Efficiency and Productivity Change in the Colombian Insurance Market*

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Abstract

In this paper we discuss cost efficiency and productivity changes in the Colombian Insurance market for the sample period 1998-2007, using Data Envelopment Analysis. The insurance industry was able to recover some of the ground lost in efficiency during the turbulent first half of the sample. There has also been significant productivity changes in the Colombian insurance sector mainly driven by shifts in the frontier of production. Our analysis also shows that there are significant differences in efficiency across types of insurers, where those offering both life and non life products exhibit higher cost efficiency scores than specialized insurers.

Keywords: Efficiency, DEA, Productivity, Insurance Market, Colombia.

JEL Classification: D24, G14, G22

*The opinions contained herein are those of the authors and do not necessarily represent those of the Banco de la República or its Board of Directors and Georgia State University. Only authors are responsible for remaining errors.

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1 Introduction

An efficient insurance industry improves welfare in societies. A recent report by USAID reviewed several studies and concluded that there is solid econometric support for the "premise that economies that experience more growth do so in part because they have access to efficient and effective insurance products"\(^1\). This positive effect of insurance on growth can go through several channels. For example, a well-functioning insurance sector helps to allocate risks better in society by reducing the exposure of individuals to risks, and their possible catastrophic consequences, and transferring them to institutions that are better endowed to cope with them. As another example, a competent insurance market allows entrepreneurs to engage in economic activities that involve higher risk but also higher returns\(^2\). Consequently, is socially desirable to improve the efficiency and productivity of a country’s insurance industry.

However, the recent development of the international financial and economic crisis are serious challenges of survival for financial institutions, and certainly for the insurance industry. Efficiency in production and technological change are key factors that allow firms to overcome periods of stress. As the IMF states it in its Global Financial Stability Report of October, 2008\(^3\), one of the principles that should drive the scope and design of measures to respond to the present stress period is to "(p)ursue the medium-term objective of a more sound, competitive, and efficient financial system"\(^4\).

The purposes of this paper are: \(i\) to investigate the efficiency and TFP implications of joint (life and non-life) and specialized production, \(ii\) to measure the efficiency and productivity changes of Colombian insurers in order to quantify the performance of different types of firms and identify the sources of inefficiency and \(iii\) to offer some insights on how to improve them. In order to achieve these, we use Data Envelopment Analysis techniques (DEA) to estimate cost efficiency scores and Malmquist indices to quantify productivity changes. The cost efficiency and productivity change analysis yield leading indicators of the best practices in the insurance industry that can be use as yardsticks that allow us to identify the sources of inefficiency. This can be useful information to market participants in order to take appropriate structural measures in the midst of the present difficult financial conditions.

We use information for the entire Colombian insurance industry focusing on the period 1998-2007. Our results show that Colombian insurers were able to recover some of the ground lost in efficiency during the turbulent first half of the sample period that spanned during a major domestic and international financial/economic crisis in 1998-1999 and catastrophic events. Moreover, the Colombian industry as a whole has experienced significant productivity growth in the last decade. The main source of this positive change has been technological changes that allow insurers to expand the production frontier. Additionally, insurers issuing both life and non life products have been more efficient on average than specialized insurers (in life or non life), but have also lost part of their advantage due to their scale of business. We suggest that, in order to increase efficiency, Colombian insurers should focus on improving

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\(^1\) USAID (2006)

\(^2\) Ibid, pag. 3.

\(^3\) Internacionial Monetary Fund (2008)

\(^4\) The bold is ours.
their allocative efficiency and that there is still room for some firms in the market to improve efficiency by increasing their scale of business through consolidation processes (M&As) and/or greater market shares.

The remainder of this paper is organized as follows. In section 2, we review some stylized facts of the Colombian insurance market. Next, in section 3 we explain the efficiency concept and the techniques used to estimate it empirically. Section 4 briefly reviews the relevant literature. In section 5 we describe the data set and discuss the output and input measures used in our estimation. Section 6 presents the results and we conclude in section 7.

2 Stylized facts of the Colombian insurance market

From a long-run perspective, the Colombian insurance market has shown a considerable expansion. The insurance penetration ratio, which is defined as total written premiums as a ratio of GDP, showed a ten-fold increase in eighty years\(^5\), and it more than doubled in the past three decades going from around 1% in the seventies to 2.5% in 2007 (Figure 1).

Figure 1: **Insurance Penetration in Colombia: 1975-2007**

Premiums/GDP

The Colombian insurance industry was characterized by a strong regulation in prices and a significant presence of public owned insurers. Nevertheless, during the second half of the eighties the insurance business grew significantly as a result of the expansion of the industrial, housing, financial and oil sectors that increased insurance demand.\(^6\)

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\(^5\)Rodríguez (2008).

\(^6\)Fadul (2005).
The nineties was a decade of significant changes for the insurance industry in Colombia. First, the market was deregulated through the financial reform of 1990. Second, minimum capital and solvency requirements were established. Third, there were significant changes in the investment rules of insurers and the valuation of assets that this set of rules allows. These significantly affected the portfolio composition of the companies. Fourth, the participation of foreign capital in the insurance market increased significantly since 1990. This was possible because the allowed foreign investment share of ownership in insurers went from 49% to 100%. In fact, foreign capital accounted for 15% of written premiums at the beginning of the 90's and it increased up to almost 43% in 2007. In this year there were 23 Non Life insurers (10 domestic, 10 foreign and 3 joint ventures) and 19 Life insurers (8 domestic, 9 foreign and 2 joint ventures). The Colombian pension reform of 1993 represented another major change in the insurance market. This allowed the life insurance companies to issue annuities and worker’s compensation insurance within the social insurance scheme of the country. This reform explains a substantial part of the increase in the life insurance business during the second part of the nineties.

From an international perspective, the Colombian insurance market exhibits a development coherent with its per capita income. The S-Curve is a concept that allows us to make cross-country comparisons of insurance development. Intuitively, the S-Curve tells us that there is a stage of economic development where the per capita income is so low that the demand of insurance is negligible; a second stage characterized by dynamic income growth which increases significantly insurance purchases and finally a stage where insurance demand stabilizes given that individuals have considerably high income so they can absorb more risk and self-insure. Therefore, deviations from the S-Curve can be understood as overdevelopment or underdevelopment of insurance according to income per capita levels.

Panels A and B in Figure 2 show the S-Curve for life and non-life insurance in the world. According to the S-curve, the Colombian life and non-life insurance markets (in the second stage of development) exhibit an insurance penetration coherent with the Colombian GDP per capita.

The Combined Ratio assesses whether operational earnings are enough to cover operational costs indicating a state of operational efficiency. Ratios below one are correlated with better performance and the opposite above one. For life insurers this ratio has been above one in the major part of the period 1975-2007(Figure 3). Nonetheless, there is a tendency in the indicator to approach one in recent years, suggesting that these insurers are starting to get almost even in their business, as well as an improvement in efficiency. Conversely, Non

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7 See Fadul (2005) and Rodríguez (2008) for a detailed exposition of the history of the Colombian insurance market.
8 The Colombian insurers are free to choose their investment portfolios but must comply with certain rules and thresholds that the regulator imposes.
9 Joint venture insurers have both domestic and foreign capital.
10 There is another type of institutions called Entidades de Capitalización that are considered part of the insurance market in Colombia but that offer a product that resembles more a saving mechanism that an insurance product. We choose to omit these institutions from the analysis given their nature.
11 It is strictly understood as the sum of losses, reinsurance commission and administrative expenses, including staff, over earned premiums.
Figure 2: Penetration in the World (2005)

Panel A
Non Life

Panel B
Life

Source: Sigma(1999, 2006), Enz(2000), Fasecolda’s and author’s Calculations

life insurers experienced a sharp decrease in the ratio after 1999, but started to increase in 2003.

