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A Stochastic Frontier Analysis of Efficiency in Argentina's Non-Life Insurance Market

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We estimate the technical efficiency of Argentina's non-life insurance industry and address some questions regarding efficiency: What are the levels of comparative efficiency in the sector? How efficient is the sector as a whole? Has efficiency evolved in recent years or has it stagnated? Is the sector improving its technology? To respond to these questions, we construct a database of the sector and run an SFA estimate to determine the efficiency of individual companies, the sector as a whole, its evolution over recent years and technology change.
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Introduction

The penetration of insurance sector (premiums/GDP) in Argentina is, compared to the regional average of approximately 2.5–3 per cent of GDP, lower than some neighbouring countries (such as Chile) and even lower than developed countries (such as Spain). The sector experienced a contraction in 2001–2002 following the macroeconomic crisis and devaluation of those years. After that, the local economy recovered and GDP grew at high rates for several years. The insurance sector density (per capita premiums) was USD 184 before the crisis and the devaluation, and it had just recovered those levels in 2008. According to Masci *et al.*,[1] while the demand for insurance is growing in the Latin American region, the market is substantially underdeveloped. The market penetration of insurance in Europe, Asia and the United States oscillates between 7 per cent and 9 per cent of GDP, while Latin America averages 2.5 per cent. Argentina falls below the regional average in penetration and density of life insurance, and above the average in both indicators for non-life insurance. Because of its macroeconomic history (of growth instability and inflation), life insurance is relatively underdeveloped in Argentina, and almost two-thirds of the business is non-life. The local insurance market shows high supply

[1] Masci *et al.* (2007).

atomisation and low product diversity (both motor vehicles and labour risks cover more than half of total premiums). Policies pay a 21 per cent VAT and an additional 10 per cent "internal" (consumption) tax, non-deductible for firms.

Following Cummins and Weiss,[2] frontier efficiency analysis creates a framework to analyse decision-making units (DMUs) that do not optimise and, thus, are not fully efficient. Efficiency is evaluated by comparing DMUs to "best practice" efficient frontiers formed by the most efficient DMUs in the sample. Frontier efficiency summarises each DMU performance in a single measure, controlling for differences among DMUs in a sophisticated multidimensional framework that is rooted in economic theory.

We intend to estimate the technical efficiency of Argentina's non-life insurance industry in recent years and address some questions regarding efficiency: What are the levels of comparative efficiency in the sector? How efficient is the sector as a whole? Has efficiency evolved in recent years or has it stagnated? Is the sector improving its technology? Is there any policy recommendation after the efficiency assessment?

To respond to these questions, we construct a database of the sector and run a stochastic frontier analysis (SFA) estimate to determine the efficiency of individual companies, the sector as a whole, its evolution over recent years and technology change.

We find a relatively low efficiency mean for the non-life industry, a stagnated level of efficiency in recent years and a negative technological change. Unfortunately, the lack of input prices or means to infer them because of the absence of physical data (of brokers, for example) do not allow the estimation of cost or profit efficiency, limiting the scope of the study to technical efficiency.

To the best of our knowledge, no other SFA efficiency studies on Argentina's insurance market exist. Moreover, we detected only two previous papers on the efficiency of this market, and both employ DEA. This latter method attributes all deviations from the frontier to inefficiency, being a "deterministic" model in the sense that it does not recognise any randomness from those deviations.[3] SFA technique, in turn, allows separating "inefficiency" from pure statistical noise, representing a more robust assessment of firm efficiency.[4] The SFA method, on the other hand, has its own limitations, which we discuss in the "Method" section.

The paper has seven sections. The next section provides contextual settings. This is followed by a brief survey of the preceding literature. The following section summarises the method, while the "Database and models" section describes the database and the estimates. The sixth section presents the discussion of results and the last section concludes.

Contextual settings

The insurance activity began in Argentina at the end of the nineteenth century, closely linked to the British capital inflows and foreign trade operations with the United Kingdom. In the wake of the crisis of 1930, the volumes of international trade fell sharply, and the country began a period of growth based on import substitution. In the late 1930s, the National

2 Cummins and Weiss (2012).
3 Coelli *et al.* (1998).
4 Alhassan and Biekpe (2016).

Insurance Authority (SSN after its acronym in Spanish) was established in Argentina. Currently, it has a dual function: to provide a regulatory framework for the insurance market (through minimum capital requirements) and to operate as a supervisor of insurers' activities.

