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Efficiency Analysis of Lloyd's Syndicates: A Comparison of DEA and SFA Approaches

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Abstract

This paper evaluates the efficiency of the twenty-one largest Syndicates of Lloyd's of London. Members of Lloyd's of London are grouped into Syndicates in order to undertake insurance liabilities. In this study, the Syndicate is regarded as the counterpart of an insurance company in a regular insurance market. The analysis covers a period of eight years between 2004 and 2011. Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are used to estimate the efficiency of the Syndicates, and comparisons are made for the consistency of the two methods. The main findings indicate, firstly, that the average annual efficiency estimates for all Syndicates are plausible and they follow three-year cycles. Secondly, the less efficient syndicates may reduce inputs by almost one-third and still produce the same output, provided that they adopt the "best practices" of the most efficient Syndicates.

JEL Classification: G22, D24, D22
Keywords: Insurance, Lloyd's, efficiency, DEA, SFA

1. Introduction

The aim of this study is to estimate the efficiency of the main Syndicates of the Lloyd's market. Efficiency analysis of insurance companies has been a common research theme in almost all developed insurance markets, but this is the first attempt to analyze the efficiency of the major Lloyd's Syndicates.[1] In this study, we consider

[1] Eling, M. and Luhnen M. 2010. "Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematization, and Recent Developments." *The Geneva Papers* 35(2): 217-265.

that a Syndicate is the counterpart of an insurance company within the Lloyd's insurance exchange. Lloyd's does not assume risks in the manner of other insurers. Instead, members of Lloyd's, called Names (physical persons as well as limited liability corporate sponsors), accept insurance risks by providing capital to an underwriting Syndicate; each Syndicate accepts risks through one or more brokers.

The arrangement of Lloyd's of London is similar to that of an organized stock exchange; the physical facilities are owned by the exchange but business is transacted by the members. Syndicates, rather than Names, make the underwriting decisions of which risks to accept. Syndicate accounts are audited annually to ensure that assets and liabilities are correctly valued and that assets are sufficient to meet underwriting liabilities. Normally, profits are distributed annually. Following losses, Names may be asked to make additional contributions. Annual reports of Syndicates have the structure of the financial statements of regular insurance companies. Therefore, it is logical to consider Syndicates as the equivalent form of an insurance company within the Lloyd's structure.

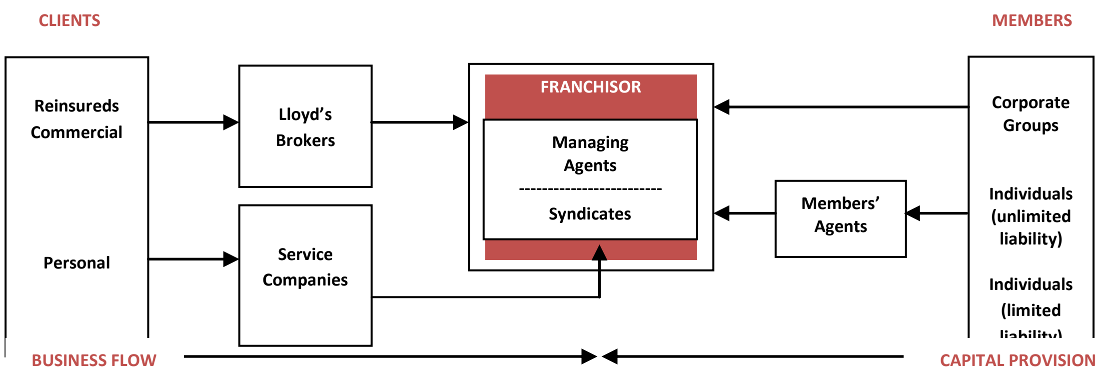
Efficiency analysis is quite appropriate for the Lloyd's of London market. This market has been going through considerable change since the late 1990's, when the market faced the consecutive losses from liability claims from asbestos and pollution risks in the US and claims from natural catastrophes and man-made catastrophes. The capital sock was so severe that many structural changes took place over a number of years: drastic consolidation in the number of Names and Syndicates, allowance of corporate Names with limited liability, change in supervision, etc. These events happened at the same time when the rest of the European insurance markets were entering a period of deregulation and fierce competition. Therefore, the reengineering process for the Lloyd's Syndicates had to be quick and effective. Under such circumstances it is logical to expect the parties concerned to react by attempting to increase the efficient use of resources. One procedure adopted for improving competitiveness is benchmarking; these results from research carried out into the industry's best practices, based on the idea that the widespread application of these practices can lead to improved performance throughout the whole industry.

In this study, we analyze the comparative efficiency of the major Lloyd's Syndicates, assessing the sector's efficiency by using a variety of metrics to measure inputs and outputs that combine financial as well as operational features. In the next section, an overview of the operational structure of Lloyd's is presented. In the third section, a literature review of the data envelopment analysis and stochastic frontier analysis applications in insurance is presented. In the fourth section an analysis of the frontier efficiency methodologies is made and the appropriate insurance inputs and outputs are analyzed. In the fifth section, the data on inputs and outputs are presented and discussed. The sixth section presents the empirical results and the seventh section provides the conclusions of this study.

