategies to mitigate the negative effect of technology on employment and social equity.

Data and Methodology

Simultaneously with literature review, the article addresses a data-driven analysis with the aim of discovering aspects of the influence of modern technologies in the insurance sector in the EU.

Using information from official reports and statistical data, the article presents a broad perspective of the current state of technological integration within insurance fields.

The study used annual data from 2013-2022 for the EU countries, obtained from the Eurostat (European Commission, 2023) and SwissRe (Sigma Research, 2023).

The variables used were: GBARD by socioeconomic objectives (NABS 2007 - Nomenclature for the analysis and comparison of scientific programmes and budgets), employed persons with ICT education, Share of R&D personnel and researchers in total active population and employment, percentage of the ICT sector on GDP; Global Innovation Index (World organization of intellectual property – WIPO (2023), Insurance density total as a premium per capita, Insurance penetration total as a percentage of gross domestic product.

The research methodology consists in applying of Gaussian graphic models (GGMs). The use of Gaussian graphical models (GGMs) provides a framework for modeling conditional dependencies between specified variables.

Table 1 contains descriptive statistics of the variables used in the model applied, GGMs. The variables used in Table 1, as acronyms, refer to the following indicators:

- GBARD: Government budget allocations for R&D (Research&Development) by socioeconomic objectives (% of GDP, data collected from Eurostat);
- E_ICT_Ed: Employed persons with ICT (Information and communication technology) education by educational attainment level (% , data collected from Eurostat);
- R&D_Personnel: Share of R&D personnel and researchers in total active population and employment (% , data collected from Eurostat);
- IP_Tot: Insurance penetration for total insurance market (% of GDP, data collected from SwissRe Institute, Sigma Research);
- ID_Tot: Insurance density for total insurance market (USD/capita, data collected from SwissRe Institute, Sigma Research);
- ICT_GDP: Percentage of the ICT sector on GDP (% of GDP, data collected from Eurostat);
- GinnI: Global Innovation Index (0-100, data collected from World organization of intellectual property – WIPO).

The methodology applied is based on the Bayesian network analysis, by applying two models, namely Gaussian Graphical Models (GGM) and Gaussian Copula Graphical Models GCGMs.

Table 1. Descriptive statistics of the variables used in the econometric model

	GBARD (% of GDP)	E_ICT_Ed (%)	R&D_Personnel (%)	IP_Tot (% of GDP)	ID_Tot (USD/capita)	ICT_GDP (% of GDP)	GinnI (0-100)
Valid	270	270	269	257	239	157	243
Missing	4	4	5	17	35	117	31
Mean	0.541	90.982	1.231	5.153	2264.650	4.336	48.765
Std. Deviation	0.237	122.866	0.519	2.828	1921.614	1.200	7.286
Minimum	0.120	3.000	0.290	1.090	107.400	1.990	35.600
Maximum	1.120	581.800	2.420	12.600	7746.000	8.130	63.800

Source: authors' contribution based on analysis in JASP.

Results and discussions

The results of the network analysis based on Bayesian Network Analysis by applying both the Gaussian Graphical Model – GGM (Figure 1, Appendix, Table A1 and Figure A1) unveiled valuable insights within the European Union (EU) countries.

Specifically, it was revealed that insurance penetration to Gross Domestic Product (IP_Tot) within the EU countries is favorable connected with the contribution of the Information and Communication Technology (ICT) on GDP (ICT_GDP) and with the share of R&D personnel and researchers in total active population and employment (R&D_Personnel). While similar results were obtained by Bayar et al. (2023), it's crucial to note that their research focused on the relationship between information and communication technologies (ICT % of population) and insurance sector development (insurance company assets to GDP).

Opposite, there exists an unfavorable connection between insurance density (ID_Tot) and contribution of the ICT sector on GDP (ICT_GDP). Also, contribution of the ICT sector on GDP (ICT_GDP) does not have favorable relations with various indicators, such as employed persons with ICT education by educational attainment level (E_ICT_Ed), the share of R&D personnel and researchers in total active population and employment (R&D_Personnel) and with the Government budget allocations for R&D (GBARD).