Figure 3: Combined Ratio in Colombia: 1975-2007

Source: Fasecolda

Expenses to written premiums ratio is another traditional indicator of performance. This indicator suggests that no significant improvements have been made in costs terms in the long run, in spite of a recent tendency of cost reduction, especially in life insurers (Figure 4). It is worth mentioning that, given the greater complexity of life insurance products and
the difficulties to explain them to costumers, the higher expenses to premiums ratio of life insurance companies can be associated to the higher costs of commercialization in which they must incur. However, in recent years greater utilization of alternative distribution channels, such as bancassurance and other channels (e.g. utility bills), have allowed Life insurers to issue more insurance polices at a lower cost. These have probably translated into a more pronounced decline in efficiency ratios of Life insurers.

Figure 4: Efficiency Ratio in Colombia: 1975-2007
Total Expenses /Premiums

For the period 1998-2007, the insurance market exhibited low concentration; however, the life insurance market has shown signs of moderate concentration. According to the Herfindahl-Hirschman index, which is a measure of concentration, the index for the entire insurance market has consistently been below 10% in the last 10 years which implies an unconcentrated industry (Figure 5). Interestingly, the non life insurance market is very unconcentrated, meanwhile the life market seems to be slightly more concentrated (Figure 5). Nevertheless, there have been some Mergers and Acquisition (M & A) processes in the non-life market, especially during 1999-2002 and in 2007, that impacted marginally this indicator of concentration (see Figure 5 and Table 1). In the particular case of life insurers, the increase in the concentration index during the last two years is basically related to increases in market shares of big players.

All these indicators give a broad idea of performance in the insurance market. However, frontier efficiency and productivity measures dominate traditional analysis based on well-know indicators. These more rigorous techniques can summarize the insurer’s performance in

\[ HH = \sum_{i=1}^{N} s_i^2, \]  

where \( s_i \) is the share of company \( i \) in the market and \( N \) is the total number of firms. An index of 100% is equivalent to a monopoly case where just one firm provides the whole market. A value below 10% means very low concentration and between this value and 18% implies a moderately concentrated industry.
Figure 5: Concentration in the insurance Colombian market

Source: Fasecolda

a single number "that controls for differences across firms in a sophisticated multidimensional framework that has its roots in economic theory". We turn now to such techniques.

Table 1: Acquisitions

<table>
<thead>
<tr>
<th>Year</th>
<th>Acquirer Firm</th>
<th>Acquired Firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Condor S.A. Compañía de Seguros Generales</td>
<td>Compañía de Seguros Generales Aurora S.A (Non life)</td>
</tr>
<tr>
<td></td>
<td>Liberty Seguros S.A.</td>
<td>Latinoamericana de Seguros S.A (Non Life)</td>
</tr>
<tr>
<td></td>
<td>La Previsora S.G.</td>
<td>Seguros Tequendama (Life)</td>
</tr>
<tr>
<td>2000</td>
<td>Liberty Seguros S.A.</td>
<td>Seguros Colmena (Non Life)</td>
</tr>
<tr>
<td>2001</td>
<td>Compañía Mundial de Seguros S.A.</td>
<td>Mundial de Seguros de Vida S.A. (Life)</td>
</tr>
<tr>
<td></td>
<td>Liberty Seguros S.A.</td>
<td>Colmena Generales (Non life)</td>
</tr>
<tr>
<td></td>
<td>Seguros Bolivar</td>
<td>El Libertador (Non Life)</td>
</tr>
<tr>
<td>2002</td>
<td>Colseguros</td>
<td>Cyberseguros de Colombia (Life)</td>
</tr>
<tr>
<td></td>
<td>Liberty Seguros S.A.</td>
<td>ABN Amro (Non-life)</td>
</tr>
<tr>
<td>2005</td>
<td>QBE</td>
<td>Central de Seguros (Life and Non-Life)</td>
</tr>
<tr>
<td>2007</td>
<td>Suramericana</td>
<td>Agricola de Seguros (Life and Non Life)</td>
</tr>
<tr>
<td>2007</td>
<td>Global Education</td>
<td>Royal and SunAlliance (Life)</td>
</tr>
</tbody>
</table>

Source: Financial Superintendence of Colombia

\(^{13}\)Cummins and Weiss (2001)
3 The Efficiency Concept

An output-efficient\textsuperscript{14} firm is one which is not able to increase its output unless it increases at least one of the inputs of production (equivalently, an input-efficient firm cannot reduce its inputs unless it decreases at least one of its outputs). A firm with these characteristics has an efficiency score of 1. Conversely, an output-inefficient firm can increase its output by adopting the best practice in the market while keeping the quantity of inputs constant. Such inefficient firm has an efficiency scores less than 1.

Figure 6 illustrates the case of a firm producing one output with just one input. The straight lines $0T_t$ and $0T_{t+1}$ represent the technology frontier at time $t$ and $t+1$ under the assumption of constant returns to scale (CRS). These frontiers are the boundaries that determine the maximum amount of output that is technologically feasible at any point in time with a given quantity of inputs.

Figure 6: Single-Output Single-Input production technology

As the frontier in period $t+1$ is to the left of the one at $t$ we can say that technological progress has occurred because more can be produced with the same quantity of inputs. Figure 6 depicts the case of firm $n$ that in period $t$ was producing $y_{n,t}$ units of output using $x_{n,t}$ units of inputs. Since firm $n$ is in the interior of frontier $0T_t$, it is said to be inefficient at period $t$ because it could produce $b(> y_{n,t})$ units of output with the same inputs just by adopting the best practice.

\textsuperscript{14}This section follows closely Fried et al. (2008), Cummins and Weiss (2001) and Alam (2001)
available in the market. In other words, the firm could produce more efficiently (more output with the same inputs) by approaching the frontier of production. The output inefficiency is measured as the ratio $0a/0b$ which is less than one in this case. Similarly, the same firm $n$ is also inefficient at time $t+1$ because, by adopting the best practice available, it could increase its production from $y_{n,t+1}$ to $f$ units of output using the same amount of input $x_{n,t+1}$. Its efficiency score is less than one and equal to the ratio $0e/0f$.

There are several methodologies to estimate the efficiency of firms. These basically differ in the way how the efficient frontier (or best practice) is estimated and can be classified into two groups: parametric and non-parametric techniques.\(^{15}\)

**Non-Parametric Techniques:** These methodologies do not assume any explicit functional form for the efficiency frontier. This is a mathematical linear programming technique that estimates the frontier which envelopes the observed output and inputs of the firms. Normally, a convex frontier is fitted to the data to represent the ”best practice” of the industry. The most used non-parametric methodology is Data Envelopment Analysis (DEA).

**Parametric Techniques:** These methods assume a particular functional form for the efficient frontier (i.e., Cobb- Douglas, Translog, flexible Fourier form). There are three principal parametric techniques: i) the Stochastic Frontier Approach (SFA), ii) the Distribution Free Approach (DFA) and iii) the Thick Frontier Approach (TFA). Specifically, the SFA consists on the econometric estimation of a function (Profits, Revenues or Costs) where the independent variables are quantities of outputs and input prices. The errors of this regression capture the differences in efficiency among firms and the unanticipated shocks that can affect the performance of firms. Thus, the error term must be decomposed into two elements: an efficiency and a random term (“bad luck” component). Under this methodology the analyst must make assumptions on the probability distributions of both error terms.

We choose DEA for the following reasons. First, it is not necessary to identify a functional form or make distributional assumptions. Second, following the recommendation of Cummins and Weiss (2001), the mathematical programming techniques, such as DEA, may give more reliable results than parametric tools in moderate sample sizes such as ours.\(^{16}\) Third, it is a more convenient approach to decompose the efficiency into its components, which we describe below. Finally, the Malmquist index, which is a standard approach to measure total factor productivity, one of the purpose of the paper, is calculated using DEA techniques.

It must be emphasized the relative-comparison nature of the frontier efficiency analysis. One has to bear in mind that in empirical applications it is not possible to estimate an absolute production frontier. On the contrary, we are interested in estimating a frontier that is defined by the ”best-practices” of the market. As a consequence, the present empirical analysis of efficiency is a relative comparison of performance among the firms in the market.

\(^{15}\)See Fried, Lovell and Schmidt (2008) for a full exposition of these methodologies.