2. Operational Organization of Lloyd's of London

Lloyd's of London is in itself not an insurance company, but an insurance exchange where insurance is bought and sold.[2] Lloyd's is the leading specialist insurance market. Although the market started to operate in 1688, by offering marine insurance, today the Lloyd's market covers some of the largest and most complex risks worldwide. Lloyd's of London is a partially mutualized insurance market where the members of Lloyd's, the Names, are grouped into Syndicates in order to assume insurance liabilities. The economic expansion through the international trade and shipping in the late 19th and early 20th century helped the Lloyd's market to diversify its portfolio by underwriting its first motor and aviation policies in 1906 and 1911 respectively. Furthermore, the immediate settlement of claims in the San Francisco earthquake and fire that occurred in 1906, elevated the reputation of Lloyd's in the US and established its position as the world's dominant insurance market.[3] Today, Lloyds is licensed to underwrite insurance business in 79 territories and accept risks from 200 countries and territories.[4] Figure 1 shows the structure of the Lloyd's market.

Figure 1: Lloyd's Market Participants.



Source: Standard & Poor's, 2011.

In this partially mutualized and competitive marketplace, insurance and reinsurance buyers, with the assistance of brokers, search in order to find the appropriate risk carriers, known as "Names" or "Members" which are Lloyd's capital providers.[5]Every year, they join together to form syndicates in order to accept insurance risks for their clients in return for insurance premiums. Before 1994, all members of Lloyd's were private individuals with unlimited liability. However, the Council of Lloyd's, after the severe losses that the market faced between 1988 and 1992 and the subsequent erosion of members' wealth allowed corporations to enter

[2]Parsons, C., 2011. Insurance Markets. SMM352: Theory of Risk and Insurance Markets. Cass Business School, unpublished.
[3]Roberts, R., 2008. CITY: A Guide to London's Global Financial Centre. 2nd ed. London: Profile Books Ltd.
[4] Lloyd's, 2008. Key Facts. London: Lloyd's.
[5] Standard & Poor's, 2011. Standard & Poor's Rating of the Lloyd's Market. London: Standard & Poor's.

the market and eliminate capital shortage problems.[6] Liability claims from asbestos and pollution risks in the US and claims from natural catastrophes and man-made catastrophes like the Piper Alpha oil-rig fire hit the Lloyd's market and the capital of Lloyd's members substantially.[7] Moreover, between 1990 and 2005 the number of Lloyd's members decreased significantly from 28,000 to 1,625. Despite the great decrease in the number of Names, the insurance capacity of the Lloyd's market has increased substantially. Table 1 displays also the rapid growth of corporate capital-backed insurance capacity from zero to 87 per cent between 1990 and 2005 and has been maintained at this level thereafter;[8] corporate members, unlike individual Names, have their liability limited to the amount of invested capital.

Table 1: Lloyd's Syndicates and Capacity, 1990-2010.

	1990	1995	2001	2005	2006	2007	2008	2009	2010
Number of Syndicates	401	170	108	62	62	65	75	80	90
Goss allocated capacity (£bn)									
Individual members	10.7	7.8	1.8	1.8	1.8	1.7	1.5	1.5	1.5
Corporate members	-	2.4	9.3	11.9	13.0	14.4	14.5	15.9	21.3
Total	10.7	10.2	11.1	13.7	14.8	16.1	16.0	17.4	22.8

Source: Richard Roberts, CITY: A Guide to London's Global Financial Centre, 2008.
AON Benfield, 2011, Lloyd's Update: 2009 Results and 2010 Capacity (AON: London)

3. Literature Review

Frontier efficiency methodologies are benchmarking techniques, which are used in order to measure the performance of firms relative to "best practice" frontiers consisting of the leading firms in a particular industry.[9] Cummins and Weiss (2012) statethat these techniques are better than other traditional benchmarking techniques, such as financial ratio analysis. This happens because frontier efficiency methodologies summarize the performance of a firm in a single statistic, which

[6] Ibid.
[7] Parsons, C., 2011. Insurance Markets. SMM352 Theory of Risk and Insurance Markets. Cass Business School, unpublished.
[8] Roberts, R., 2008. CITY: A Guide to London's Global Financial Centre. 2nd ed. London: Profile Books Ltd. and AON Benfield (2011).
[9] Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematisation, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.

controls for the differences among firms by using a sophisticated multidimensional framework[10].

Frontier efficiency methodologies have been used extensively in the past twenty years in the financial services sector. A recent review article by Eling and Luhnen (2010) summarizes 95 papers, which focus on frontier efficiency in the insurance industry; these 95 studies consist of 63 published articles and 32 working papers. Earlier literature reviews documented the initial steps in efficiency frontier applications for the banking sector (Berger and Humphrey, 1997) and the insurance sector (Cummins and Weiss, 2000).

Generally, frontier efficiency methodologies measure the performance of a firm relative to a "best practice" frontier. The "best practice" frontier is determined by the most efficient firms in the particular industry. The efficiency score ranges between zero (0) and one (1). The least efficient firms in the industry receive the value of zero (0), and the most efficient firms receive the value of one (1).[11] Cooper, Seiford and Tone (2007) state that the difference between the firm's estimated value and the value of one (1) is a measure of "inefficiency gap" and can be explained as the firm's improvement potential in terms of efficiency in the particular industry. Moreover, efficient frontier analysis is implemented by employing two main approaches. The first is the econometric approach and the second is the mathematical programming approach. Both of them will be used in this study.