On the other hand, the results unveiled a significant association between the Global Innovation Index (Ginni) and several key variables. Firstly, it observed a positively relationship with the contribution of the ICT sector on GDP (ICT_GDP) and with the share of R&D personnel and researchers in total active population (R&D_Personnel). These results are similar with those observed in previous research by Billon et al. (2017) and Preda et al. (2016), which have demonstrated positive connection of Global Innovation Index (Ginni) with information and communication technologies (ICT) and with the total research and development (R&D).

Additionally, the results indicated association of Global Innovation Index (Ginni) with the Government budget allocations for R&D (GBARD) and with the employed persons with ICT education level (E_ICT_Ed).

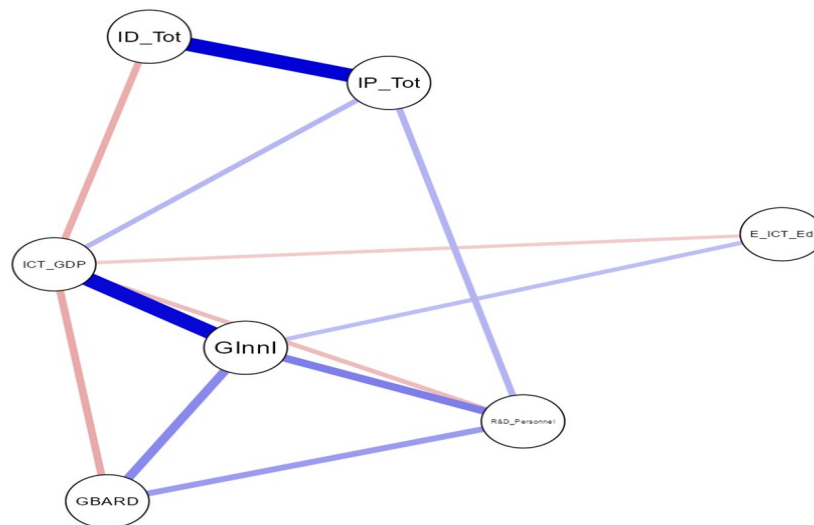


Figure 1. Bayesian Network Analysis results by applying the GGM, 2013-2022

Source: Authors' own research results/contribution in JASP.

As regards the results obtained by applying the Gaussian Copula Graphical Models - GCGMs (Figure 2, Appendix, Table A2 and Figure A2), insurance density (ID_Tot) was observed to be positively connected with the Global Innovation Index (GinnI) and with the share of R&D personnel and researchers in total active population and employment (R&D_Personnel), which also has a positive connection with Government budget allocations for R&D (GBARD). Moreover, a favorable connection was discerned between insurance penetration to GDP (IP_Tot) and Global Innovation Index (GinnI). This finding is supported by those of Bertoni and Croce (2011), which suggests a strong relationship between innovation and insurance and predicts that innovation can improve growth, leading to increased productivity in best performs, predominantly technological transformation in five European Union countries, based on data of life insurance companies. These statements can be correlated with the results in this article, even if it investigates the correlation between innovation and insurance within the insurance companies.

In contrast, the results revealed an unfavorable connection between insurance density (ID_Tot) and contribution of the ICT sector on GDP (ICT_GDP). Unfavorable relationships can also be observed between contribution of the ICT sector on GDP (ICT_GDP) with Government budget allocations for R&D (GBARD) and with the employed persons with ICT education level (E_ICT_Ed). These results are in line with those of Lindmark et al. (2018), which addresses the disparity between the lower R&D intensity in the EU's ICT sector, particularly in certain sub-sectors and related data from the United States.

The results from this study offer valuable insights into the complex economic connections between EU countries, particularly the relationships between insurance indicators and key measures of technological advancement and research activity.