\(^{16}\)Our unbalanced panel of insures has around 300 observations which might be reduced by 10% to 15% when adjusting the degrees of freedom by the number of estimated parameters in the econometric approach.
3.1 Input Oriented Measures

Detailed analysis of DEA methodologies are provided in Fried et al. (2008), Cummins and Weiss (2001) and Coelli et al. (1998). In this paper we use an input oriented measure to estimate cost inefficiency, which address the issue of how effectively a firm chooses the inputs to produce a certain amount of output. Cost inefficiency (CE)\textsuperscript{17} can be further decomposed into allocative and technical efficiency (AE and TE, respectively). The former measures the degree in which a firm chooses the appropriate combination of inputs. TE refers to the ability of the firm to produce as much output as possible given a set of inputs. Firms showing this type of inefficiency use more inputs to produce a given amount of output than the firm in possession of the best-practice. Therefore, cost inefficiency can be expressed as:

\[
\text{Cost Inefficiency} = \text{Technical Efficiency} \times \text{Allocative Efficiency}
\]

In this paper we estimate CE with respect to frontiers that exhibit both constant returns to scale (CRS) and variables returns to scale (VRS). We do this to check the robustness of our results because there is no prior reason to assume one or the other. TE, which is achieved by moving towards the frontier, can be further decomposed into pure technical efficiency and scale efficiency (respectively, PTE and SE) by solving additional linear programming problems. Therefore, TE can be expressed as \(TE = PTE \times SE\). PTE is measured relative to a variable returns to scale (VRS) frontier, which may have parts where the firms that represent the best practice operate with increasing returns to scale (IRS), CRS or decreasing returns to scale (DRS). Thus a firm achieves PTE by moving towards a VRS frontier.

SE is related to the inefficiency losses associated to being too big or too small. Small companies may operate with IRS. This implies that the firm has incentives to increase their size because this allows it to reduce its average cost. Nonetheless, there is a limit to increments in size. A big firm may operate with DRS. This implies that an increase in inputs produces a less-than-proportional increase in output. Therefore a firm can improve efficiency by operating at the socially efficient level of production, i.e., CRS, which allows a firm to double its output when inputs are doubled.

The cost efficiency measures are between zero and one, where a very inefficient firm has a CE measure close to zero and a firm that represents the best-practice exhibits a CE of one. For example, if CE is 75%, the firm could reduce its total costs by 25% if it applies the best-practices to its business.

Notice that efficiency estimates as describe above cannot be used to analyze changes in productivity. Therefore, we explain briefly in the next subsection an appropriate methodology for this end.

\textsuperscript{17}We use indistinctively cost efficiency and cost inefficiency. Nevertheless, in a rigorous sense what is being estimated is the inefficiency of firms.
3.2 Malmquist Index Approach

We use Malmquist indices\(^{18}\) to analyze productivity dynamics, i.e., to quantify productivity changes that allow us to measure over time if more output is produced with the same quantity of inputs. This is easy to measure in a context of just one input and one output. Nevertheless, we want to talk about Total Factor Productivity change (TFP), i.e., the case where we have multiple outputs and inputs. This approach allows us to account for changes in technical efficiency (catching up with the best practice or firms getting closer to the frontier, TEC from now on) and changes in the technological frontier (innovation or shifts in the frontier itself, TC)\(^{19}\). This decomposition can be illustrated for the case of firm n in Figure 6:

\[
\text{Malmquist Index} = \frac{(O_e/0f)}{(0a/0b)} \left[ \frac{(O_e/Oc)(Oa/Ob)}{(Oe/0f)(Oa/Od)} \right]^{1/2}
\]

\[
= \left( \frac{O_e}{O_f} \right) \left( \frac{O_b}{O_a} \right) \left[ \left( \frac{O_f}{O_c} \right) \left( \frac{O_d}{O_b} \right) \right]^{1/2}
\]

\[
= TEC_{t+1} \ast TC_{t+1}
\]

Malmquist indices quantify changes in productivity by comparing data from two periods. \(TEC_{t+1}\) captures changes in relative efficiency (firms getting closer to the frontier) and \(TC_{t+1}\) reflects shifts in the frontier between period \(t\) and \(t+1\). If the Malmquist index is greater than one the industry exhibits TFP improvement from one year to another; meanwhile, if it is less than one, we have a decrease in TFP. Notice that just as in the case of technical efficiency explained above, TEC can be also decomposed into a Pure Technical Efficiency change (PTEC) and Scale Efficiency change (SEC)\(^{20}\). This requires the solution of additional linear programming problems that compares the distances with respect to a CRS and a VRS frontier\(^{21}\).

In summary, we estimate for each firm in the sample and for each year cost efficiency measures and its components assuming both CRS and VRS technologies. Additionally, we calculate changes in the productivity of factors of production and its components for two different samples that we explain below.

\(^{18}\)See Fried et al. (2008) for a detailed explanation of Malmquist indices.

\(^{19}\)We assume a CRS technology to calculate our Malmquist indices. One can use VRS technologies but as suggested by Coelli et. al. (1998), there are difficulties in the interpretation of TFP measures based upon technologies exhibiting VRS. Additionally, the authors argue that sometimes one can experience computational problems because the distances may not be defined for some inter-period DEA linear programs.

\(^{20}\)PTEC is greater than one when the firm is closer to the VRS frontier in period \(t+1\) than in period \(t\); and less than one when it is further away from the best practice in \(t+1\) than in \(t\). Likewise TFP and PTEC, TC are equal to one when there is no change in the frontier; TC takes values greater or less than one when there has been technological progress or regress. Finally, improvements in the scale of the firms are represented by a SEC greater than one, and the opposite when less than one.

\(^{21}\)TEC = PTEC \ast SEC. The TEC component is calculated under the assumption of CRS, meanwhile the PTEC component is measured assuming a VRS technology. A scale change greater than 1 means that the firm is moving towards the CRS frontier, while if less than 1 the firm is moving away from CRS.
4 Literature Review

There is a considerably large and increasing literature regarding efficient frontier and productivity changes estimations for insurers. This section attempts to briefly summarize the studies\textsuperscript{22} relevant to this paper.

In the Colombian case, the frontier efficiency literature has focused mainly on Commercial Banks. The following table summarizes the existent literature in Colombia for the banking sector, the period of study and the methodology used.

Table 2: Summary of Efficient Frontier Studies for Colombian Banks

<table>
<thead>
<tr>
<th>Date</th>
<th>Autor</th>
<th>Period</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Misas and Suescum</td>
<td>1989-1995</td>
<td>TFA</td>
</tr>
<tr>
<td>2000</td>
<td>Mendoza</td>
<td>1996-1999</td>
<td>DEA</td>
</tr>
<tr>
<td>2001</td>
<td>Castro</td>
<td>1994-1999</td>
<td>DFA</td>
</tr>
<tr>
<td>2002</td>
<td>Badel</td>
<td>1998-2000</td>
<td>DFA</td>
</tr>
<tr>
<td>2004</td>
<td>Estrada and Osorio</td>
<td>1989-2003</td>
<td>SFA</td>
</tr>
</tbody>
</table>

Additionally, Estrada (2005) also estimated the effects of M&A on efficiency for the Colombian Banking sector.

Regarding the insurance Colombian sector, to our knowledge, the scarcity of literature is evident. Vera (2005) attempts to identify the determinants of exits in Colombian insurance market for the period 1991-2003; nevertheless, he does not estimate an efficient frontier. The author estimates a panel probit model for the case of non-life insurers where he finds the determinants of the probability that an insurer exits the market. He found that the main factors affecting this probability are the financial returns of the portfolio, size of the firm, nature of capital (foreign or domestic) and the macroeconomic performance of the economy (captured by the unemployment rate).

It is worth emphasizing that there exists a research gap in frontier efficiency analysis for Insurers in the Latin American context. To our knowledge, Masci et al. (2005) is the first and only attempt to analyze the "effectiveness" (not efficiency as explained above) of the insurance markets in the region. They developed a survey - performed on 18 industry superintendents, 19 industry associations and 126 insurance companies - from which they are able to construct an Effectiveness index and several explanatory variables for this index. The main results show that countries with more stable macroeconomic and political conditions, better rule of law and stricter supervisory agents exhibit a more effective insurance market.