The *econometric approaches* define a function, which can be production, cost, revenue or profit, with a specific shape and make assumptions about the distribution of the inefficiency and error terms.[12] The econometric frontier approach is divided in three principal types. The first is the stochastic frontier approach (SFA). SFA is used more regularly than the other two approaches and was introduced by Aigner, Lovell and Schmidt (1977); under this approach, there is a composed error model where inefficiencies follow an asymmetric distribution, such as half-normal, exponential or gamma, and a random error term that follows a symmetric distribution which is usually normal.[13] The second is the distribution-free approach (DFA), which makes fewer assumptions, but commands many years of data. The third is the thick frontier approach (TFA), which does not consider random error and inefficiency terms, but assumes that inefficiencies differ between the highest and the lowest quartile firms.[14]

The *mathematical programming approaches* use also multiple inputs and outputs and they differentiate themselves from the econometric approaches in two ways. They do not impose any functional form on the data, and the second is that they do not

[10] Cummins, J.D. and Weiss M.A, 2000. Analyzing Firm Performance in the Insurance Industry Using Frontier Efficiency Methods. In: G. Dionne, ed. Handbook of Insurance Economics. Boston, MA: Kluwer Academics Publishers.
[11] Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematization, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.
[12] Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematization, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.
[13] Ibid.
[14] Kumbhakar, S.C. and Lovell, C.A.K., 2000. Stochastic Frontier Analysis. New York: Cambridge University Press.

decompose the inefficiency and error terms[15]. Data envelopment analysis (DEA) is the most well known mathematical programming approach. DEA uses linear programming in order to measure the relationship of produced goods and services (outputs) to assigned resources (inputs).[16]

Efficient frontier methodologies changed the way insurance economics work. The traditional micro-economic theory, which postulates that only profit-making companies survive, gave Farrell (1957) the chance to expand this absolute theory and provide additional information for certain production inputs and outputs that determine firm performance and allow for the survival of the less competitive firms for a longer period of time. Farrell showed that companies that are not very efficient could be evaluated by comparing them to the most efficient companies in the industry (companies on the “best practice” efficient frontier).

Cummins and Weiss (2000) state that the efficiency frontier analysis has rendered the traditional analysis of financial ratios for the insurance industry obsolete. Moreover, numerous studies have been undertaken in many insurance markets around the world that compare insurance companies relative to other companies in the same industry or among national industries.

Most efficiency analyses to date in insurance have focused on production and cost efficiency. The most basic frontier is the production frontier, which is estimated based on the assumption that the firm is minimizing input use conditional on output levels: the input-oriented frontier. Production frontiers can be estimated even if data on input prices are not available; if such data are available; a cost-frontier can be estimated.[17]

In the survey by Eling and Luhnen (2010), which summarizes 95 papers on frontier efficiency in the insurance industry, 55 papers use DEA, 22 use SFA, seven use DFA and one uses FDH (Free-Disposal Hull), which is a special configuration of DEA. The remaining ten papers followed the advice given by Cummins and Zi (1998) and used both econometric and mathematical programming approaches in their analyses.

Mahlberg and Url (2003) analysed the effects of liberalization on technical efficiency and the productivity development in the Austrian insurance market between 1992 and 1999. They used four inputs: number of employees, liquid investment, gross technical provision, and reinsurance premium; and four outputs: market share, profits, total investment income, and premium written. They found that inefficiencies still existed in this market despite the implementation of the Single Market Directive in 1994. More specifically, the average insurance firm in the Austrian market had the potential to reduce costs by 34 percentage points by increasing technical efficiency close to the benchmark level.

[15] Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematization, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.
[16] Ibid.

[17] Cummins, J.D. and Weiss M.A., 2000. Analyzing Firm Performance in the Insurance Industry Using Frontier Efficiency Methods. In: G. Dionne, ed. Handbook of Insurance Economics. Boston, MA: Kluwer Academics Publishers.

Hardwick, Adams and Zou (2004), used a sample of 50 UK life insurance companies during 1994-2001 and surveyed the empirical relation between various organizational forms and cost efficiencies. The findings showed that cost efficiency is positively related to the size of the corporate board of directors. However, they also found that the presence of non-executive directors and the separation of the functions of the CEO and the Chairman reduce UK life insurer's cost efficiencies. Barros, Barroso and Borges (2005) found that increased competition from the European's Union (EU) Single Market Programme (SMP) increased the technical efficiency of 27 Portuguese insurance companies during 1995-2001, but did not cause any improvement in technological change. Tone and Sahoo (2005) evaluated the efficiency of the life insurance industry in India between 1982 and 2001. The findings of this paper showed an increase in cost efficiency scores over this period.

