Assessing Total Factor Productivity for Insurance Companies in Saudi Arabia Using DEA-Malmquist Approach

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Abstract

The present study measures the changes in both productivity and efficiency of insurance companies working in Saudi Arabia. To this end, the non-parametric frontier method Data Envelopment Analysis (DEA,) combined with the Malmquist index was employed to measure changes in productivity and efficiency of 26 Saudi insurers over the period 2019-2022. The study revealed that the changes in total productivity during the period is mainly imputed to the technological component. This increase was caused by a technological progress. But, the study raised a deterioration of the technical efficiency component for some insurers (10 companies). This result can be explained to a lack of managerial expertise and, in particular, poor resource management, which resulted in a decline in technical efficiency. Furthermore, the results revealed that the technological component, referring to the efforts made by insurers in terms of innovation, is more encouraging than those provided at the level of technical efficiency during the studied period. Finally, our study revealed that Saudi insurers can improve their practices and governance by introducing new innovative methods enabling an improvement in managing and governing more suitable the use of inputs to produce more outputs and to improving productivity of Saudi insurers.

Keywords: Saudi Insurers, Productivity Changes, Technical Efficiency Changes, Technological Progress, DEA, Malmquist Index.

Introduction

Currently, the growth of any economy basically depends on the strength and efficiency of its financial system. In the same way, the management of each company continuously strives to improve its performance, particularly concerning its efficiency and productivity.

Efficiency, in particular, is a concept that has gained increasing attention in recent years. The primary players in the financial system, especially insurance companies, are interested in this idea since it would increase their competitiveness in the market and improve their managerial abilities in terms of resource optimization. Efficiency is defined as an insurer's capacity to generate the maximum of outputs with a certain level of inputs, or, conversely, to generate a given quantity of outputs with the least amount of resources (inputs) (Koopmans (1951)). Numerous studies conducted in various nations and areas over the past few decades have examined the efficiency of insurance firms (Cummins and Weiss (2013), Cummins and Xie (2013), Cummins and Rubio-Misas. (2022)…..), . Efficiency frontiers, which compare a company's performance to a frontier made up of the most efficient businesses in the market, are the most widely used contemporary techniques. One of the most popular non-parametric techniques for evaluating and contrasting insurance firms' efficiency is data envelope analysis, or DEA. However, research on the efficiency of insurers in Saudi insurance industry is scarcer.

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Although it is still in its infancy in comparison to many industrialized nations, the insurance industry in Saudi Arabia has experienced considerable development and improvement over the past ten years. This is because the market is highly competitive and has a very low insurance penetration rate (varies between 0.7% in 2011 and 1.22% in 2022 with a maximum 1.5% in 2016) when compared to the neighbors' countries (e.g., 2.6% for UAE, 2.1% for Jordan, 1.7% for Bahrain). Even in terms of insurance density, Saudi Arabia had the lowest one with 299 in 2022, but in the same year UAE, Qatar and Kuwait had recorded 1305, 584 and 352 respectively.

Additionally, the region's insurance market suffers a number of obstacles, including low financial literacy and the underdeveloped financial sector, all of which put these financial institutions under a lot of competitive pressure right now (Suter et al. (2012)). In addition, Saudi insurers are also impacted by political, economic, and regulatory changes. Thus, the difficulties and aforementioned modifications may make it more difficult for insurance companies to carry out their responsibilities, which include bolstering and assisting the financial sector and promoting investment and capital formation that are essential to the general growth of the economy.

Furthermore, at the religious level, the demographic characteristics associated with the organizational and societal culture in the region may make it more difficult for insurers to operate effectively and notably have a big impact on how much insurance is used there. This explains the recorded a low level of insurance density (299 in 2021 and 273 in 2020).

The several unique characteristics of Saudi Arabia encourage us to look into the performance of the Saudi insurance market and serves as a reminder of the significance of evaluating and contrasting Saudi insurers' performance not only in terms of productivity change but also in terms of efficiency change. These two metrics are, in reality, the primary markers of internal management success and the primary areas that insurance companies aim to enhance. Therefore, by trying to maximize the usage of inputs in the production process, the industry can respond to the specificities of the market. This process is considered necessary to enhance the overall performance and competitiveness of the insurance industry, which has fallen short of expectations and is comparable to that of the most developed areas.