As discussed below, one of the key issues in frontier estimations for insurers is the definition of outputs. In early studies, premiums were used as output measure of life insurers (e.g., Fecher et al. (1993)). This can be a misleading measure of output because premiums are instead a

\textsuperscript{22}See Cummins and Weiss (2001) for a complete review of literature.
measure of revenue (price times quantity of policies issued). Nevertheless, recent studies have used more appropriate measures of output such as incurred losses and change in reserves. Examples of this literature are Fenn et al. (2008), Cummins et al. (1999) and Cummins and H. Zi (1998). For non life insurers, output can be captured through the present value of losses or undiscounted losses. Just a few studies use the present values of losses (e.g., Berger et al. (1997) and Cummins et al. (1998)), while most of the others use undiscounted losses. Regarding input measures, there is more consensus in the choice of inputs since most of the studies use labor, capital and a third category called business services and materials. More recently, capital has been disaggregated into financial equity and debt capital.

Most of the studies focus on the U.S and some European insurance markets. Nonetheless, there is an increasing amount of papers applying frontier efficiency methodologies to other insurance markets, especially in Asia and Europe (e.g., Bikker et al. (2005) for the Dutch case, Leverty et al. (2007) for the Chinese market, Eckles et al. (2005) for the Thai market, Hao (2006) for Taiwan, Trigo-Gamarra (2007) for the German Life Insurance case).

The most used technique is the econometric approach, followed by DEA and finally just a few use FDH approach. Additionally the main focus of the literature has been to estimate, cost and technical efficient frontiers (e.g., Cummins et al. (1999); Yuengert (1993); Grace (1995)). However, profits and revenue functions are also estimated (e.g, Fenn et al. (2008), Klumpes (2006)). Cummins and Weiss (2001) find that the average cost efficiency estimates for life insurers in the US are considerably consistent between 0.3 and 0.5. This is not the case for P/L, where the average cost efficiency of the US industry ranges between 0.39 and 0.86.

One of the main topics studied in the literature is the existence of economies of scale, which are present if the cost per unit of product is reduced when the output volume increases. It has to be emphasized that DEA approach solves the problem for each insurance company which implies that the estimated scale economies are specific to each insurer. On the contrary, the econometric approach estimates one equation for the whole sample which is less informative of particular economies of scale. In the case of the U.S. life insurers, Cummins et al. (1999) and Cummins and H. Zi (1998), which use DEA, found increasing returns to scale in insurers with less than $1 billion in assets, while most of the larger firms operate in decreasing returns to scale. Cummins and Weiss (2001) argue that the results found by Grace and Timme (1992), who use the econometric approach, are consistent with the DEA’s results.

Another relevant issue addressed in the literature is the existence of economies of scope. This topic gains more relevance in the context of increasing mergers that involve life, P/L and other financial institutions. Scope cost economies arise when an insurance company (from now on joint insurer) that underwrites jointly two different products (e.g., life and non-life insurance) incurs in smaller costs than a specialized insurer that decides to produce the same two products separately. Intuitively, the main driver of this outcome would be the fact

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23 In the life insurers case the equivalent measure of output is incurred benefits. However, from now on we use the term incurred losses for both the life and non life outputs, recognizing that it strictly applies to non-life insurance.

24 The rationale of this disaggregation is given below in the paper.
that the joint insurer is able to benefit from production complementarities (i.e., the joint usage of some or all inputs)\textsuperscript{25}. In the same fashion, Revenue Scope economies arise due to consumption complementarities, because customers are willing to pay more in order to avoid the search costs that buying insurance from specialized insurers would imply. Revenue scope diseconomies could arise if the quality of specialized insurers is higher than the diversified insurers and therefore the consumer is willing to pay more. Finally, profit scope economies are just the difference of production and consumption complementarities. The most representative paper of scope economies is Berger et al. (1999). The authors study the existence of scope economies in U.S. Life and P/L insurance companies and estimate cost, revenues and profit scope economies. They find evidence of cost scope economies for the first, median and third size quartile of insurers. They also find revenue diseconomies for the first two quartiles which remove all the cost scope economies. Nevertheless, there is evidence of profit scope economies in the third quartile.

Finally, since the middle of the 90’s there has been an increase in studies of productivity change in the insurance industry. Cummins et al. (2006) is a representative paper of this literature. For the case of the Spanish insurance industry, they find significant TFP change during the period 1989-1998.

5 Data, outputs and inputs

The data used in this paper are drawn from the annual statistical year book of insurance companies kept in the information system of Colombian Insurance Association (Fasecolda). We have annual data for all firms that were present in the life and non-life insurance markets between 1998 and 2007. All monetary values are expressed in 1998 monetary units of domestic currency by deflating with the CPI, calculated by the Departamento Administrativo Nacional de Estadistica (DANE).

5.1 Decision Making Units (DMU)

In the present study the DMUs (i.e., the firms under analysis) are defined in the following way. In the Colombian insurance industry, by legal restrictions a company cannot participate simultaneously in life and non life business\textsuperscript{26}, in fact, two separate legal entities with capital requirements must be constituted in order to issue life and non-life insurance. Nevertheless, there are life and non life companies, normally owned by the same economic group or global insurers, that act as one, sharing expenses, actuaries, back-office and so on. Thus, making the present analysis separately for life and non-life companies could yield results that are driven by accounting issues according to how the companies assign the total expenses of the companies. To avoid this, we aggregate companies that share the same manager, which is a

\textsuperscript{25}Cummins and H. Zi (1998)
\textsuperscript{26}However, there are a few life products that non life companies can exploit, which account for a marginal share of the total non-life business.
reasonable indicator of the interdependence of the firms\(^{27}\). This information was provided by Fasecolda.

### 5.2 Outputs

Consistent with the mainstream literature on financial institutions (see Berger et al. (1992) and Cummins and Weiss (2001)) there are three principal approaches that have been used to measure outputs in the financial services industry\(^{28}\): i) the asset or intermediation approach\(^{29}\), ii) the user-cost\(^{30}\) approach, and iii) the value-added approach.

The value-added approach is considered the most appropriate method for analyzing efficiency in the insurance industry. Under this approach all asset and liability categories are considered to have output and inputs characteristics instead of distinguishing inputs from outputs in a mutually exclusive way. According to the operating cost allocations, the categories having significant value-added are considered important outputs. This is the approach that is going to be used in this paper.

#### 5.2.1 What are the services provided by Insurers?

Since insurance is a very heterogenous product, it is not an easy task to determine the outputs and inputs to be used. However, there is some consensus in the services provided by an insurers. These can give us hints to find proxies correlated with these services. According to Cummins and Weiss (2001) insurers provide mainly three services:

**Risk-pooling and risk-bearing:** Insurers provide to the insured individual mechanisms to cover contingencies through risk pooling. Insurance companies collect premiums from policyholders and redistribute part of the collected funds among insured costumers that sustain losses. The actuarial, underwriting, and related expenses incurred in operating the risk pool are the principal elements of value added in insurance. Moreover, equity capital, which allows insurance companies to exert risk-bearing activities, increases value-added because it provides a cushion against investment shocks and unexpected losses.

\(^{27}\)In a few cases the figure of a common manager for two companies was not so clear. In those cases, these companies gave us their vision of the independence of each company.

\(^{28}\)see Cummins and Weiss (2001) for further reference

\(^{29}\)This approach treats firms in the financial sector as pure financial intermediaries. Even though this might partially apply to life insurers, it does not apply to Non-life insurers since intermediation is a less important activity for them. Therefore, it is not sound to use this approach to measure the insurer’s output.

\(^{30}\)This approach uses the net contribution of a certain financial product to the revenues of the financial institution in order to determine whether it is an input or output. In particular, if the financial returns on an asset is greater than de opportunity costs of the funds, it is consider an output, otherwise it is consider an input. The problem with this approach is that it requires accurate data on product revenues and opportunity costs. Additionally, the classification of inputs and outputs has been found to be not robust over time to the choice of opportunity costs (Cummins and Weiss (2001), fn 13). This approach is difficult to implement on insurers because insurance policies are heterogeneous products that bundle together many services (e.g., risk pooling, intermediation, etc.), which are included in the price.
"Real" financial services related to insured losses. Insurers provide a multiplicity of real services for policyholders such as financial planning, risk management programs (e.g., risk surveys to identify unusual loss exposures) and loss prevention. Overall, policyholders benefit from these "real" services because they can reduce the costs of risk management.