Diboky and Ubl (2007) measured the effects of different ownership structures (such as public, mutual and stock) on cost efficiency in the German life insurance industry during 2002-2005. They found that stock and mutual insurers operated more efficiently than public insurers. Yao, Han and Feng (2007) 24 analysed the technical efficiency of 22 insurance companies in China during 1999-2004. They found that many insurers had improved their technical efficiency during this period, but at the same time competition forced insurers to invest more inputs in order to produce the same amount of outputs. Also, general insurers had an efficiency score of 0.77 and life insurers had a score of 0.70. Xie (2008) measured that US property-liability insurance companies that issued initial public offerings (IPO) did not performed differently than non-listed insurance companies in relation to cost and revenue efficiency. The study covered a period of 11 years between 1993 and 2004. Barros, Nektarios and Assaf (2010) examined the effects of deregulation on the efficiency of the Greek insurance market between 1994 and 2003. An important finding of this paper was that competition for market share was a significant parameter that increased efficiency in this market. However, the consolidation that occurred during this period was not enough to maintain the level of efficiency and after 1997 a large number of Greek insurance companies operated on declining efficiency. The main reasons of this declining efficiency were inadequacies in management, scale and technology. In 2011, a DEA analysis was undertaken in the newly researched field of micro-insurance; the results were inconclusive (Biener and Eling, 2011).

In addition to efficiency analyses of national insurance markets, there are some major international comparative studies. Diacon (2001) measured the efficiency of 431 general insurance companies in six countries (UK, Germany, France, Italy, Netherlands and Switzerland) for the year 1999. He observed that UK insurers had the highest average efficiency score with 77%. The other countries had the following efficiency scores: Germany – 70%, France – 67%, the Netherlands – 69%, Switzerland – 66%, Italy – 56%. Croce and Bertoni (2008) analyzed the efficiency of 602 life insurance companies between 1997 and 2004 in five European countries (UK, Germany, France, Spain and Italy). Their purpose was to investigate inefficiencies among life insurance companies and recognize differences among these insurance markets. By using data envelopment analysis (DEA), they found that there are significant inefficiencies among European life insurance companies and also that important differences existed across these countries both at the level and the source of the inefficiency. More specifically, the German and the French insurance markets showed high scale inefficiencies, when evaluated in their own market and when compared to the other European insurance markets. However, the interesting point that this paper revealed was the on-going convergence process towards "best practices" that has started to reduce the differences among these countries.

4. Methodology

Data envelopment analysis (DEA)

Data envelopment analysis (DEA) was originally established in order to measure efficiency in an input-output orientation based on the concept of Pareto optimum.[18] DEA uses linear programming inorder to estimate the relationship between produced goods and services (outputs) to assigned resources (inputs).[19] Moreover, DEA models can be based in either of two assumptions. The first assumption is the Constant Returns to Scale (CRS) and the second is the Variable Returns to Scale (VRS); respective models have been developed. Charnes, Cooper and Rhodes (1978) developed the CCR Model which follows the assumption of constant returns to scale (CRS); and Banker, Charnes and Cooper (1984) developed the BCC Model which follows the assumption of variable returns to scale (VRS). Also, both CCR and BCC Models can be input or output oriented.[20]

In this paper, we follow the DEA methodology in order to estimate technical efficiency of Lloyd's syndicates by assuming variable returns to scale (VRS): varying an input x by k, the output y varies by ky. In insurance efficiency studies both VRS and constant return to scale (CRS) have been considered.[21]Additionally, we follow the output oriented model of the VRS Model, which aims to maximize outputs while satisfying at least the given input levels, if we assume that insurance companies act in a competitive market.[22,23,24] DMUs are output-oriented, since we assume that inputs are under the control of the DMU,which aims to maximize its output subject to market demand (something thatis outside the control of the DMU).

The technical efficiency of the decision-making unit (DMU) *i* is measured by the following ratio:

[18]Charnes, A, Cooper, W.W. and Rhodes, E., 1978. Measuring the Efficiency of Decision Making Units. European Journal of Operational Research, 2, pp. 429-444.

[19] Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematisation, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.

[20] Yao, S., Han, Z. and Feng, G., 2007. On Technical Efficiency of China's Insurance Industry after WTO accession. China Economic Review, 18(1), pp. 66-86.

[21]Borges MS, Nektarios M, Barros CP. 2008. Analysing The Efficiency Of The Greek Life Insurance Industry European Research Studies Journal (3) 35-52

[22]Ibid.

[23]Khumabhakar, SC. 1987. Production Frontiers-Issues and Practice and panel data: An application to US class 1 railroads. Journal of Business and Economic Statistics 5(2): 249-255

[24]Zellner, A, Kmetra, J and Dreze J. 1996, Specification and estimation of Cobb-Douglas functions. Econometrica 34(4):784-795.

$$\max \sum_{s=1}^{S} U_s Y_{s0}$$

$$st.$$

$$\sum_{s=1}^{S} U_s Y_{si} - \sum_{m=1}^{M} V_m X_{mi} \leq 0$$
$$\sum_{m=1}^{M} U_m X_{mi} = 0$$
$$U_s, V_m \geq 0$$

A last requirement for the effective application of the DEA method is that the number of DMUs should be greater than three times the sum of the input and output variables; in such a case, the model has the increased capacity to locate and classify the efficient DMUs. In the next section, we shall show that our data set satisfies this requirement.