In the 1940s, the State began to participate in the insurance market, in line with a more active public participation in resource allocation. The only local reinsurer (with mixed capital) was nationalised and was renamed as the National Institute of Reinsurance (INDER after its acronym in Spanish). Subsequently, the State established a monopoly of INDER's reinsurance.[5] The National Postal Savings Bank, created in 1915, joined the insurance business in 1946 and changed its name to the National Savings and Insurance Fund (CNAS) in 1973. This was a state-owned insurance company, which had a monopoly on mandated property and life insurance of state personnel. Some provincial administrations created insurance companies afterwards, with the public operators managing to hold 15 per cent of the production of the market by the end of the 1970s. At present, State participation exists through provincial insurance entities, primarily Province Insurance, belonging to the Bank of the Province of Buenos Aires.[6]

After the founding of the SSN, a regulatory framework set the legal infrastructure basis for insurance activity development. The relevant legislation for the sector comprises the following:

- Law 17,418/1967, which rules the nature and characteristics of the insurance contract;
- Law 20,091/1973, which regulates the functioning and supervision of insurance companies;
- Law 22,400/1981, which establishes the intermediation system for insurance through the insurance brokers and brokerage firms;
- Law 24,240/1993, which oversees consumer duties;
- Law 24,557/1995, which legislates risk prevention and compensation for work-related accidents; and
- Law 25,246/2000, which protects against money laundering and the financing of terrorism, and includes individual provisions for the insurance industry.

During the 1960s, legislation attempted to incorporate more competitors into the industry; this policy changed in the mid-1970s, suspending the creation of new insurance operators. More than 300 insurers operated in a highly permissive regulatory framework, which resulted in the bankruptcy of entities after the financial crisis of the 1980s.[7] Thus, between 1986 and 1995, the SSN revoked the authorisation of more than 100 entities to operate.

The country underwent a hyperinflationary process between 1989 and 1990 that led to the disappearance of the life insurance sector with savings.[6] After 1991, when the authorities managed to curb inflation, many international life insurance companies set up businesses in the country. In 1994, a reform to the social insurance system transformed a traditional pay-as-you-go mechanism into a fully funded one, and introduced compulsory collective insurance for death or disability risks, covering all contributors. This situation gave rise to new insurers, since the legislation mandated specialised suppliers for this type of insurance.

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[5] Zappino (2007).
[6] García Rapp and Collich (2011).
[7] Peluffo (1997).

The sector experienced the financial crisis of 2001–2002. The currency devaluation led to a sharp fall in premiums measured in dollar terms and was only able to recover in 2008. Following the 2001 crisis, and in particular, owing to the compulsory conversion to pesos of life and retirement dollar-denominated insurance contracts, the life insurance industry confronted a generalised loss of confidence. Following the disappearance of the collective life insurance segment in late 2007 owing to a new pension system reform (reversing that of 1993), representing almost 40 per cent of the life segment, the current market has recorded a continuous decline of up to 20 per cent.[6]

According to Peluffo,[7] in the 1990s—while state intervention in the premiums setting relaxed and the SSN's approval processes for new products moved more swiftly—solvency and liquidity requirements remained the same, maintaining them at much lower levels than those of other countries in the region such as Chile, Brazil and Mexico. Since 2000, the capital requirements have gradually increased, along with the other general requirements and conditions that must comply with the insurance companies to operate in the local market.[8]

Table 1 shows the evolution of the sector in recent years. Nowadays, there are 184 companies (111 non-life and 73 life branches). From 2004 onwards, 20 life insurers closed, and 12 new non-life insurers began activities. The system employs more than 29,000 full-time workers (almost 7,500 more than 10 years ago), almost 28,000 individual brokers (compared to 23,000 in 2004) and 564 brokerage firms. Net premiums in the non-life branches grew by 259 per cent in real terms between 2004 and 2014, but life net premiums grew by only 89 per cent in the same period. The reasons for the latter's slow growth are related to the elimination of the fully funded social security system since 2008, and the revamping of the inflation rate after 2007. Consequently, life business decreased from one-third of the market's net premiums in 2004 to only one-fifth in 2014.

Literature

Luhnen[9] reviews 93 studies in insurance sector efficiency and focuses on three main aspects that are central to the field: (1) methodologies, (2) input and output factors and (3) fields of application and results. He also systematises 10 comprehensive categories of different applications of the frontier efficiency measurement in the insurance industry (distribution systems, financial and risk management, capital utilisation, the general level of efficiency and evolution over time, inter-country comparisons, market structure, mergers, methodology issues—comparing different techniques or assumptions—organisational form and corporate governance, regulation change, and scale and scope economies). Most of the surveyed studies apply DEA to estimate efficiency in the insurance sector. A few studies use both methods—DEA and SFA—and reach consistent results.