Intermediation. Insurance policies are very similar to debt contracts because insurers invest funds received from policyholders until they are needed to pay claims or withdrawn (in the case of asset accumulation products sold by life insurers). In property-liability insurance costumers receive a discount in the premiums they pay to compensate for the opportunity cost of the funds given to the insurer. In life insurance, where intermediation is an important function, policyholders receive interest credits to reflect investment income. Insurers’ value-added from intermediation is the net interest margin between the rate of return on investment assets and the interest rate credited to policyholders.

Obtaining measures of output as defined above is difficult because publicly available data does not distinguish costs according to the services provided. Therefore, we have to use proxies that are highly correlated with the services that we want to measure.

Fenn et al. (2008) define output as the expected present value of the future claims that might be paid on the insurance policies issued. Since this is an unobservable variable we must use proxies. Written premiums are a natural proxy, nevertheless, as Yuengert (1993) claims, premiums are price of insurance times the quantity of policies issued. A possible alternative that has been used in the literature is using losses incurred as proxy, which is the sum of claims paid to policyholders and the reserves that the insurers estimate will cover their losses in the future.

Therefore, following Yuengert (1993), Cummins et al. (1999), Fenn et al. (2008), Berger et al. (1999) and Berger et al. (2000), we use net losses incurred to define life and non-life insurance output. These are defined as gross losses paid less claims received from reinsurers plus additions to loss reserves.

Losses incurred are a proxy of the risk-pooling and risk bearing activities since they are the amount of money that was pooled during a period of time and that is used to pay for losses that policyholders suffered in that period and for future expected losses. Losses incurred are also a reasonable proxy of real services provided by insurers because the amount of claim settlements and risk management services are correlated with the loss aggregates.

To account for intermediation activities of insurers we use total invested assets for each year as defined in Berger et al. (1997), Cummins et al. (1999) and Cummins and Weiss (2001).

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31 We acknowledge that it is now a common practice to further disaggregate into different lines of business. Nevertheless, we chose not to do so since DEA methodology is very sensitive to the number of products in a sample with small number of firms like ours.

32 Leverty et al. (2007)
5.3 Inputs and Input Prices

Following Berger et al. (1997), Berger et al. (1999), Fenn et al. (2008), and Cummins and Weiss (2001) inputs are i) labor, ii) Business Services, iii) Debt Capital and iv) Financial Equity Capital.

As described in Cummins and Weiss (2001), we define the quantity of Labor as total labor expenses and commissions to agents divided by a measure of the average wages in the insurance industry. For the latter we use the annual average of wages in the insurance industry, provided by the Central Bank of Colombia.

Similarly, Business Services are defined as the total amount of non-labor expenses divided by the GDP deflator of Financial Services and related Activities, which was calculated using the estimation of GDP by sectors of the DANE.

Debt Capital for insurers is basically composed by the funds borrowed from policyholders. The rationale for including this input is that insurers raise funds in the form of debt capital from policyholders by issuing policies and transforming them into invested assets.

Finally, financial equity capital, is an important input because, besides satisfying regulatory requirements, insurers must hold capital to ensure that policyholders receive their loss payments in case that claims exceed the insurer’s expectation. As a consequence equity capital serves the purpose of reducing the insurer’s insolvency risks. \(^{33}\)

For measuring the cost of debt and equity capital, respectively, we use as prices the one-year Colombian Treasury bill rate (provided by the Central Bank of Colombia) and a 6-year average of the ROE of the Colombian Insurance Industry.

To summarize, we use three outputs, namely: life and non-life incurred losses and invested assets; and four inputs: labor, business services, debt capital and financial equity capital. Table 3 shows the average values in 2007 of output, inputs and input prices.

6 Results

This section presents the results focusing on the period 1998-2007 and the entire Colombian insurance market. We first show our efficiency scores results and then our Malmquist analysis. We analyze the results at the aggregate level and at the disaggregated level by type of insurers, i.e. joint producers (companies issuing both life and non life insurance products), companies specialized in life products and insurers specialized in non life insurance.

\(^{33}\)Cummins and Danzon (1997).
Table 3: **Summary Statistics, 2007**

Average values

(All monetary units in Millions of Colombian Pesos of 2007)

(Exchange rate 2007: COP$2,044 per US$1)

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<td>0.09</td>
<td>0.21</td>
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### 6.1 Efficiency Scores

#### 6.1.1 Aggregate Analysis

Table 4 shows the simple average efficiency scores of the industry. Specifically, the table shows the cost efficiency scores and its components, assuming both CRS and VRS technologies.

The simple average of the CE for 1998-2007 was 61% under CRS and 72.5% under VRS (See Table 4). Efficiency scores are normally higher under VRS because given this assumption the production frontier makes a tighter envelope on the observations, which allows firms to be closer on average to the frontier (See Figure 7).

There is a slight upward trend in the industry efficiency since 2002. Assuming CRS (VRS), the simple average CE scores of the insurance industry increased from 55.7% (66.9%) in 2002 to 57.5% (76.1%) in 2007 (see Table 4). There is a similar trend when calculating averages of CE weighted by total assets.\(^{34}\)

However, the average CE in the Colombian insurance industry (assuming CRS) decreased from 72% in 1998 to 57.5% in 2007. When we assume VRS those efficiency scores were 80% and 76%, respectively (Table 4).

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\(^{34}\)In the rest of the paper, we present only simple average efficiency scores because weighted averages yielded similar conclusions.
Table 4: Simple averages of efficiency scores in the Colombian insurance industry

|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|         |
|                      | Averages|         |         |         |         |         |         |         |         |         | 1998-2007|
| Cost Efficiency: CRS | 71.7%   | 60.9%   | 62.5%   | 62.8%   | 55.7%   | 59.6%   | 60.2%   | 54.5%   | 63.5%   | 57.5%   | 60.9%   |
| Allocative Efficiency: CRS | 75.2% | 66.1% | 68.8% | 72.2% | 63.3% | 72.6% | 71.6% | 65.3% | 73.7% | 67.5% | 69.6% |
| Pure Technical Efficiency | 97.7% | 94.4% | 94.3% | 94.7% | 96.8% | 93.3% | 93.3% | 94.6% | 94.7% | 95.6% | 94.9% |
| Scale Efficiency     | 97.3%   | 95.3%   | 95.3%   | 91.1%   | 90.3%   | 88.3%   | 90.6%   | 89.8%   | 91.1%   | 89.7%   | 91.9%   |
| Cost Efficiency: VRS | 80.3%   | 72.4%   | 69.4%   | 69.0%   | 66.9%   | 72.8%   | 71.0%   | 69.6%   | 77.9%   | 76.1%   | 72.5%   |
| Allocative Efficiency: VRS | 82.0% | 75.3% | 72.4% | 72.3% | 68.7% | 77.8% | 75.8% | 73.4% | 82.1% | 79.1% | 75.9% |
| IRS                  | 20.0%   | 25.7%   | 17.6%   | 27.3%   | 25.0%   | 25.8%   | 25.8%   | 22.6%   | 29.0%   | 22.6%   | 24.1%   |
| CRS                  | 60.0%   | 51.4%   | 44.1%   | 33.3%   | 34.4%   | 25.8%   | 45.2%   | 41.9%   | 41.9%   | 45.2%   | 42.3%   |
| DRS                  | 20.0%   | 22.9%   | 38.2%   | 39.4%   | 40.6%   | 48.4%   | 29.0%   | 35.5%   | 29.0%   | 32.3%   | 33.5%   |
| Number of DMUs       | 35      | 35      | 34      | 33      | 32      | 31      | 31      | 31      | 31      |         |         |

Note 1: In the first five rows of the table, CRS denotes efficiency scores calculated under the assumption of Constant Returns to Scale. Similarly, VRS denotes efficiency estimations under the Variable Returns to Scale assumption.