The stochastic cost frontier function (SFA)

Our method constructs a best-practice cost frontier from the data in the sample. Frontier approaches do not necessarily observe the *true* (unobserved) technological frontier, but rather the best-practice reference technology. An observation is cost inefficient if it does not minimize its cost given its output. Efficiency scores of unity mean that the contract is on the frontier. Efficiency scores greater than unity mean that the contract is above the frontier: in this case, a further proportional decrease in cost is feasible, given output level and technology.

We consider a cross-section data model for inefficiency effects in stochastic cost frontiers based on the Battese and Coellimodel.[25] Our stochastic frontier cost model allows inefficiency effects to be a function of a set of explanatory variables, the parameters of which are estimated simultaneously with the stochastic frontier. The approach is stochastic and the observations may be off the frontier because they are inefficient or because of random shocks or measurement errors.

The cost of insurance for i Syndicate is represented by the log of the cost function, which is typically:

$$\ln \mathrm{C}_i = \ln \hat{C}(\mathrm{Y}_m, \mathrm{P}_j) + \varepsilon_{ic}$$

[25] Battese GE, Coelli TJ. A Model for Technical Inefficiency Effects in a StochasticFrontier Production Function for Panel Data. *Empir Econ* 1995; 20: 325-332.

Where C_i are the costs of the Syndicate i, Y_m is a vector of the output, P_j is a vector of the input prices and ε_{ic} is an error term which composes inefficiency and the random deviations from the cost frontier: $\varepsilon_{ic} = \Phi_{ic} + v_{ic}$. The first term reflects the random deviations from the frontier and usually distributed normally with a mean of zero. Also the term v_{ic} is the inefficiency term. It defines how far the DMU operates above the cost frontier and many and it assumed to follow many types of distributions. Usually it follows a half normal, a truncated normal or an exponential distribution. In our case we used the exponential distribution.

In order to be able to estimate inefficiency we need firstly to compute the residual $\hat{e}_{ic}$. The function $\ln \hat{C}_i$ it is estimated econometrically as follows:

$$\ln C_i - \ln \hat{C}_i = \hat{e}_{ic}$$

After breaking down the residual we are able to estimate v_{ic} as the conditional expectation $E(\exp(-v_{ic} \mid \varepsilon_{ic}))$.[26] As Coelli (1996) proposed, the cost-efficiency component of ε_{ic} could be calculated as: [27]

$$Eff_i = E(C_i^{\#} \mid v_{ic} = 0, G_i) / E(C_i^{\#} \mid v_{ic}, G_i) ,$$

where $C_i^{\#}$ is the cost of the i[th] firm $= \exp(C_i)$ if the dependent variable is the logarithm of the cost of production, and G_i is a vector of the input prices and output of the i[th] firm.

Moreover it has to be said that the efficiency varies from 0 to 1, with 1 signifying 100% efficiency for the DMU. A functional form is needed to compute the estimation of $\ln C_i$, and the translog is used in the literature most of the times[28]:

$$\ln C_i = a_0 + \sum_{i}^{n} \beta_i \ln(y_i) + \sum_{i=1}^{m} \gamma_i \ln(p_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{k=1}^{n} \beta_{ik} \ln(y_i)\ln(y_k)$$
$$+ \frac{1}{2}\sum_{j=1}^{m}\sum_{k=1}^{m} \gamma_{jk} \ln(p_i)\ln(p_k) + \sum_{i=1}^{n}\sum_{j=1}^{m} \delta_{ij} \ln(y_i)\ln(p_j) + \varepsilon_i$$

[26]Greene, H.(1993). The Econometric Approach to Efficiency Analysis, in: H. O. Fried,C. A. K. Lovell, and S. S. Schmidt, eds., The Measurement of Productive Efficiency (NewYork: Oxford University Press).

[27] Coelli,T. (1996). A Guide to FRONTIER Version 4.1:AComputer Program for Stochastic Frontier Production and Cost Function Estimation, Centre for Efficiency and Productivity Analysis (CEPA), Working Paper 96(7).

[28] Choi, P. and Weiss, A. (2005). An empirical investigation of market structure, efficiency, and performance in property-liability insurance. J Risk Insur 72(4):635–673.

5. Data

Most efficiency analyses use a common terminology. Charnes, Cooper and Rhodes (1978) started this by indicating that each firm can be regarded as a decision-making unit (DMU). In the data section below, we shall provide input and output information on the 21 largestLloyd's Syndicates that comprise our sample; each Syndicate is a DMU, as Table 2 shows. The relevant data have been collected from Standard & Poor's (2011).

Table 2: Lloyd's Syndicates – DMUs.

Syndicate	DMU
2003 / Catlin Underwriting Agencies Ltd	DMU1
2001 / Amlin Underwriting Ltd	DMU2
623 / 2623 / Beazley Furlonge Ltd	DMU3
4472/ Liberty Syndicate Management Ltd	DMU4
2999 / QBE Underwriting Limited	DMU5
510 / R J Kiln & Co Ltd	DMU6
2987/ Brit Syndicates Limited	DMU7
33 / Hiscox Syndicates Ltd	DMU8
1084 / Chaucer Syndicates Ltd	DMU9
1183 / Talbot Underwriting	DMU10
3210 / Mitsui Sumitomo	DMU11
444 / Canopius Managing Agents Ltd	DMU12
2007 / Novae Syndicates Limited	DMU13
1414 / Ascot Underwriting Limited	DMU14
218 / Equity Syndicate Management Ltd	DMU15
386 / QBE Underwriting Ltd	DMU16
2488 / ACE Underwriting Agencies Ltd	DMU17
1919 / Starr Managing Agents Limited	DMU18
5000 / Travelers Syndicate Management Ltd	DMU19
1209 / XL London Market Limited	DMU20
457 / Munich Re Underwriting Ltd	DMU21