DEA is a non-parametric technique, such as free-disposal hull or FDH (less commonly used in the empirical literature). SFA, on the other hand, is a parametric technique as well as distribution-free approach (DFA) and thick frontier approach. Both of the latter are less common than SFA in the empirical literature.[4] Parametric studies specify an efficiency

[8] Ayerbe and Bongiorno (2010).
[9] Luhnen (2009).

Table 1 Recent sector evolution

Variable	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
Non-life companies	99	99	99	96	98	99	100	101	104	108	111
Life companies	93	93	89	88	85	79	81	79	76	78	73
Non-life plus life companies	192	192	188	184	183	178	181	180	180	186	184
Employees (full time)	21,648	22,179	22,282	23,573	24,943	25,088	25,863	27,095	28,190	28,952	29,259
Employees (temporary)	541	528	687	1013	868	549	594	368	435	576	532
Total employees	22,225	22,707	22,969	24,586	25,811	25,637	26,467	27,463	28,625	29,528	29,791
Brokers (individuals)	22,922	24,870	25,095	26,803	22,632	23,788	22,892	23,132	25,031	27,304	27,970
Brokerage firms	358	387	409	420	394	442	450	470	508	545	564
Non-life net premiums in constant 2014 pesos	100	105	118	135	157	187	202	242	281	339	359
Life net premiums in constant 2014 pesos	100	37	119	136	137	117	108	129	156	181	189
Non-life plus life net premiums in constant 2014 pesos	100	112	118	136	151	165	172	206	241	289	305
Non-life/total output	0.68	0.64	0.68	0.68	0.71	0.77	0.80	0.80	0.79	0.80	0.80
Life/total output	0.32	0.11	0.32	0.32	0.29	0.23	0.20	0.20	0.21	0.20	0.20
Premiums/GDP	2.07	2.17	2.09	2.11	2.04	20.8	2.11	2.19	2.37	2.65	3.02

Source: Authors' elaboration from SSN data.

frontier as a function (being the most common functional forms both the Cobb–Douglas and the Translog, but also other more flexible alternatives such as the Fourier, are used in particular cases). Once estimated, the function inefficiency is separated from the residuals of the regression of the statistical noise under different distributional assumptions for the error term: truncated normal, half normal, exponential or gamma.[10]

Luhnen[9] and Eling and Luhnen[11] identify several SFA frontier studies of non-life insurance to assess the general level of technical efficiency and to perform international comparisons of efficiency.

Those studies are Delhausse *et al.*,[12] Eling and Luhnen,[13] Ennsfellner *et al.*,[14] Fecher *et al.*,[15] Fuentes *et al.*,[16] Rai,[17] Weiss[18] and Vencappa *et al.*[19] We identified some articles after the Luhnen[9] survey which use the SFA method. These are Mose,[20] Bhishma Rao and Venkateswarlu[21] and Alhassan and Biekpe.[22]

The articles of Luhnen[9] and Eling and Luhnen[11] also review many studies on technical efficiency in non-life insurance using DEA. They are Barros *et al.*,[23] Barros and Obijiaku,[24] Chaffai and Ouertani,[25] Cummins *et al.*,[26] Leverty *et al.*,[27] Luhnen,[9] and Worthington and Hurley.[28] We identified some articles after the Luhnen[9] survey included in the international literature, as well as two papers on the specific case of Argentina. These are Al-Amri *et al.*,[29] Biener and Eling,[30] Bikker and Gorter,[31] Huang and Eling,[32] and Ferro *et al.*[33] and Schneider and Sánchez,[34] for Argentina.

Mostly all authors seem to agree in the variables to consider as inputs (mostly labour, capital and business services or equivalents) and outputs. To proxy the risk-pooling/risk-bearing function in non-life insurance, the present value of losses is a measure of output,