This study analyses and compare the performance of Saudi Arabia's insurance carriers in term of productivity and efficiency.

To measure efficiency levels, the study employs the mathematical programming technique, the Data Envelopment Analysis (DEA) methodology, first proposed by Charnes et al. (1978) to compare a group of insurance companies under various assumptions (CRS or VRS). To examine changes in productivity and efficiency over a given period of time (2019-2022), we shall integrate the DEA approach with the Malmquist index. In order to use our approach, a set of inputs and outputs that describe the organizational and financial aspects of insurers must be integrated. Thus, the Malmquist index can be used to measure changes in production. generally associated with advancements in technical efficiency and technology.

To the best of our best knowledge, this research paper is the first to assess changes in productivity and their two components (technical and scale efficiency) associated with Saudi insurance companies.

The paper is structured as follows: section 2 outlines the theoretical framework that serves as a reminder of the primary ideas covered in this article, namely efficiency and productivity. The significance of evaluating the productivity and efficiency of Saudi insurance companies (i.e.,

challenges, the role of managers and related aspects) is discussed, as along with the contribution made by this study. Furthermore, a literature revue addressing total factor productivity change and its components, presented in previous publications, is provided. Section 3 outlines the main variables selected for empirical investigation and the employed methodology. The findings and their interpretations are presented at the conclusion of this study.

Theoretical Context

Performance, Productivity and Efficiency

The concept of performance is too vague, intricate, and challenging to describe. In fact, it is regarded as a multifaceted idea that encompasses other concepts like productivity, efficiency, and effectiveness. In order to assess an organization's degree of success, the concept of performance is far more frequently utilized in literature than in organizational settings. However, according to Bourguignon (Bourguignon (1995)), the term "performance" is widely used in management science and can represent one of three things: activity, the outcome of an action, or success. The accomplishment of organizational goals is identical with performances, as the author also reminds us. Performance is now linked to efficiency in the field of organizational management since it is associated with attaining results while taking into account the resources used and the efforts made to obtain them. The term "performance" as it relates to organizational management has been defined by a number of authors since the middle of the 20th century (Steers (1975); Sink (1985), among many others). Effectiveness, efficiency, and productivity are the three primary components that make up the performance idea. The focus of this study is on the concepts of efficiency and productivity and their variations over time, which will be measured using frontier efficiency method, the non-parametric approach, DEA. However, it is vital to differentiate these two notions by offering the definitions that are integrated into organizational management.

First, economists acknowledge that one of the primary drivers of an organization's growth is productivity. This idea is also referenced while discussing overall productivity, which ties resources (inputs) to production (outputs) in physical or monetary terms. As is the case in the insurance sector, a company can position itself in comparison to rivals in a specific market by measuring the quantity of production components employed for a given output and in reference to a set of decision-making units. An organization's productivity rises as it produces more outputs with fewer resources. This concept can appear to be comparable to that of efficiency, which focuses more on the caliber and manner in which resources are employed for a certain production. Lindsay (1982) asserted that an organization's productivity is typically measured over a longer time span than its efficiency. Furthermore, Harold and al (2008) also explored the difference between productivity and efficiency, indicating that productivity stressed the quantity of outputs generated measured by the amount of resources consumed by one or more units. As for efficiency according to these authors, it emphasizes the quality of the production process, thereby determining how resources are used.

Efficiency is defined as "the success of an organization in producing the maximum possible outputs from the available resources." Farrell (1957) was the first to empirically study the concept, while Koopmans (1951) was the first economist to mention it. Efficiency is the ability of a production unit to produce a fixed quantity of output with a minimum of resources, or to maximize the quantity of outputs with the available inputs. He then suggested a disentangling economic efficiency into "technical efficiency" and "allocative efficiency". The first pertains to obtaining the maximum outputs from a given quantity of accessible resources. The best use of

inputs while accounting for their costs for a specific (fixed) level of output is known as allocative efficiency.

Measuring Changes in Productivity and Efficiency of Saudi Insurance Companies

The ability of these companies to generate a set of outputs, represented by insurance premium income and investment income, which is the result of using a set of factors or resources (inputs) represented by general and administrative expenses, capital, claims paid and other inputs that can be taken into account, is what it is meant by efficiency in the context of insurance.