Note 2: The last three rows represent the percentage of DMUs in the sample that were operating under Increasing Returns to Scale (IRS), Constant Returns to Scale (CRS) and Decreasing Returns to Scale.
These results have to be interpreted in the context of the financial and economic crisis in 1998-1999 in the Colombian economy, a major earthquake in an important city, as well as the 9/11 and the Katrina events that most likely affected the performance of insurance companies. In fact, the scarce literature in Colombia (Vera (2005); and Harker (2005)) found that both the business cycle and international events such as 9/11 do affect the performance of insurers in Colombia.

Together, these results would suggest that Colombian insurers were able to gain some of the ground lost during the national and international stress periods that took place during the first half of the sample period.

As Cummins et al. (2006) suggest, efficiency measures are useful to make relative comparisons of the performance among companies and the components of efficiency across time. Nonetheless, as explained above this analysis cannot be used to make any conclusions about productivity change because it does not take into account movements in the production frontier itself, which in fact, as we will see in the Malmquist section, drove the positive TFP change experienced in the Colombian insurance industry during the last decade.

Regarding the components of CE, the major source of inefficiency is AE. This was 70% on average under CRS (76% under VRS) during the period 1998-2007 (Table 4). This implies that the Colombian insurers should improve the way they are choosing the combination of inputs of production.

However, insurers’ AE is also the main source of the slight efficiency improvement seen in the last five years of the sample. Contrary to the other components of CE which decreased slightly or remained constant, when assuming CRS (VRS), the AE scores increased between 2002 and 2007 by more than 4 (10) percentage points (Table 4).
Regarding SE and PTE, the Colombian insurance market exhibited high efficiency scores. There are fewer losses in efficiency due to SE, which was 92% on average during the whole sample period, nonetheless, it decreased during the 10 year period. This score implies that on average a considerable number of firms were operating at the efficient scale during the ten years; in fact, on average, 42% of the total DMUs during the period 1998-2007 were operating at the efficient scale (i.e., with CRS).

However, the results also imply that there is still room to improve performance via SE. The last three rows of table 3 show the percentage of firms that were operating with IRS, CRS and DRS. Consistent with the reduction in the SE scores during the sample period, the percentage of firms operating at the efficient scale (CRS) decreased. In 2007, 23% of the insurers were operating with IRS, 45% with CRS and 32% with DRS.

Finally, PTE was on average 95%. This would imply that an important part of the insurance companies were able to keep up with technological changes. Nevertheless, there are still insurers that are not able to do an optimal job producing a certain amount of output without wasting inputs.

In sum, in the midst of the global crisis, Colombian insurers have still room to improve their cost efficiency in two ways. First, the main source of inefficiency in the Colombian market is allocative inefficiency. Although, it improved in the second half of the sample, insurers should focus more on improving the way they choose the mixture of inputs and less in increasing their market share. Second, there are some companies that exhibit IRS which suggest that they could boost their efficiency by increasing their business scale and/or by pursuing consolidation processes. Obviously, increasing their scale through more sales is very difficult during an economic crisis, however, through careful and strategic mergers and acquisitions these insurers could attain a scale efficient size. The regulator must take into account this information when assessing potential mergers and acquisitions that could translate into less efficient entities because of the presence of DRS.

6.1.2 Disaggregated Analysis

The type-disaggregation reveals that joint insurers dominate, in CE terms, the companies specialized in life and non life insurance products. Table 5 shows the average efficiency scores disaggregated by types of insurers. Assuming CRS (VRS), for the period 1998-2007, efficiency scores of joint insurers were on average around 14 (18) percentage points above life specialized insurers and 6 (10) percentage points over the scores of non life specialized firms. Table 5 shows pairwise differences-in-mean tests according to the type of insurer. The results in this table show that joint insurers have statistically significant higher means than those insurers specialized in both non life and life insurance products. Notice that joint insurers were more efficient than the average of the market because their CE scores for the ten years were on average 66% (80%) when assuming a CRS (VRS) technology, meanwhile the market exhibited 61% (73%), as we saw above.

The CE advantage of joint insurers basically resides in AE. When CRS is assumed, Tables 5
and 6 imply that joint firms exhibited AE scores that were on average almost 19 (9) percentage points higher during the ten year sample than insurers specialized in life (non life) products. Similar results are observed when assuming VRS technologies.

The rationale of this result is as follows. Joint insurers can benefit from the joint usage of inputs of production to issue different types of insurance. This allows them to use more efficiently their inputs and distribution channels reducing the costs of issuing insurance policies. Additionally, joint firms can spread the fixed costs of production along all the business lines in which they participate. This would be consistent with the conglomeration hypothesis\textsuperscript{35} which sustains that an insurer can exploit cost scope economies by sharing inputs in joint production\textsuperscript{36} as well as the benefits of "the one stop shopping". More research and data is needed in order to estimate profit scope economies, as calculated in Berger et al. (1999). This methodology allows to test for the validity of the conglomeration hypothesis versus the strategic focus hypothesis, where the latter defends that by specializing in one line of services, financial firms can maximize value. Thus, it is left to be studied if the significant advantages in cost efficiency of the joint producers over specialized insurers is maintained once revenue and profit maximization is incorporated in the analysis.

When comparing across types of specialized insurers, non life firms showed higher CE scores than pure life insurers. Assuming both CRS and VRS, specialized firms in non life insurance exhibit a statistically significant average CE higher in almost 8 percentage points than the scores of companies specialized in life products (see Table 5 and 6).

The advantage of insurers specialized in non life over those in life products is basically explained by AE. Non life firms exhibited average AE scores of 68\% over the whole sample, whilst the pure life insurers showed an AE of 58\% (Table 5), which according to Table 6 represent a statistically significant difference in mean of 10 percentage points.

However, it is worth noticing the important catch-up that insurers specialized in life products have made given the significant increase in cost efficiency since 2003. In opposition to the other types of insurers, companies issuing only life insurance increased their CE scores in more than 16 percentage points since 2001 under the CRS assumption and almost 30 percentage points assuming a VRS technology (Table 5). By 2007, this type of insurers exhibited average CE scores around 60\%, which were practically equal to the ones showed by joint insurers in that year.

The improvement in efficiency of specialized life insurer is primarily due to a significant increase in AE scores since 2001, which increased almost 15 (28) percentage points, when assuming a CRS (VRS) technology. Regarding the pure technical dimension, it is worth noticing that insurers specialized in life products exhibit higher PTE scores than the other types of firms (Table 5 and 6). Furthermore, these types of firms exhibited a steady increase in PTE since 2003 that ended up in PTE scores of 100\% in the last two years of the sample. However, both joint and non life insurers exhibited high PTE scores around 98\% and 92\%, respectively.

\textsuperscript{35}Berger et al. (1999)
\textsuperscript{36}Ibidem
Table 5: Simple averages of efficiency scores by type of insurer (joint, specialized in life insurance and specialized in non life)

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<tbody>
<tr>
<td>Cost Efficiency: CRS</td>
<td>71.3%</td>
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<td>69.4%</td>
<td>61.2%</td>
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Specialized: Life