[10] Battese and Coelli (1988, 1992, 1995).
[11] Eling and Luhnen (2010a, b).
[12] Delhausse *et al.* (1995).
[13] Eling and Luhnen (2008).
[14] Ennsfellner *et al.* (2004).
[15] Fecher *et al.* (1993).
[16] Fuentes *et al.* (2005).
[17] Rai (1996).
[18] Weiss (1991).
[19] Vencappa *et al.* (2008).
[20] Mose (2013).
[21] Bhishma Rao and Venkateswarlu (2014).
[22] Alhassan and Biekpe (2015, 2016).
[23] Barros *et al.* (2005).
[24] Barros and Obijiaku (2007).
[25] Chaffai and Ouertani (2002).
[26] Cummins *et al.* (1996).
[27] Leverty *et al.* (2004).
[28] Worthington and Hurley (2002).
[29] Al-Amri *et al.* (2012).
[30] Biener and Eling (2012).
[31] Bikker and Gorter (2008).
[32] Huang and Eling (2013).
[33] Ferro *et al.* (2011).
[34] Schneider and Sánchez (2012).

while premiums or incurred benefits, and present value of losses are used to proxy outputs in life insurance. Additions to reserves or invested assets are generally used to proxy the output of the financial intermediation function. The present value of losses as well as additions to reserves/invested assets correlate with the third function of insurance: to provide real financial services.[26]

In practice, sometimes the inputs and outputs have to rest on proxies in empirical work, according to the disaggregation level or the overall quality of the available data.

Ferro *et al.*[33] explore the insurance sector in Argentina after a severe macroeconomic crisis. It offers an interesting scenario to explore using Luenberger's productivity indicators to determine what happened in a sector highly sensitive to macroeconomic performance, inflation and currency devaluation. The methodological choice assumes maximising benefits, not constraining the orientation of the models that help measure changes in productivity due to modifications either in output or only in the inputs. Depending on the model, the results show a sector with low or stagnant productivity growth, with much variability in the best and worst results. The indicator used allows us to separate modifications in the efficiency of those caused by technical change. The outputs considered are insurance premiums grouped in life and non-life. The inputs are wages, commissions and other costs.

Schneider and Sánchez[34] propose a model to evaluate the Argentine insurance sector, analysing the efficiency and relative productivity of insurance companies during the period 2002–2011, using DEA and the Malmquist index. The results indicate that, in the last 10 years, the productivity of the market has not improved. One of the causes is technological deterioration during the period. Companies needed more resources to continue producing the same thing. However, they had not invested in their administrative practices and technology, or their investments had not translated into an increase in the level of premiums they had negotiated.

While labour, business services (or equivalent) and capital seem to be the consensus inputs, there are variants for them in the literature. For instance, Delhausse *et al.*[12] employ "other outlays" as an encompassing measure of non-labour costs. Eling and Luhnen[13] and Ennsfellner *et al.*,[14] contemplate "net operating expenses" as the sum of labour and commercial costs, and separate "technical provisions" from "capital". Fecher *et al.*,[15] Fuentes *et al.*,[16] and Rai[17] include also "benefits and claims"; Weiss[18] adds "material"; Vencappa *et al.*[19] include "material"; Mose[20] and Bhishma Rao and Venkateswarlu[21] include other components, since its definition of outputs is more related to profits; and Alhassan and Biekpe[4] differentiates equity from debt capital.

Concerning outputs, Eling and Luhnen,[13] Vencappa *et al.*,[19] and Alhassan and Biekpe[4] use incurred claims, and Ennsfellner *et al.*[14] and Weiss[18] use losses, while Delhausse *et al.*,[12] Fecher *et al.*,[15] Fuentes *et al.*,[16] Rai[17] and Mose[20] use premiums. The problem of using premiums is that they are the product of price times quantity.[35]

In Table 2, we present a summary of the SFA studies on insurance efficiency.

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[35] Yuengert (1993).

Table 2 SFA studies on non-life insurance technical efficiency

Author	*Inputs*	*Outputs*	*Approach*	*Efficiency under analysis*
Delhausse *et al.*[12]	Labour costs Other outlays	Premiums	Value added	Technical Scale
Eling and Luhnen[13]	Labour and business services Financial debt capital Equity capital	Claims + addition to reserves	Value added	Technical Cost
Ennsfellner *et al.*[14]	Net operating expenses Equity capital Technical provisions	Losses incurred Total invested assets	Value added	Technical
Fecher *et al.*[15]	Labour cost Other outlays	Gross premiums	Value added	Technical
Fuentes *et al.*[16]	Labour cost Composite input	Annual premiums	Value added	Technical
Rai[17]	Labour Capital Benefits and claims	Premiums	Value added	Technical
Weiss[18]	Labour Material Capital	Incurred losses Reserves	Value added	Technical Allocative Scale
Vencappa *et al.*[19]	Labour and materials Financial capital Debt capital	Incurred claims	Value added	Technical
Mose[20]	Management expenses Commissions Capital (physical, equity, debt and materials)	Net earned premiums income Investment income	Value added	Technical
Alhassan and Biekpe[4]	Net investment income Commissions and management expenses Total liabilities and assets Annual premium Net incurred claims	Total profits	Value added	Technical
Alhassan and Biekpe[4]	Labour Equity capital Debt capital	Incurred claims Investment inputs	Value added	Cost

Source: Luhnen (2009) and authors' elaboration.