Choice of Input Factors

The input factors that are mainly used in efficiency measurement for the insurance industry are: a) labour, b) business services and materials and c) capital.[29] The first factor can be divided into administrative expenses, agent expenses and other home-

[29]Choi BP, Weiss MA (2005) An empirical investigation of market structure, efficiency, and performance in property-liability insurance. J Risk Insur 72(4):635–673.

office expenses. The second factor can be divided into travel, communications and advertising expenses. According to Cummins and Weiss (2000), the third factor can be divided into physical, debt or equity capital. At this point it is important to mention that in order to choose which input factors to use in our analysis, we have to consider the published data that are available. Additionally, data concerning the number of employees or hours worked are not usually available in the insurance industry. Thus, Cummins and Zi (1998) and Berger, Cummins and Weiss (1997) in order to proxy the first two input factors (labour and business services), divided the expenditures for this two inputs with wage variables or prices indices that are publically available.
In the survey by Eling and Luhnen (2010), 61 out of 95 papers used as insurance inputs at least labour and capital. Also, most of them used a third category such as business services as an input. Nevertheless, 34 papers did not apply the above input categories; more specifically, Rees, Kessner, Klemperer and Matutes (1999), Mahlberg and Url (2003) and other 19 papers used as inputs broader expenditure categories, such as total operating expenses, without dividing them into quantities and prices.

Choice of Output Factors

Eling and Luhnen (2010) outline three principal approaches to measure output factors for the insurance industry. The first is the intermediation approach, which has been used by Brocket, Cooper, Golden, Rousseau, Wang (1998) and Leverty and Grace (2004). The second is the user-cost method, which has been used by Hancock (1985) and Cummins and Weiss (2000); and the third is the value-added approach, which has been used extensively in numerous research papers such as Cummins (1999), Grace and Timme (1992) and Cummins and Zi (1998).

The value-added approach postulates that an insurance company provides three main services to their customers. The first service is risk pooling and risk bearing; insurers create value by this risk pool that contains premiums from policyholders and compensates policyholders that experience a loss. The second service is financial planning; insurers again create value for their customers by providing services like financial planning and design of coverage programs.[30] The final service is intermediation; through intermediation, insurers create value because they invest the premiums that they receive from policyholders into capital markets in order to pay claims or other administrative expenses.[31]

Berger and Humphrey (1997) state that different output proxies are used for life and property-liability insurers. Life insurers in order to proxy the risk pooling and risk bearing functions use incurred benefits, whereas property-liability insurers use the present value of losses. Moreover, Yuengert (1993) questioned the use of premiums as output proxy for the risk pooling and risk bearing functions because they represent price times quantity of output and not output. However, Cummins and Weiss (2000) state that the present value of real losses incurred can be used as an output proxy. This happens because the risk pool contains funds from every policyholder and

[30]Eling, M. and Luhnen M., 2010. Frontier Efficiency Methodologies to Measure Performance in the Insurance Industry: Overview, Systematisation, and Recent Developments. The Geneva Papers, 35(2), pp. 217-265.
[31] Cummins, J.D. and Nini, G.P., 2002. Optimal Capital Utilization by Financial Firms: Evidence From the Property-Liability Insurance Industry. Journal of Financial Services Research, 21(1-2), pp. 15-33.

redistributes them when they experience a loss; consequently, losses express the total amount redistributed by the risk pool and are a good proxy.

In the survey by Eling and Luhnen (2010), value-added approach is applied in 80 out of 95 papers. However, although most papers used claims/benefits to proxy output, there is a debate as to whether claims/benefits or premiums/sum insured were the most appropriate proxy for the value-added approach.[32]

Frontier models require the identification of inputs and outputs. Several criteria may be used in their selection. First, the empirical criterion is availability. The second criterion is the literature survey in order to ensure the validity of the research. And the third criterion is the contextual setting of the specific sector. We have applied all three criteria in selecting the appropriate inputs and outputs for our analysis (see Table 3).

The dataset of this paper refer to the twenty-one (21) largest Lloyd's syndicates. The sample of syndicates selected generates the two-thirds of the Gross Written Premiums (GWP) underwritten by the Lloyd's market. The panel data used for the analysis are derived from the Annual Reports of each Lloyd's syndicate. The analysis covers a period of eight years from 2004 to 2011. The number of observations is 168 (= 21* 8). The Syndicates that are considered in this analysis are listed in Table 2.

We respected the DEA convention that the minimum number of DMUs (listed in Table 2) is greater than three times the number of inputs plus outputs [168 observations > 3(3+2)].[33] The inputs and the outputs used for the analysis are shown in Table 3. At this point, it is important to mention that all values have been deflated by using the UK deflator (2011 = 100) obtained from the HM Treasury (2011).