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Specialized: Non Life

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<td>Cost Efficiency: CRS</td>
<td>71.2%</td>
<td>64.0%</td>
<td>70.7%</td>
<td>68.6%</td>
<td>55.1%</td>
<td>60.9%</td>
<td>53.9%</td>
<td>47.3%</td>
<td>59.5%</td>
<td>53.3%</td>
<td>60.4%</td>
<td>IRS% 33%</td>
</tr>
<tr>
<td>Allocative Efficiency</td>
<td>74.6%</td>
<td>68.3%</td>
<td>76.9%</td>
<td>79.1%</td>
<td>61.5%</td>
<td>71.5%</td>
<td>64.2%</td>
<td>54.4%</td>
<td>68.8%</td>
<td>60.9%</td>
<td>68.0%</td>
<td>CRS% 42%</td>
</tr>
<tr>
<td>Pure Technical</td>
<td>97.6%</td>
<td>93.3%</td>
<td>90.7%</td>
<td>89.5%</td>
<td>92.7%</td>
<td>89.6%</td>
<td>89.0%</td>
<td>95.6%</td>
<td>91.2%</td>
<td>93.4%</td>
<td>92.2%</td>
<td>DRS% 25%</td>
</tr>
<tr>
<td>Scale Efficiency</td>
<td>97.7%</td>
<td>97.5%</td>
<td>98.9%</td>
<td>94.1%</td>
<td>94.6%</td>
<td>94.7%</td>
<td>95.1%</td>
<td>91.5%</td>
<td>93.9%</td>
<td>93.2%</td>
<td>95.1%</td>
<td></td>
</tr>
<tr>
<td>Cost Efficiency: VRS</td>
<td>79.8%</td>
<td>70.3%</td>
<td>72.7%</td>
<td>70.9%</td>
<td>60.7%</td>
<td>72.4%</td>
<td>68.1%</td>
<td>63.0%</td>
<td>74.0%</td>
<td>69.5%</td>
<td>70.1%</td>
<td></td>
</tr>
<tr>
<td>Allocative Efficiency: VRS</td>
<td>81.7%</td>
<td>73.7%</td>
<td>77.2%</td>
<td>77.2%</td>
<td>64.5%</td>
<td>79.9%</td>
<td>75.8%</td>
<td>65.7%</td>
<td>80.6%</td>
<td>73.6%</td>
<td>75.0%</td>
<td></td>
</tr>
<tr>
<td>Number of DMUs</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>12</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>11</td>
<td>11</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: In the first five rows of the table, CRS denotes efficiency scores calculated under the assumption of Constant Returns to Scale. Similarly, VRS denotes efficiency estimations under the Variable Returns to Scale assumption.

Note 2: The last two columns exhibit the percentage of DMUs in 2007 that were operating under Increasing Returns to Scale (IRS), Constant Returns to Scale (CRS) and Decreasing Returns to Scale (DRS).
<table>
<thead>
<tr>
<th></th>
<th>Joint vs. Life</th>
<th>Joint vs. Non Life</th>
<th>Non Life vs. Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost Efficiency :CRS</td>
<td>4.43</td>
<td>1.77</td>
<td>2.26</td>
</tr>
<tr>
<td>Allocative Efficiency:CRS</td>
<td>6.29</td>
<td>2.81</td>
<td>2.95</td>
</tr>
<tr>
<td>Pure Technical Efficiency</td>
<td>-2.40</td>
<td>3.18</td>
<td>-5.11</td>
</tr>
<tr>
<td>Scale Efficiency</td>
<td>-1.14</td>
<td>-3.76</td>
<td>2.65</td>
</tr>
<tr>
<td>Cost Efficiency :VRS</td>
<td>5.02</td>
<td>5.34</td>
<td>2.12</td>
</tr>
<tr>
<td>Allocative Efficiency:VRS</td>
<td>5.82</td>
<td>4.11</td>
<td>3.12</td>
</tr>
</tbody>
</table>

Note 1: Pairwise comparison tests for mean difference are based on average efficiency scores for each type of insurers for the sample period 1998-2007.

Note 2: To conduct the test, in each comparison test we subtract the average efficiency of the second type of insurer from the average score of the first type. For example the t-test for the comparison Joint vs. Life tests the null hypothesis that the firms issuing both life and no life insurance products (joint) have the same sample average efficiency scores as the insurers specialized in the Life insurance business (Life).

Note 3: CRS denotes efficiency scores calculated under the assumption of Constant Returns to Scale. Similarly, VRS denotes efficiency estimations under the Variable Returns to Scale assumption.

/a*** Significant at the 1% level, ** significant at the 5% level and * significant at the 10% level.
In our sample of pure life insurers we have traditional firms issuing different types of life products as well as insurers specialized in compulsory workers’ compensation (WC). Therefore, this better performance of pure life insurers could be related to the recent development of bancassurance (and other distribution channels) that have taken place in life insurance markets and that significantly helps to reduce costs, as well as a better performance of WC insurers in minimizing costs. As Mora and Zarruk (2008) highlight it, the bancassurance channel allows the insurers to access immediately to a large and established distribution net that banks have already in place. Consequently, insurers can benefit from more efficient premium collection and better information systems at lower costs. It also allows to access rapidly to a critical mass of possible clients that significantly increase the benefits of risks pooling via large numbers.

Currently, there is no sufficient information to assess the effect of this distribution channel on efficiency, nonetheless, market participants recognize the importance that bancassurance and other channels (such as utility bills) have gained in recent years. Mora and Zarruk (2008) make an international comparison and found that in Colombia 29% (21%) of the life premiums are sold through banks (other channels). This contrasts with more mature markets like Europe where there are countries with more than 70% of the premiums being written through banks. Therefore, as Mora and Zarruk (2008) imply, we should expect Colombian life insurers taking more advantage of this powerful distribution channel.

Conversely, pure non life insurers have not been able to show the same pace of recovery of life insurers. In fact, between 2002 and 2007, CE scores increased around 9 percentage points when assuming a VRS technology, and it decreased slightly 2 percentage points under the CRS assumption.

Figure 8: **Scale Efficiency by Type of Insurer: 1998-2007**

It is worth mentioning that there is a general trend in all types of insurers to reduce their SE, however, the efficiency scores are still high (Figure 8). When comparing the first and the last year of our sample period, joint, pure life and pure non life insurers SE score decreased 11, 9 and 5 percentage points, respectively. Nonetheless, they still remain above 90% in the case
of both types of specialized firms and around 85% for joint companies.

Joint insurers lost part of their AE advantage due to lower SE. In fact, both types of specialized insurers dominated joint firms in this component of CE. The differences-in-mean tests in table 6 show that joint insurers were on average less scale efficient than non-life specialized insurers. In addition, pure non life insurers showed the highest average SE followed by pure life firms.

In 2007, the 75% of insurers issuing just life products were operating at the efficient scale of business (i.e., with CRS), meanwhile 42% of non life insurers were doing it so. Conversely, most of the joint insurers were operating with DRS, which is consistent with the lower SE exhibited in 2007 by these firms. However, there are still firms of all types that are operating with IRS, which can attain further gains in efficiency by increasing the scale of the business.

To summarize, the disaggregated analysis suggests that joint producers dominate specialized insurers in CE terms by means of higher AE. However, part of this advantage of joint producers is partially offset by scale inefficiency.

6.2 Malmquist Indices

Malmquist indices measure TFP changes by taking into account the performance of firms relative to the production frontiers for two different years. As a consequence we must have the same companies available for any two-year comparison. Because there have been some exits/entries of firms and M & As during the sample period we use two samples, namely: 1) a complete panel with the firms that were present both at the beginning and end of the sample period; and 2) an adjacent-year sample as defined by Cummins et al. (2006). The complete panel represents mature firms in the insurance Colombian market. Nonetheless, to control for any survivorship bias we also use the adjacent-year sample that includes entering and exiting firms whenever it is possible.

For each sample, we calculate the geometric mean of the results to represent industry-TFP change. For the complete panel, we calculate Malmquist indices using the information of all years. We conduct this analysis both at the aggregate level and disaggregating by type of insurer.