Technically, a firm is efficient if it only uses the fewest resources possible and optimizes them while maintaining a constant level of outputs (input-oriented), or if it maximizes outputs while maintaining the same amount of inputs (output-oriented). As a result, an insurer's technical inefficiency can be attributed to either a scale inefficiency (Farrell (1957)), which is the result of either too big or too small enterprises, or a purely technical inefficiency brought on by a lack of managerial expertise in resource management.

Traditional techniques like the financial ratio method, which includes the solvency ratio, return on assets ratio, or claims ratio (which shows the amount of losses or claims paid out over a given year compared to the amount of premiums issued), are used to gauge how effective insurance companies are. However, because they only evaluate the performance of a single company and not a group of enterprises simultaneously (Benchmarking), these approaches have drawbacks when it comes to assessing performance in terms of efficiency. Moreover, they prevent the identification of best market practices in terms of governance. It should be mentioned that the approach does not take into account the homogeneity of the units (i.e., insurance companies) to be investigated. Lastly, traditional ratios cannot identify the reasons behind inefficiency.

Hence, more recent techniques and methodologies compare the units in the sample using efficiency frontiers to gauge their efficiency. These approaches have features that do, in fact, get around the mentioned drawbacks of conventional approaches. Modern methods involve parametric and non-parametric approaches that allow for the identification of the best companies (known as best practice) in terms of efficiency. The set of these companies forms what is called "the efficient frontier," which contains only the most efficient companies or decision-making units (DMUs) in the studied sample. Therefore, the insurance companies that are below the frontier are the companies that exhibit inefficiencies and will need to take further corrective measures to improve their performance.

In terms of the parametric approach, the stochastic frontier approach (hereafter, SFA method) is the most popular and widely applied technique in management science. This approach uses a production, cost, revenue or profit frontier function to ascertain the structural links between various inputs and outputs. Although it includes usual error term (for example measurement mistakes), the SFA approach has several drawbacks. In fact, efficiency can be mistaken for measurement mistakes, for instance, if the parametric functional form is not well specified can lead to erroneous results.

However, non-parametric approaches, like the Data Envelopment Analysis (DEA) method proposed by Charnes et al (1978), employ linear programming to construct the efficient frontier without imposing a specific functional form as in the case of parametric frontier approach. It is true that errors brought on by a poor selection of a production function can be avoided by not specifying the functional form. Therefore, the most efficient units (DMUs) are those with the highest technical efficiency ratings as determined by programming resolution. Yet, and against

the parametric production function, the DEA methodology does consider a wide range of inputs and outputs in the analysis (in the case of parametric production frontier, we only uses one output and several inputs). Lastly, it makes it possible to use the Malmquist index, which is the DEA method extension modified over time, to measure changes in productivity and efficiency.

In fact, the Malmquist index enables the measurement of productivity changes for a group of DMUs while accounting for the technical efficiency and technological progress (regress) of the relevant industry (the insurance sector) (Coelli (1996)). It enables the measurement of productivity increases (decreases) across several firms. According to Färe et al (1994), the index thus has the unique ability to measure changes in productivity over time by breaking them down into changes in technical efficiency and changes in the technological progress (regress) of the industry.

Studying the Changes in Productivity and Efficiency of Saudi Insurers: State of the Art

An important factor in the growth of the financial and economic sectors in Saudi Arabia is the insurance industry. Currently, all segments of Saudi society enjoy great protection and support from the insurance sector. Conversely, insurance encourages investment by mitigating the risk of losses, and helps achieve stability and sustainability in all sectors. However, the fierce competition in the insurance industry and the pressures resulting from economic and social changes make it difficult for the industry to operate in the optimal way, especially when it comes to supporting the financial and economic system.

Even if it is low compared to other countries, the penetration rate of the insurance market in Saudi Arabia is nevertheless very promising and has not yet reached its peak. In fact, according to STATISTICA, the maximum of insurance penetration was recorded in the UAE (2.6%) during 2022, but in Saudi Arabia was equal to 1.3%. This percentage is still modest when compared to the most developed regions in the world or even to some neighboring countries (e.g., UAE and Bahrain). The financial sector in Saudi Arabia has been undergoing a period of modernization and transition for a few years. This period is marked by new laws and reforms that address the internal management practices of insurance companies, the most significant of which is the creation of the Insurance Authority. At the same time, the kingdom is experiencing the effects of technological progress and the rapid acceleration of international economic exchanges. Because of its influence on economic growth, Saudi Arabia has thus recognized the significance of creating and growing the insurance sector, which is regarded as a key tactic in the Kingdom's Vision 2030.Therefore, one strategy to improve this sector is to increase the efficiency of insurance sector. This is supported by the Vision 2030 initiative, that has been placed to put emphasis on the development of the insurance industry in the kingdom. This is due to their belief in the importance of the insurance sector in economic growth.