Certain comments about the data and the inputs and outputs are necessary. First, the Annual Reports of Lloyd's Syndicates are readily available for the period 2004-2011, whereas data for previous years are accessible only at a high subscription cost. Second, we had to restrict our analysis to the 21 largest Syndicates, which cover almost two-thirds of the volume of business, because it was not possible to secure an electronic file for all Syndicates. Moreover, these 21 Syndicates are included in the Lloyds's Annual Report of Standard and Poor's (2010 and 2011) for the largest 20 Syndicates, for the years 2010 and 2011 (one syndicate was not included in both years).

As far as the "inputs" are concerned, we chose the appropriate variables on the basis of the previous discussion. "Administrative expenses" were chosen as a proxy for operational costs of the Syndicate, and "salaries" as a proxy of personnel expenses, whereas "member balances" serve as a proxy of the equity capital of the Syndicate (this choice facilitates the running of the model, despite the unique and complex capital structure of Lloyd's Syndicates). The output used in our model is calculated as

[32] Berger, A.N. and Humphrey, D.B., 1997. Efficiency of Financial Institutions: International Survey and Directions for Future Research. European Journal of Operational Research, 98(2), pp. 175-212.

[33] Vassilioglou M and Giokas D (1990). A study of the relative efficiency of banks' branches: An application of data envelopment analysis'. The Journal of Operational Research Society 41(7):591-597.

an aggregation of "gross written premiums" and "claims incurred net of reinsurance". The same aggregation is used in several insurance efficiency studies.[34,35]

Table 3: Inputs and Outputs.

INPUTS	OUTPUTS
Administrative expenses Salaries Member balances (Equity)	[(Gross Written Premiums) – PV(Claims incurred net of reinsurance)]/PV(Claims incurred net of reinsurance)

The DEA model that we have estimated is that of a "production frontier", which means that Syndicates are minimizing the use of inputs given the level of output. Also, we assume that Syndicates have a production function with variable returns to scale. The estimated efficiencies reflect the general level of efficiency of each Syndicate and the evolution over time; that is, efficiency scores are presented for each year as well as for all years.

6. Empirical Results

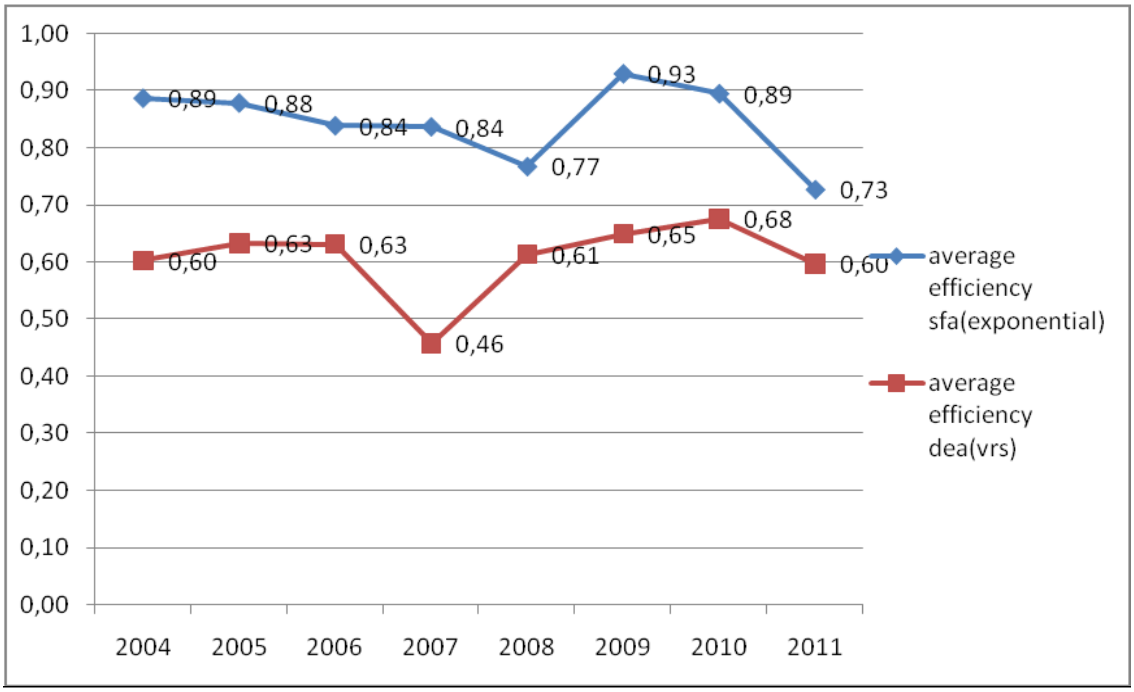
Table 4 shows that the average annual efficiency estimates for all Syndicates are plausible and they follow three-year cycles, with values ranging between 46% and 68% for DEA and between 73% and 93% for SFA. Therefore, the average inefficiency gap ranges between 54% and 32% for DEA and 27% and 7% for SFA, indicating that in "good" years the 21 largest Syndicates could decrease inputs in order to attain the same production, whereas in "bad" years these Syndicates have to reduce inputs in order to have the same output.

Table 4. Average efficiency of DMUs.