Method

In the estimation of efficiency, this study favours the SFA technique over the DEA technique. DEA, a non-parametric method, does not impose any functional form on the data. In fact, DEA does not estimate a function. Thus, it is a very flexible method. Nevertheless, it does not allow statistical tests of the results. Moreover, the method uses only a subset of the sample (the observations on the frontier), while the rest of the observations are ignored. Being a method very sensitive to outliers, it gives warnings to detect strange data in the sample, sometimes neglected in the econometric work, especially with large samples.[36]

On the other hand, the SFA method is parametric (estimates a function) and stochastic (separates efficiency and randomness from the errors of estimation). The election of the adequate functional form is a disadvantage of the method, as well as the need for a criterion for separating stochastic from deterministic components (as stated, there are several possible decompositions of the error term, following different statistical distribution). The main advantage of the method, besides the possibility of separating randomness from inefficiency, is that it is possible to apply statistical tests to the results.[36]

The general form to estimate a production frontier according Battese and Coelli[37] is

$$Y_{it} = Y(x_{it}, z_{it}; \beta) + v_{it} - u_{it}, \quad (1)$$

where Y_{it} is the observed output for each decision-making unit (DMU) i in period t; x_{it} is the input vector; z_{it} is the environmental variable vector; β is the unknown parameter vector to estimate; $v_{it} \sim N(0, \sigma_{\mathrm{v}}^2)$ is a random error (independently and identically distributed); $u_{it} \sim N^{+}(\mu, \sigma_{\mathrm{u}}^2)$ is an inefficiency parameter (with truncated normal distribution). In addition, u_{it} and v_{it} are independently distributed from each other and from the model's covariates.

Both, the stochastic frontier model and the inefficiency term are estimated simultaneously through maximum likelihood. The likelihood function is expressed in terms of the variance parameters for the compound error, σ^2, that is, the sum of the variances σ_{v}^2 and σ_{u}^2 and gamma, which is the ratio between the variances σ_{u}^2 and σ^2, $\gamma = \frac{\sigma_{\mathrm{u}}^2}{\sigma^2}$, where $0 < \gamma < 1$. If $\gamma = 1$, the residual variability can be totally explained by the efficiency component u. Instead, if $\gamma = 0$, all the residual variability is randomness.

The inefficiency score for an individual DMU is $\exp(u_{it})$, with values between one and infinite. Efficiency measures are the multiplicative inverse of the preceding value, taking a maximum value of one for efficient DMUs, and fractional values ($0 \leq$ scores < 1) for inefficient DMUs.

As to the specific form of the production function, the real functional form is unknown. The more common choices in the literature are the Cobb–Douglas and the translogarithmic (or "translog") forms, and to test whether the efficiency is invariant in time versus the opposite hypothesis, a time-varying decay (TVD) model and a time-invariant (TI) model are estimated. In the first one, there is a different u_{it} for each period t, while in the second, u_i is uniform for each t.

[36] Coelli *et al.* (1998).
[37] Battese and Coelli (1992).

The following is a simplified representation of the Cobb–Douglas function in its logarithmic form:

$$\ln y = \ln \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_n, \tag{2}$$

where Y is the output; X is the input vector, and β are the unknown coefficients to estimate.

The Cobb–Douglas formula is quite common in the empirical literature because of its simplicity and easy interpretation.

The trans-logarithmic formulation is

$$\ln y = \beta_0 + \sum_{n=1}^{N} \beta_n \ln x_n + \frac{1}{2} \sum_{n=1}^{N} \cdot \sum_{m=1}^{M} \beta_{nm} \ln x_n \cdot \ln x_m \tag{3}$$

The trans-logarithmic function has the advantage of being more flexible than Cobb–Douglas. It does not impose a priori constraints on input substitution feasibility and allows scale economies to vary together with the output level.