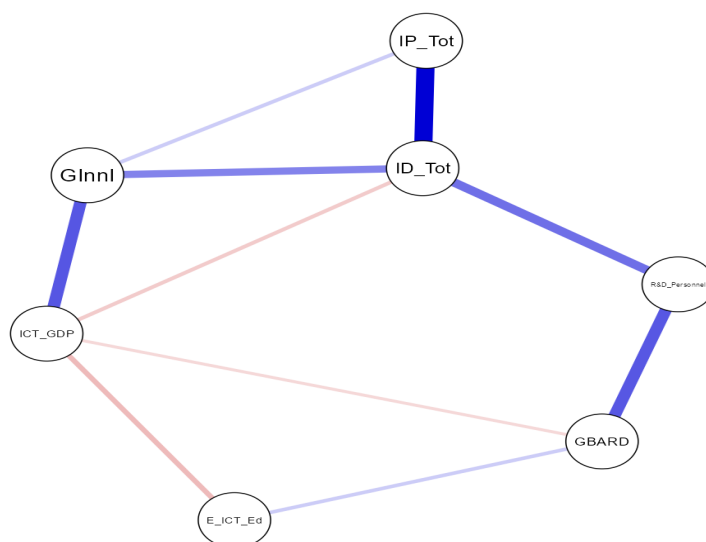


Figure 2. Bayesian Network Analysis results by applying the GCGM, 2013-2022

Source: Authors' own research results/contribution in JASP.

Conclusion

This article analyses the complex relationship between advanced technologies, digital transformation and the European Union (EU) insurance sector. Using Bayesian network analysis, specifically Gaussian graphical models (GGM and GCGM), relevant connections were obtained,

highlighting the links between various variables covering the insurance sector, technological innovation and economic indicators. The results obtained highlight the impact of digital transformations and new technologies on the insurance market, showing both favorable and unfavorable connections between the variables analyzed. One of the limitations of our research is that the data for certain years are missing for some of the countries analyzed.

These findings provide valuable input to policy makers who play a crucial role in establishing regulatory frameworks that promote sustainable innovation, protecting the interests of stakeholders and the smooth functioning of the entire sector, and also to researchers looking at the future of insurance in the context of the economy's ability to receive the benefits of technologies. By adopting advanced technologies within the insurance sector, new opportunities for growth, efficiency of operations in the insurance sector are benefited from and a model of innovation applicable in an increasingly digitalized economy can be achieved. Thus, the hypothesis is fulfilled due to the analysis of the indicators that show us both favorable and unfavorable links and connections between advanced technologies and the insurance sector.

In order to prosper with these changes and to thrive in a dynamic landscape, participants in the insurance sector must implement technological transformations, and in the current context, strategic investments in technology adapted to the workforce and collaborations with IT developers are needed. Thus, understanding the relationship between technology, innovation and the insurance sector is becoming increasingly necessary for the proper functioning of the economy in the EU and beyond.

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Appendix

Table A1. Evaluation of centrality measures on variables within the GGM (2013-2022)

Variable	Network			
	Betweenness	Closeness	Strength	Expected influence
GBARD	-0.730	-0.358	-0.493	-0.450
E_ICT_Ed	-0.730	-1.504	-1.649	-1.053
R&D_Personnel	-0.337	0.458	-0.094	0.066
IP_Tot	-0.337	-0.494	0.129	0.926
ID_Tot	-0.730	-0.501	-0.296	-0.242
ICT_GDP	1.235	1.082	1.340	-0.944
GInnI	1.628	1.317	1.062	1.696

Source: Authors' contribution based on analysis in JASP.

Table A2. Evaluation of centrality measures on variables within the GCGM (2013-2022)

Variable	Network			
	Betweenness	Closeness	Strength	Expected influence
GBARD	-0.638	-0.445	-0.404	-0.148
E_ICT_Ed	-0.981	-1.778	-1.613	-1.369
R&D_Personnel	0.049	0.488	0.049	0.401
IP_Tot	-0.981	-0.032	4.619×10^{-4}	0.360
ID_Tot	1.766	1.350	1.769	1.258
ICT_GDP	0.049	-0.286	-0.101	-1.277
GInnI	0.736	0.704	0.300	0.776

Source: Authors' contribution based on analysis in JASP.