The ability to reduce the resources utilized in the process of production-which primarily comprises the income gained from issued premiums, placements and investments made-is, in fact, necessary to increase the efficiency of insurers. The purpose of this study is to evaluate the change in productivity and efficiency of the Saudi insurers. Thus, the objective is to estimate the changes in efficiency and productivity over a four-year span (2019-2022). Besides, changes in total factor productivity can be disentangled into changes in technical efficiency and changes in technological progress using the Malmquist index proposed by Färe et al. (1994).

The Saudi's insurance companies' resource management and, consequently, their unique managerial techniques are the main target of performance improvements. Regarding technical

advancement, it measures how well companies can develop and apply new strategies, tactics, and processes in the intermediation process between insurers. However, advancements in technology also reveal how well insurers are able to utilize the technological environment in which they operate.

Literature Review

Given that there is, to the best of the author's knowledge, no paper dealing with total factor productivity in the Saudi insurance industry, the present study represents the main contribution to the existing literature.

So, a worldwide literature review dealing with productivity and efficiency changes in insurance industry is provided.

Many studies conducted in various nations and areas have focused on measuring improvements in the insurance industry's productivity and efficiency. However, newer research measures changes in insurance company productivity using frontier methodologies. Below a review is provided of previous studies that have addressed the measurement and analysis of productivity and efficiency changes using the non-parametric technique (DEA) and the Malmquist index.

Donni et al. (1997), used the DEA-Malmquist approach to quantify productivity improvements after analyzing the performance and efficiency of insurance companies in OECD nations. According to their findings, insurance companies' average efficiency is 70%. This implies that in order for businesses to reach their maximum efficiency, their efficiency level must rise by 30%. Furthermore, they discovered that technological developments in the industry drove the productivity evolution of insurers in the region between 1983 and 1991 more so than shifts in technical efficiency. This explains the insurers' dynamism and innovation efforts during that time.

However, the study by Mahlberg and Url (2003) looked at how Austrian insurance firms' productivity and efficiency changed from 1992 to 1999 following the country's 1994 adoption of the European Single Market. Their findings showed that, on average, production increased by 10% during the course of the study; the authors credit this improvement more to advancements in technical efficiency than in technology.

Additionally, the productivity of Portuguese insurance companies following the 1994 implementation of the European single market was examined by Barros et al (2005). Using the DEA-Malmquist method, the authors obtained findings that demonstrated that over 70% of the enterprises under study had a gain in productivity, primarily as a result of the technological element that the companies displayed following the adoption of the single market.

On the Asian side, we highlight the research conducted by Norma and Nur Edzalina (2011), which used the DEA-Malmquist approach to analyze the productivity change of life insurance firms in Brunei and Malaysia. With an average growth of 2.8% and 1.2%, respectively, the authors' findings showed that improvements in technical efficiency and industry advancement are what drive productivity growth in both nations.

Conversely, Al-Amri et al (2012) examined 39 insurers that operate in the GCC countries in order to investigate the performance of insurance companies in Arab nations. Using the DEA-Malmquist method, the productivity results showed that the improved technical efficiency of insurers is the reason for the change in productivity in the insurance sector in GCC countries. This explains why the insurers in the region do not innovate enough or adjust to market demands.

Lastly, Jaloudi (2019) also used the non-parametric DEA method to analyze the performance of insurance businesses in Jordan. Technical efficiency increased slightly from 89% in 2000 to 92.5% in 2016, according to the results. In order for insurance companies in Jordan to reach their maximum technical efficiency, the author suggests recommendations in his study to raise the efficiency levels of Jordanian insurers. He concludes that, generally speaking, equity and debt should drop by 6.33%, technical reserves by 0.85%, and operating expenses by 0.27%.