A temporal variable can also be included to capture the technological progress or frontier shift occurring in time. We assume that technological progress directly affects the production function; that is, DMUs are subject to the same technological shocks overtime. These shocks include a linear indication of time in the Cobb–Douglas (T) and a quadratic polynomial of time in the trans-logarithmic equation, because this functional form is a second-order approximation (including the T term as well as the T^2 term). The rate of technological change is given by $T^* = \partial y / \partial t$. Time can affect productivity due to technical change. If $T^* > 0$, technical change is positive, indicating a growth in productivity, and vice versa.

Some selective "environmental" variables can also be included in the preceding basic models (also known as hedonic or control variables). They imply fairer comparisons, explaining heterogeneous situations that affect firms that they cannot control.

We run two versions of stochastic frontiers: with time-invariant inefficiency (TI) and with variable inefficiency or a time-varying decay model (TVD).

In the TI version, we assume a truncated normal distribution for inefficiency, while in the Battese and Coelli[37] parameterisation of the time effect, the inefficiency term is a truncated normal stochastic variable multiplied by a specific function of time.

In the TVD model, $u_{it} = \exp\{-\eta(t - T_i)\}u_i$, where T_i is the last period in the panel for DMU i, and η is the variation in the time parameter for inefficiency.

While efficiency levels change over time in the TVD models, they vary in the same proportion for every firm, not producing changes in rankings across years. Note the inefficiency increase (decrease) over time when coefficient η is positive (negative). If η is zero, inefficiency will be constant over time.

Database and models

The literature uses three main approaches to measure outputs in insurance markets: the asset or intermediation approach, the user-cost approach, and the value-added approach. The inputs in the intermediation approach consist of borrowed funds—such as policy

Table 3 Description of the variables

Variables	*Abbreviation*	*Type*	*Definition (as in insurers' balance sheets)*
Total losses	Loss	Output	Technical losses + financial losses
Direct labour costs	Wage	Input	Wages (operative staff) + salaries and honorariums (directives and managers) + payroll and social security taxes = exploitation expenses − marketing and publicity
Commissions to brokers	Comm	Input	Total production expenses (commissions to brokers + marketing and publicity)
Financial capital	Capi	Input	Liabilities + equity capital

Source: Authors' elaboration on SSN data.

reserves—and the outputs are assets. It would not be applicable for non-life insurers because they provide many services in addition to financial intermediation. For life insurers, intermediation is the most important function. The user-cost method determines whether a financial product is an input or output based on its net contribution to the revenues of the financial institution. The value-added approach is the most suitable method to study insurance efficiency.[2]

As Cummins and Weiss[2] point out, for non-life insurers, a good proxy for the quantity of risk-pooling and insurance services is the present value of real losses incurred. Losses incurred are those paid for providing coverage. Average real invested assets, in turn, measure the intermediation output for non-life insurers. Labour, business services and materials, and capital are the main inputs. Labour can be divided into brokers labour (commissions mostly) and home office labour (mostly wages). In addition, there are at least three types of capital: physical capital (fixed assets), debt capital (liabilities) and equity capital (or financial capital).

Table 3 presents a description of the variables we use in the estimates. We use Loss (total losses) for the dependent variable (output). The inputs are Wage (direct labour costs) for own personnel, and Comm (commissions to brokers) for brokerage, and Capi (financial capital, including liabilities and equity capital). The estimated model is, then, Formula (4).

The selection of those variables rests, on the one hand, on the structure of the sector and the way it is organised, and on the other hand, on the form the SSN presents the data. The sector is mostly motor insurance. Companies sell their policies through agents, who earn commissions, and rely for back office work on their own staff, who earn wages, salaries and honorariums (plus social security taxes). Portfolio management expenses are included in the former. The balance sheets for the insurers, as informed by the SSN, include Technical and Financial Losses (our variable for total losses—output), and open costs into Exploitation Expenses (mainly labour costs as explained above) and Production Costs (mainly commercial costs—commissions—but also including marketing and publicity). Those are our proxies to own administrative labour and commercial expenses, respectively. Finally, Liabilities and Equity Capital together proxies the capital input for the industry.

Table 4 Descriptive statistics—period 2009–2014

Variables	*Observations*	*Mean*	*SD*	*Minimum*	*Maximum*
Financial capital	416	1,654	2,817	16	20,264
Commissions to brokers	416	220	356	1.4	2,922
Direct labour costs	416	157	290	497	3,043
Total losses	416	2,513	4,501	2.3	31,084

In million pesos of 2009.