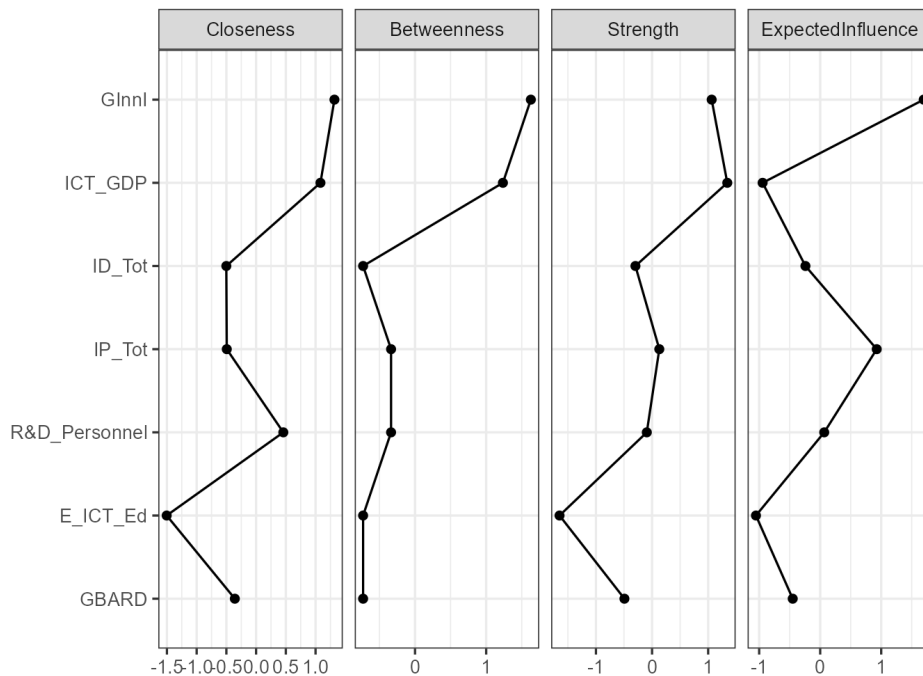


Figure A1. Graphic representation for centrality measures within the GGM (2013-2022)

Source: Authors' contribution based on analysis in JASP.

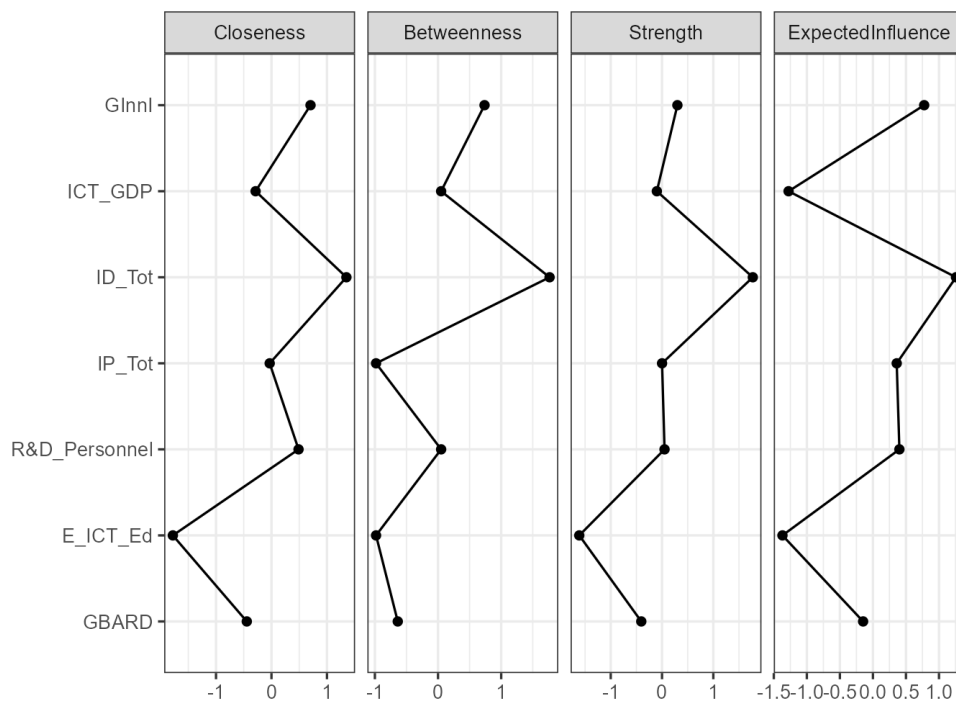


Figure A2. Graphic representation for centrality measures within the GCGM (2013-2022)

Source: Authors' contribution based on analysis in JASP.