Methodology

To assess the total factor productivity change in the Saudi insurance sector the non-parametric methodology, DEA-Malmquist method is employed.

DEA, Orientation, Basic VRS Model

The DEA approach is a useful tool to gauge, examine, and contrast the efficiency of insurance companies' operations. According to this technique, results vary between 0 and 100%; a 100% score indicates that the firm (insurance company) has achieved maximum efficiency and is situated on the efficient frontier. However, if a firm receives a score lower than 100%, it will have to work harder to manage its resources in order to perform better.

Two orientations (input orientation or output orientation) can be used to gauge how efficient insurance companies are. Unlike the second, the first concentrates on reducing inputs to increase efficiency.

Distance Function

Either we analyze production or cost function, we can use input or output-oriented distance functions proposed by Fare et al (1985). In our context, we suppose that insurance companies use a vector of m inputs, $x = (x_1, x_2, \ldots, x_m)'$ to produce an $(n \times 1)$ vector of outputs, $y = (y_1, y_2, \ldots, y_n)'$.

The input-oriented distance function for a given insurance companies (generally decision-making unit: DMU) minimizes input consumption conditional on output.

$$D_I(y, x) = sup\left\{\theta : \frac{x}{\theta} \in V(y)\right\}$$

Where,

θ: is a scalar wich is estimated from a radial distance and $V(y)$ is a subset of all inputs vectors which yield at least y.

Last but not least, the constant return to scale (CRS) model and variable return to scale (VRS) model are two fundamental "technologies" for determining the efficient frontier. Assuming that all firms being examined are operating at their optimal sizes and in a market with perfect and pure competition, the first model (CRS) denotes consistent returns to scale. However, in today's financial industry, complete competition is uncommon. Because of this, the CRS model is unable to differentiate between pure technical efficiency and scale efficiency, which are the two main causes of technical inefficiency. Conversely, firms that use variable returns to scale are referred to by the VRS model. Because of this, the VRS model makes the assumption that insurers do not all function at their ideal sizes and that they do so in a market with imperfect competition. Thus, when firms are not operating at their best scale, this approach enables us to pinpoint the

causes of their inefficiencies. For this reason, the VRS model is selected to assess the changes in the efficiency and productivity of Saudi insurers.

Malmquist Total Factor Productivity Index

The DEA method's Malmquist index makes it possible to track changes in firms efficiency over a given period of time. According to Färe et al. (1994), the productivity change index can be broken down into changes in technical efficiency and technological progress (regress). Thus, this paper relates two factors: efficiency and productivity. The efficiency shift (shifting toward the frontier) is technically known as the "catch-up effect", while the technology shift is known as "shifting the frontier". The degree to which insurance companies are moving toward the efficient frontier is known as the "catch-up effect". But, the shift of the frontier during the study era, represents technological progress (technological regress) depending of the shift of the frontier.

In order to solve the shortcomings of the index initially proposed by Malmquist (1953), a number of authors have advocated the decomposition of the Malmquist index, including Ray and Desli (1997), Simar and Wilson (2007) and Färe et al (1994). This study follows the decomposition proposed by Färe et al (1994). The technical efficiency change index and the technological change index are combined to generate the Malmquist index, which has the following arithmetic form:

The input-based Malmquist index is given via:

$$M_I^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \left[\frac{D_I^t(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \times \frac{D_I^{t+1}(y^{t+1}, x^{t+1})}{D_I^{t+1}(y^t, x^t)} \right]^{1/2}$$

Where M describe the productivity inherent to the most recent production point (y^{t+1}, x^{t+1}) using the technology of production used in the period t+1 relative to the production point in period t using the technology of production used in the same period (i.e., period t). D is the input-based distance functions, and I designate CCR input-orientation. In the case where $M_I^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) > 1$, then we obtain an increase of the total factor productivity.

The decomposition of the Malmquist index leads to:

$$M_I^{t+1}(y^{t+1}, x^{t+1}, y^t, x^t) = \frac{D_I^{t+1}(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \left[\frac{D_I^t(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} \times \frac{D_I^t(y^t, x^t)}{D_I^{t+1}(y^t, x^t)} \right]^{1/2}$$

The first part of the equation represents the technical efficiency change index, while the second one in parentheses represents technological change.