Source: Authors' elaboration on SSN data.

$$\ln(\text{Loss}) = f[\ln(\text{Wage}), \ln(\text{Comm}), \ln(\text{Capi}), \text{Time Trend}] \quad (4)$$

We run a Cobb–Douglas and a trans-logarithmic model, with both time-invariant (TI) and time-variant decay (TVD) versions of each specification. In the case of the trans-logarithmic model, the time trend term is quadratic.

Table 4 presents the descriptive statistic of the main components of the system's balance sheet and the variables we create to run the models. We consider the period 2009–2014; all money variables are expressed in constant pesos of 2009 (USD 1 = ARS 3.80 at 31 December 2009). The sample is an unbalanced panel of 73 companies and 416 observations.

Table 5 Results

LnLoss	*Cobb–Douglas models*	
	Time-invariant	*Time-variant decay*
LnWage	0.3772***	0.3714***
LnComm	0.0422***	0.0420***
LnCapi	0.7228***	0.7270***
T	−0.0430***	−0.0460***
Constant	−0.5822	−0.5512
Mu	0.9255***	0.9159***
Eta		0.0041
Lnsigma2	−1.5746***	−1.5908***
Ilgtgamma	2.2320***	2.2144***
Sigma2	0.2071	0.2038
Gamma	0.9031	0.9015
Sigma_u2	0.1870	0.1837
Sigma_v2	0.0201	0.0200
Groups	73	73
Observations	416	416
Technical efficiency		
Mean	0.42	0.42
SD	0.17	0.17
Minimum	0.12	0.11
Maximum	0.93	0.93

Source: Authors' elaboration.

Table 6 Technical efficiency scores (firms by quintile)

Technical efficiency scores	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
1 More than 80%	2	2	2	2	2	2
2 Between 60–80%	8	8	8	8	8	8
3 Between 40–60%	23	23	23	23	23	23
4 Between 20–40%	32	32	32	32	33	33
5 Less than 20%	3	4	3	4	5	5
Total firms	68	69	68	69	71	71
Mean	0.43	0.42	0.43	0.42	0.42	0.42
SD	0.17	0.17	0.17	0.17	0.17	0.17
Minimum	0.14	0.12	0.14	0.12	0.12	0.12
Maximum	0.93	0.93	0.93	0.93	0.93	0.93

Source: Authors' elaboration.

Results

Table 5 presents the results of the Cobb–Douglas estimates. We reject the trans-logarithmic versions because (1) most of the quadratic and interaction variables were not significant and (2) Cobb–Douglas was preferable after testing the functional forms because of the results of the likelihood ratio test and the values of Akaike and Bayesian decision criteria.

In turn, we present both time-invariant and time-variant decay versions, the former being the preferred version since eta is not significant in the time-variant decay version.

As was expected, the signs of the LnWage, LnComm and LnCapi are positive. All the variables are significant at 99 per cent. The time trend is significant and negative, indicating that technological change was negative. The most efficient company has 93 per cent technical efficiency, the mean of the sample registering 42 per cent, with a standard deviation of 17 per cent. The value of gamma is 0.90, indicating that the 90 per cent of the variance of the composed error ($u + v$) is due to inefficiency (the remaining 10 per cent is pure randomness).

In Table 6, we present the number of companies that make up each quintile of technical efficiency scores for each year of the period studied. More than 70 per cent of the sample

Table 7 Technical efficiency scores, size ratio and technical business ratio

Technical efficiency scores	*Size ratio* $Assets_i \big/ \left(\sum_i Assets\right)$				*Technical business ratio* $\frac{TechnicalLosses_i}{(TechnicalplusFinancialLosses_i)}$			
Quintiles (per cent)	*Mean*	*SD*	*Minimum*	*Maximum*	*Mean*	*SD*	*Minimum*	*Maximum*
1. More than 80	0.0060	0.0040	0.0010	0.0110	0.8580	0.0670	0.8030	0.9930
2. Between 60–80	0.0100	0.0110	0.0006	0.0480	0.8550	0.0680	0.7660	0.9980
3. Between 40–60	0.0120	0.0200	0.0003	0.0780	0.8500	0.0690	0.6890	0.9990
4. Between 20–40	0.0180	0.0250	0.0003	0.1060	0.8440	0.0840	0.3530	1.0070
5. Less than 20	0.0100	0.0130	0.0002	0.0350	0.8360	0.0760	0.7180	1.0000

Source: Authors' elaboration.