6.2.1 Aggregate Analysis

Table 7 shows in the first two columns the components of TFP change, i.e., TEC (firms getting closer to the frontier, i.e., catching up) and TC (shifts in the technological frontier, i.e., innovations). The following two columns show the two components of TEC, namely, PTEC (efficiency change with respect to VRS) and SEC. The final column exhibits TFP change. Additionally, Table 7 also presents the information explained above for the whole

37For instance, in the adjacent-year sample 1998-1999 we calculate Malmquist indices for the companies that were present during these two years, even though they were not present during the rest of the years.
Table 7: Malmquist Productivity Indices

<table>
<thead>
<tr>
<th>Industry</th>
<th>Technical Efficiency Change (CRS)</th>
<th>Technical Efficiency Change (VRS)</th>
<th>Pure Technical Efficiency Change (VRS)</th>
<th>Scale Efficiency Change</th>
<th>Total Factor Productivity Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel all years</td>
<td>0.987</td>
<td>1.043</td>
<td>0.996</td>
<td>0.991</td>
<td>1.030</td>
</tr>
<tr>
<td>Adjacent-year Sample Average</td>
<td>0.984</td>
<td>1.035</td>
<td>0.997</td>
<td>0.987</td>
<td>1.018</td>
</tr>
<tr>
<td>Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel all years</td>
<td>0.984</td>
<td>1.035</td>
<td>0.997</td>
<td>0.987</td>
<td>1.018</td>
</tr>
<tr>
<td>Adjacent-year Sample Average</td>
<td>0.989</td>
<td>1.046</td>
<td>0.998</td>
<td>0.990</td>
<td>1.034</td>
</tr>
<tr>
<td>Specialized: Life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel all years</td>
<td>0.983</td>
<td>1.061</td>
<td>1.000</td>
<td>0.983</td>
<td>1.043</td>
</tr>
<tr>
<td>Adjacent-year Sample Average</td>
<td>1.001</td>
<td>1.081</td>
<td>1.007</td>
<td>0.994</td>
<td>1.082</td>
</tr>
<tr>
<td>Specialized: Non Life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel all years</td>
<td>0.992</td>
<td>1.043</td>
<td>0.992</td>
<td>1.000</td>
<td>1.035</td>
</tr>
<tr>
<td>Adjacent-year Sample Average</td>
<td>0.990</td>
<td>1.016</td>
<td>0.990</td>
<td>0.999</td>
<td>1.006</td>
</tr>
</tbody>
</table>

Note: All the entries in the table are geometric averages.

industry and disaggregated by type of insurer for the complete panel and the adjacent-year sample. All values in Table 7 are geometric averages.

The first important conclusion is that the Colombian insurance market experienced a productivity growth over the sample period. In the complete panel there was a 30% increase in TFP between 1998 and 2007, which implies a 3% TFP annual change. Similarly, for the adjacent-year sample, the geometric average TFP change for all two-year comparisons (i.e., 1998-1999, 1999-2000,...,2006-2007) was 1.8%, which implies a 17% of productivity change in the ten-years period.

The second conclusion is that the source of the shift in productivity is explained by positive technological changes which offset a slightly negative TEC growth. This means that the production frontier has expanded significantly in the last 10 years, allowing insurance companies to produce more given any amount of inputs. In fact, on average, in the entire industry there was a 4.3% annual technical change in the complete panel, and a 3.5% change in the adjacent-year sample. For the whole industry, the annual TEC was -1.3% (in the complete panel) and -1.6% (in the adjacent-year sample). This slightly small negative change was explained by negative SEC -and to a lesser extent due to PTEC since most of the firms are already close to the frontier-, which is consistent with the reduction trend in SE scores of the insurance industry mentioned above.

As a response to severe shocks, the Colombian insurers found several ways to increase their productivity via shifts in the production frontier. In Colombia there was a major economic and financial crisis (1998-1999) and a major earthquake in an important city of Colombian in 1999 that seriously affected the performance of the insurance companies. Obviously, the
9/11 and the Katrina also affected the insurance industry. The Colombian insurers undertook major changes in their cost structure and also started to compete by adding value in already existing insurance products (e.g., additional coverages and services in traditional products). Also, as mentioned above, insurers started to use more cost effective distribution channels. More recently, insurers have become interested in microinsurance products as a means to expand their markets. Therefore, these insurance contracts with more value added, new distribution channels and, to a lesser extent, new products like microinsurance might have allowed the Colombian insurance industry to make technological innovations that translated into a positive TFP change.

6.2.2 Disaggregated Analysis

Insurers specialized in life insurance experienced the largest TFP change, basically explained by TC which totally offset a slight decline TEC. This would suggest that pure life insurers were very successful at incorporating new technological innovations into their business, such as bancasurance and other distribution channels, that allowed the industry to expand the production frontier.

Under the complete panel, this type of insurers experienced an average annual change in TFP of 4.3%, meanwhile, in the adjacent-year sample this change was 8.2%. In the complete panel (adjacent-year) sample, this positive TFP change was totally related to a 6.1% (8.1%) annual average TC change (Table 7).

The positive TC change in pure life insurers fully compensated a negative TEC which was basically explained by its SEC component. The latter exhibited an average annual change of -1.7% (-0.6%) in the complete (adjacent-year) sample. This is consistent with the reduction in scale efficiency of this type of insurers mentioned in the previous section. Finally, also notice that these insurers did not show any significant PTEC change because they were already close to the technological frontier on average.

Joint insurers show a more moderate but positive TFP change coming also from TC which also offset a negative change in scale efficiency. These insurers experienced an annual TFP change of 1.8% (3.4%) on average under the complete (the adjacent-year) sample. This was due to an average annual TC growth of 3.5% (4.6%) under the complete panel (adjacent) sample that totally compensated the negative change in scale efficiency of -1.3% (1%, respectively). Similar to pure life insurers, joint firms did not experience PTEC because they are also close to the technical frontier.

Finally, in the pure non life insurers’ case, there is a significant difference in the TFP growth in the two samples. On one hand, in the complete panel, that represents mature and consolidated firms in the unconcentrated Colombian non life market, this type of firms exhibited an average annual TFP growth of 3.5% primarily explained by a 4.3% TC growth. On the other hand, in the adjacent sample, which includes insurers exiting, entering and being absorbed during the sample period, the firms specialized in non life products exhibited an average annual TFP growth of 0.6%. This modest TFP growth is explained by the combination of a TC change of
1.6% and a negative PTEC growth (-1%). Together, these results suggest that unconsolidated pure non life insurers (i.e., new, exiting or absorbed firms) have found difficulties to take advantages of innovations and catching up with the best practice of an unconcentrated market such as the Colombian non life insurance market. However, consolidated firms have been able to achieve this task.

7 Conclusions

In this paper we analyze the cost efficiency scores of the Colombian Insurance sector during the period 1998-2007, in which the insurance industry experienced an economic crisis and the effects of severe national and international catastrophic events that affected its performance. We used the non-parametric method of Data Envelopment Analysis (DEA) to estimate input-oriented measures of efficiency. We also use DEA to estimate total factor productivity change using Malmquist indices. We present our results both at the aggregate level of the insurance market and disaggregating by type of insurer (i.e., joint insurers, insurers specialized in non life products and companies issuing only life insurance products).

Our results suggest that the Colombian insurance market increased its efficiency since 2002. This allowed the Colombian insurance industry to gain part of the efficiency lost during the turbulent first half of the sample period 1998-2007. Even though it remains the main source of inefficiency, allocative efficiency (i.e., a better choice of input combinations) was also the source of the improvement in cost efficiency. Colombian insurers have still room to improve their cost efficiency in two ways: i) insurers should focus more in improving the way they choose the mixture of inputs and less in increasing their market share; ii) however, there are some companies that exhibit increasing returns to scale which suggests that they could boost their efficiency by increasing their business scale and/or by pursuing consolidation processes. The regulator must take into account this information when assessing potential mergers and acquisitions that could translate into less efficient entities because of the presence of DRS.

Our analysis disaggregated by type of insurer reveals that, in the period 1998-2007, joint insurers showed higher CE scores than specialized insurers due to advantages in allocative efficiency. Nevertheless, diversified insurers lost part of their allocative efficiency in scale efficiency. This gives support to the conglomeration hypothesis which sustains that an insurer can exploit cost scope economies by sharing inputs in joint production. More research and data is needed to study if specialization can overcome the significant advantages in cost efficiency of the joint producers once revenue and profit maximization is incorporated in the analysis. Additionally, insurers specialized in life products have shown a significant increase in CE, due to improvements in AE, that allowed them to catch up with joint insurers.

Using Malmquist indices, our paper also found an increase in the total factor productivity of the Colombian insurance sector. This should translate into welfare gains to society. This productivity change is basically explained by positive technological shifts (i.e., shifts in the frontier of production). This might be related to more efficient distribution channels (such as bancassurance and utility bills) as well as to already existing insurance contracts to which
insurers added more value (e.g., additional coverages and services in traditional products) and to a lesser extent to new microinsurance products that the insurers introduced in the market.
References