Malmquist index = Technical efficiency change x Technological change

Then,

$$\frac{D_I^{t+1}(y^{t+1}, x^{t+1})}{D_I^t(y^t, x^t)} = \frac{TE(t+1)}{TE(t)}$$

Furthermore, according to Färe's decomposition under the VRS model, the technical efficiency change is further broken down into pure technical efficiency change and scale efficiency change. In this case, we have:

Technical efficiency change = pure technical efficiency change x scale efficiency change

The productivity difference between t and t+1 using VRS technology is seen in the following graph. The frontier has a concave shape, and its movement signifies the progress (regress) of industry technology between the two periods (t and t+1). Technical efficiency can change from one period to another since the firm Z in the figure can be efficient at time t but not at time t+1. Technology has progressed between the periods, as evidenced by the figure's shifting frontier.
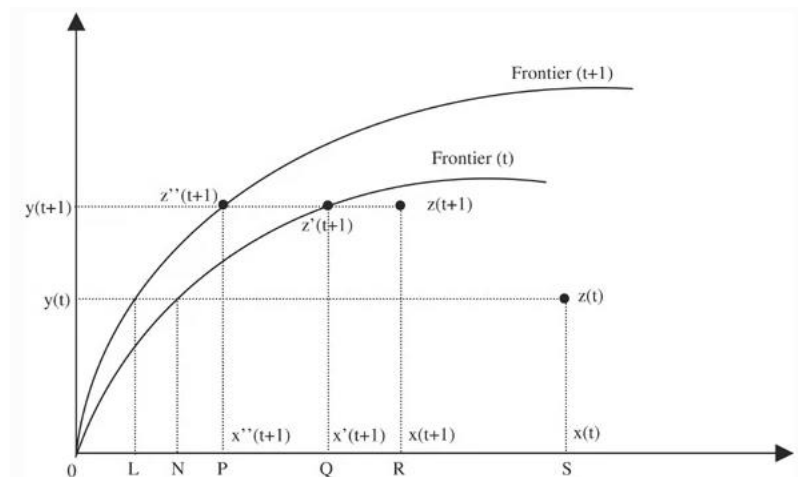

Figure 1: Change in the Malmquist Productivity Index from t to t+1

Source: Barros et al. (2005).

Data, Output/Input Variables

Data

This study uses a sample comprising 26 Saudi insurance companies observed over the period 2019-2022 in order to evaluate the change in productivity and determine its two components (technology changes and changes in technical efficiency). All data were collected from yearly financial reports of the Saudi insurance companies that are publicly published by Tadawil.com.

Inputs and Outputs Variables

The specification of input and output variables is a difficult task when utilizing the frontier approach to measure productivity and efficiency, particularly for financial institutions like

insurance companies. Generally speaking, a distinction is made between the three primary components of production commonly utilized in the literature, which can be summed up as labor and capital. Moreover, outputs are the goods or services created that have the potential to bring in money (Diacon (2001)).

In the financial literature, authors generally adopt two main approaches, namely the production approach and the intermediation one, to determine inputs and outputs of financial firms like banks and insurance companies. (Diacon (2001), Zijiang (2006), Berger et al (1997), Cummins and Weiss (2014) and Robi-Misas (2022)). The definition of input and output variables follows the approach of Diacon (2001), Barros et al (2005), Al-Amri et Al. (2012) and Jaloudi (2019). As a result, the production elements that enable insurers to make money from their investments, placements, and premiums are taken into account. According to Diacon (2001), labor and the capital needed by insurers are normally regarded as inputs that are utilized to produce a single output: premiums. In order to gauge the shifts in the efficiency and productivity of the insurance companies in the sample of the study, the following inputs and outputs have been selected. Inputs include, capital and labor (personnel expense or administrative personnel costs since we do not have the number of employees). Output comprised investment income and premium income.

Main Findings

According to Färe et al. (1994), the input-oriented DEA-Malmquist method is used to estimate the productivity changes and their two components. Furthermore, the sources of inefficiency, namely scale efficiency and pure technical efficiency, can be estimated.

Table 2 bellow shows the mean, by company, of changes in total factor productivity (TFPCH), technological change (TECCH) and technical efficiency change (TECH).