Table 8 Technical efficiency scores and ratio of claims paid/technical losses

Technical efficiency scores	*Ratio of claims paid (claims paid/technical losses)*			
Quintiles (per cent)	*Mean*	*SD*	*Minimum*	*Maximum*
1. More than 80	0.6441	0.0468	0.5678	0.7262
2. Between 60–80	0.5760	0.1786	0.0844	0.9393
3. Between 40–60	0.5201	0.1726	0.0597	0.8265
4. Between 20–40	0.4525	0.1795	0.1795	0.7951
5. Less than 20	0.3644	0.1691	0.1691	0.7101

Source: Authors' elaboration.

record efficiency values between 20 per cent and 60 per cent, as well as an average of between 42 per cent and 43 per cent. Although the selected model estimated a stable level of efficiency over time for each firm, the average efficiency for the insurance market can vary over time if the firms that make up the sector vary. In this case, the variation on average has been small because few firms exited or entered the market during the period 2009–2014.

The company with the lowest technical efficiency for years 2009 and 2011 registered a value of 14 per cent and 12 per cent efficient in the remaining years. Indeed, the company with a greater level of efficiency recorded a value of 93 per cent in all the years of the period under study.

We segmented the efficiency scores throughout the period under analysis, relating their levels with "size" and "technical business ratio" (Table 7). "Size" is the share of each individual company's assets with respect to total assets of the sample. In turn, "technical business ratio" is the participation of each firm's technical loss to total losses. Companies that cover most of the market showed low to average levels of technical efficiency (ranging between 20 per cent and 60 per cent), while the average size of the companies was similar in all segments of efficiency, with an average relatively small size for the segment of the more efficient firms. The smallest firms tended to be somewhat efficient, respectively (quintiles 1 and 5). On the other hand, the technical business average ratio was quite similar for all the quintiles but grew slightly with each quintile.

The most efficient company throughout the period was Segurcoop (93 per cent efficient) with a market share of between 0.8 per cent and 1.1 per cent from 2009 to 2014. The technical ratio was from 99 per cent to 81 per cent between 2009 and 2014. The least efficient companies were 12 per cent and 14 per cent efficient, respectively, in different years. Both are small companies, and in the two cases, the technical business ratio decreased over the period (84–78 per cent and 97–72 per cent, respectively, between 2009 and 2014).

Finally, Table 8 shows that the higher the technical efficiency, the higher the ratio of claims paid to technical losses (proposed by Mose[20]). The lowest average ratio is for the less efficient firms.

Conclusions

We have estimated the technical efficiency of the non-life insurance industry for Argentina in recent years to try to answer four questions: What are the levels of comparative efficiency in the sector? How efficient is the sector as a whole? Has efficiency evolved in recent years or has it stagnated? Has the sector improved its technology in the recent years? Is there any policy recommendation?

We built a database of the sector and ran a SFA estimate to determine the efficiency of individual companies and the sector as a whole, its evolution during recent years and technology change. The selected model was the estimation of a Cobb–Douglas production function in logarithms, with total losses as a dependent variable and wages, commissions to brokers and financial capital as independent variables.

A time-invariant efficiency model was preferable to a time-variant decay model given the results of the decision criteria tests. The results advanced some answers to the questions we proposed: We found a relatively low efficiency mean for the non-life industry, a stagnated level of efficiency in recent years and a negative technological change.

The average technical efficiency of the non-life insurance market obtained from the selected model yielded a value of 42 per cent.

More than 70 per cent of the firms in the sample obtained between 20 per cent and 60 per cent efficiency levels. It seems that the sector's performance did not reveal significant changes that would show efficiency evolution over time (time-variant decay models fail to reject a null hypothesis for eta = 0).

Likewise, there was evidence of a negative technological change (through the sign and significance of the temporal variable), most likely reflecting the lack of investment in information technology in recent years. Finally, we observed that most of the efficient firms had a small size ratio, as well as an average ratio of technical business, which means smaller companies are more efficient, and that they are doing similar business than the average firms of the sample.

The results of the study highlight two policy points: efficiency improvements are possible by increasing the output with the same existing inputs or decreasing the inputs but maintaining current output levels. One way for inducing the former is to decrease the heavy taxes on policies (to induce an increase of insurance demand, which permits apportioning more appropriately the inputs in use). Another theoretical way to achieve the latter goal, is to promote mergers to eliminate redundancies in inputs and to gain scale economies. Nevertheless, the estimates are contradictory with regard to the latter goal, since the more efficient insurers of the sample are the smaller ones. Both proposals (lower taxes and higher scale) deserve more research, especially the latter item. If data were available, estimates of cost and profit efficiencies would add elements to the comprehension of the sector performance.

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