	2004	2005	2006	2007	2008	2009	2010	2011
av. Eff.sfa (exp.)	0,89	0,88	0,84	0,84	0,77	0,93	0,89	0,73
av. Eff. dea (vrs)	0,60	0,63	0,63	0,46	0,61	0,65	0,68	0,60

[34]Choi, B P and Weiss M. "An Empirical Investigation of Market Structure, Efficiency, and Performance in Property- Liability Insurance."*Journal of Risk and Insurance* 72.4 (2005): 635-673.
[35]Cummins, J. D, and Xiaoying X. "Mergers and acquisitions in the US property-liability insurance industry: Productivity and efficiency effects." *Journal of Banking & Finance* 32.1 (2008): 30-55.

Chart 1. Average efficiency of DMUs.



Because the sample is small, we checked the correlation between the DEA and SFA methods. The Spearmans's rank correlation coefficient, as a non-parametric test, has been used in order to examine the existence of relationship between two variables (exp_av_efficiency, vrs_av_efficiency). The high result (0,738) indicates a strong correlation between the exponential stochastic frontier model and the specific (vrs) data envelopment approach (Table 5). Average efficiency scores according to SFA are substantially higher compared to DEA scores.

Table 5. Correlation between the DEA and SFA methods.

Correlations				
			exp_av_efficiency	vrs_av_efficiency
Spearman's rho	exp_av_efficiency	Correlation Coefficient	1,000	0,738*
		Sig. (2-tailed)	.	0,037
		N	8	8
	vrs_av_efficiency	Correlation Coefficient	0,738*	1,000
		Sig. (2-tailed)	0,037	.
		N	8	8
*. Correlation is significant at the 0.05 level (2-tailed).				

As a conclusion of this section, we emphasize certain implications of our findings for managerial policy. First, the management of the Syndicates with the poorest performance should adopt a benchmark procedure in order to evaluate their relative position and employ appropriate managerial procedures, which would enable them to catch up with the efficient frontier. Second, they should upgrade the quality of their management practices, by undertaking specific measures to upgrade the know-how of the workforce. Third, they should improve the governance structure of Syndicates in such a way as to minimize the difficulty of controlling those empowered as managers to act on behalf of the shareholders. Fourth, they should pursue market-oriented strategies that increase outputs and decrease inputs. And finally, the supervisory authorities should promote policies that introduce greater transparency into the market, resulting in increased competition and enforcing the solvency rules.

7. Conclusions, Limitations and Further Analysis

This study represents a first attempt to evaluate the efficiency of the main Syndicates in the market of Lloyd's of London, whereas many such studies have been undertaken for almost all developed insurance markets around the world. We have assumed that a Syndicate is the counterpart of an insurance company in a regular insurance market. Indeed, the structure, the operation, the financial statements, and the regulation of the Lloyd's Syndicates are very comparable to that of an insurance company.

The Lloyd's market has gone through a very difficult period since the late 1990's and it is logical for its Syndicates to react by improving their efficiency in the use of resources. DEA analysis is dealing exactly with this issue: to evaluate the evolution of firm efficiency over time and to suggest ways for improving its relative position.

The estimated results show that the average efficiency of the Lloyd's Syndicates is relatively high and has been improving during the sample period, ranging between 66% and 86%. In any case, the inefficiency gap of the Lloyd's market is about 34% in the "bad" years, whereas this inefficiency declines to only 14% in the "good" years. Certainly, this efficiency score seems to be higher than that of the traditional UK insurance market, which was found to have an average efficiency of 77% in 1999 for general insurance companies (Diacon, 2001). This kind of analysis is useful for the firms concerned, because they have an objective way to determine their position in the market, as far as economic efficiency is concerned. The most efficient firms have enough information on how to maintain their lead, whereas the less efficient ones may use the leads suggested in the previous section in order to improve their relative position.

What might be the explanations for the results? A plausible explanation derives from organizational factors associated with X-efficiency, also resulting in inadequate combination of inputs and outputs. Differences in efficiency among the units analyzed are explained by strategic-group theory and by resource-based theory. Specific strategic dynamics and specific resources explain the variations observed, with the more efficient units being those with better strategic dynamics and better resources.

In this framework, we emphasize certain implications of our findings for managerial policy. First, the management of the Syndicates with the poorest performance should adopt a benchmark procedure in order to evaluate their relative position and employ appropriate managerial procedures, which would enable them to catch up with the efficient frontier. Second, they should upgrade the quality of their management practices, by undertaking specific measures to upgrade the know-how of the workforce. Third, they should improve the governance structure of Syndicates in such a way as to minimize the difficulty of controlling those empowered as managers to act on behalf of the shareholders. Fourth, they should pursue market-oriented strategies that increase outputs and decrease inputs. And finally, the supervisory authorities should promote policies that introduce greater transparency into the market, resulting in increased competition and enforcing the solvency rules.

The limitations of this study stem from the limited data for the years before 2004 and the limited scope of the analysis. Hopefully, more data will be made available in the future. As far as the analysis is concerned, the scope may be extended by employing more advanced methods in estimating and decomposing the efficiency values of the individual units; this decomposition will greatly enhance the explanatory capacity of the DEA model in identifying more detailed factors that determine the overall efficiency of a firm. Therefore, more policy instruments will be available to the management to improve efficiency.

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