DMU	TFPCH	TECH	TECCH	DMU	TFPCH	TECH	TECCH
1	1.1500	1.0492	1.0920	14	1.3522	1.2024	1.1874
2	1.5627	0.9851	1.5779	15	1.1836	1.0634	1.1922
3	0.9910	0.9453	1.0531	16	1.2963	1.0000	1.2963
4	0.9588	0.9208	1.0706	17	1.0394	1.0000	1.0394
5	0.9425	0.8476	1.1998	18	1.0702	1.0000	1.0702
6	1.4656	1.3333	1.1358	19	0.9567	0.8907	1.1011
7	1.2100	1.0005	1.2046	20	0.9832	0.8609	1.1586
8	1.0455	0.9595	1.0889	21	0.9111	0.8976	1.0377
9	1.0552	1.0022	1.0693	22	0.9748	0.8401	1.2938
10	0.7137	0.7000	1.0182	23	1.1529	0.9444	1.3845
11	0.8603	0.8489	1.0122	24	0.9762	0.9750	1.0011
12	1.3138	1.1711	1.1779	25	1.4601	1.3588	1.0773
13	1.1209	0.9620	1.1750	26	1.5828	1.5374	1.0323

Table 2: Changes in TFP And Their Two Components (Technical Efficiency And Technology).

	TFP	*TECH*	*TECCH*
Average	1.128	1.011	1.144
Min	0.714	0.700	1.001
Max	1.583	1.537	1.578

Table 3: Descriptive statistics of TFPCH, TECH and TECCH

Tables 2 and 3 show that, on average, total factor productivity change index, was 1.128. This means that the KSA insurance sector experienced a gain of productivity of about 12.8%. This result is explained by an amelioration of technical efficiency (1.14%) and a technological progress (14.41%). This interesting result implies that, in mean, insurers were boosted their productivity during the study period, according to an analysis of the scores derived from changes in productivity relative to each company.

Analysis of TFP change according to TECH and TECCH

	TFP < 1	TFP > 1	TECH > TECCH	TECH < TECCH
Number of Companies	10	16	05	21

Table 4: Distribution of Companies According to TFP And Their Two Components,

TECH and TECCH

Table 4 shows that only 38.46% of the sample have demonstrated a decrease of the TFP, with over 84.62% of them putting more effort into creativity than technical efficiency. This explains why the technology advancements made by the organizations over the study time had the biggest impact on improvements in insurance productivity. In fact, it should be mentioned that innovation is seen as a source of success and a driving force for businesses, particularly in a sector that is expanding quickly and is impacted by a wide range of outside influences.

During the study period, the technical efficiency, attributable to internal management and managerial practices. Technical efficiency improved in just 16 insurance companies. However, between 2019 and 2022, 10 companies had a decline in technical efficiency, which was the main cause of the average decline in total factor productivity.

On the other hand, the technological change (TECCH) component indicates that 16 companies experienced an improvement during the period of study. This score indicates that these insurance companies in the sample as a whole worked hard at management and had strong managerial abilities that motivated them to make efficient use of their resources during the production process mainly those related to new technologies.

Analysis of the Total Factor Productivity Change, TFPCH

At a first glance, an interesting conclusion can be drawn: the main source of the total factor productivity change is due to technological change (23 companies among 26 companies). This useful result suggests that the Saudi insurers showed rapid growth due to their focus on improving efficiency through technology-driven operations during the period 2019-2022, but may still be in the process of improving their operational efficiency. This could be the outcome of the industry's strategies of investment in digital transformation and artificial intelligence (AI)

to improve the overall service delivery, risk assessment, and claims management. For example, automating claims processing and using big data to enhance pricing models could drastically improve overall efficiency without needing a significant investment in new technology. Furthermore, claims automation, can lead to faster, more accurate claims handling, improving customer satisfaction while reducing operational costs.

In the case of the insurance sector, the decomposition of total factor productivity Change (TFPCH) into its two components, technical efficiency change (TECH) and Technological Change Component (TECCH), is highly relevant. Actually, the productive efficiency of insurance companies depends not only on the adoption of new technologies (e.g., advanced risk modeling, automation, digital customer service) but also on how effectively these technologies are exploited.

Table 2 above shows the TFP change and their decomposition into technical efficiency change and technological change within the KSA insurance industry over the period 2019-2022. These changes can be imputed essentially to the intensive use of new technologies and the automation of the main insurance's operations, i.e., underwriting algorithms, automation of claims processes, advanced data analytics, and the adoption of InsurTech (insurance technology). Thereby, in the insurance sector, the rise of InsurTech (technology-driven innovations) dramatically reshaped the landscape. Companies that successfully implemented InsurTech solutions, such as artificial intelligence (AI) in underwriting, blockchain for claims processing, and big data analytics, often showed a combination of high TECH and TECCH scores. If a company were able to utilize AI to optimize claims processing and underwriting, it could significantly improve both productivity and efficiency. This approach would likely result in high TECCH and TECH values, similar to the positive results seen in DMU 26.

DMUs with high TECCH (efficiency) but relatively lower TECH growth suggest that some insurance companies were realizing the value of refining operational processes to achieve higher productivity, even in the absence of groundbreaking technological advances. In fact, insurers with moderate technological change but high efficiency gains may be following an incremental innovation path, fine-tuning existing technologies to optimize performance, such as claims automation or automated customer service solutions (e.g., chatbots).

Coughlan & Wooldridge (2021) suggested that in the insurance sector, efficiency gains often follow after technological investments. The key challenge for insurers, however, is that it takes time for the operational benefits of technological change to materialize fully. This is reflected in the slow TECCH improvements for some DMUs in our data. Heshmati (2019) stated that insurance firms that focus on efficiency improvements (via better use of data analytics, process optimization, and customer service automation) see greater gains in TFP than those that focus exclusively on technological innovation. This aligns with the findings in our data, where high TECCH often leads to higher TFP growth.

Studies also noted the challenges faced by traditional insurers when adopting new technologies. Feng & Xie (2020) emphasized the slow pace of technology adoption in some parts of the insurance sector due to legacy systems and regulatory hurdles. This may explain why some DMUs (e.g., DMU 10) show slower technology improvements. But, on the other hand, some studies showed that simply implementing technology did not immediately translate to productivity gains unless there was a complementary improvement in internal processes (e.g., Feng and Xie, (2020)). Barros & De Almeida (2010) showed that productivity improvements in the insurance sector often stemmed from improving operational efficiency rather than solely

relying on new technologies.

Conclusion and Discussion

Using the DEA-Malmquist index, this study examined and quantifies the shifts in technical efficiency and productivity of sample of 26 Saudi insurers over the period 2019 and 2022. Färe et al. (1994)'s decomposition makes it possible to identify the causes of the productivity fluctuations seen during the research period.

The decomposition of Färe et al (1994) made it possible to identify the reasons behind the variations in productivity fluctuations seen during the study period. In fact, there is a 12.8% average productivity increase that appears to be influenced by both the technological change and the shift in technical efficiency at the same time. In order to position themselves on the efficient frontier where the best-performing companies are located, some Saudi insurers will need to adjust their management style and methods in order to improve technical efficiency (10 companies). They will also need to adopt more efficient managerial practices that enable them to better manage the employed resources (Farell (1957)). Furthermore, it should not be overlooked that increasing productivity is also linked to the industry's technological advancement, namely the capacity of insurers to develop and implement novel strategies to enhance their overall performance.

Our study's findings also showed that, rather than scale efficiency over the whole time period examined, the increase in TFP was mostly attributable to the insurers' increased technological change.

The study also revealed that the primary cause of the productivity increase, which was 12.8% over the study period, was favorable technological change. The efforts and investments made in innovation over time to raise insurers' performance and productivity were referred to as this productivity component. In a market with fierce competition, innovation is in fact seen as a source of success and a driving force for insurance companies. Nonetheless, technological advancements in the insurance sector underscore the endeavors of insurers to use novel protocols, techniques, and efficient managerial strategies in order to sustain a competitive edge.

Our study's findings demonstrated that, generally speaking, the technological component showed more notable improvements than technical efficiency. This indicates that throughout the years 2019–2022, Saudi insurers showed innovation. it can be concluded that these companies successfully adapted to their surroundings and capitalized on the technical environment of the sector.

Lastly, the study gave us the opportunity to benchmark Saudi insurers, which helped in finding the best practices in terms of productivity and efficiency. It may also be added that some insurers could be more efficient, and that in order to improve the performance of these decision-making units, it is crucial to consider the technological advancements in the sector.

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