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Efficiency in the international insurance industry: A cross-country comparison

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ABSTRACT

The purpose of this paper is to provide new empirical evidence on frontier efficiency measurement in the international insurance industry, a topic of great interest in the academic literature during the last several years. A broad efficiency comparison of 6462 insurers from 36 countries is conducted. Different methodologies, countries, organizational forms, and company sizes are compared, considering life and non-life insurers. We find a steady technical and cost efficiency growth in international insurance markets from 2002 to 2006, with large differences across countries. Denmark and Japan have the highest average efficiency, whereas the Philippines is the least efficient. Regarding organizational form, the results are not consistent with the expense preference hypothesis, which claims that mutuals should be less efficient than stocks due to higher agency costs. Only minor variations are found when comparing different frontier efficiency methodologies (data envelopment analysis, stochastic frontier analysis).

1. Introduction

In recent years, efficiency measurement has captured a great deal of attention. The insurance sector in particular has seen rapid growth in the number of studies applying frontier efficiency methods. Berger and Humphrey (1997) and Cummins and Weiss (2000) surveyed eight and 21 studies, respectively. Now, less than 10 years after the Cummins and Weiss survey, there are already more than 90 studies on efficiency measurement in the insurance industry (see Eling and Luhnen, in press). Recent work in the field has refined methodologies, addressed new topics, and extended geographic coverage from a previously US-focused view to a broad set of countries around the world, including emerging markets such as China and Taiwan.

Existing cross-country comparisons of efficiency in the insurance industry provide valuable insights into the competitiveness of insurers in different countries. However, the geographic coverage of these studies is limited to certain countries or regions. Weiss (1991) compares the US, Germany, France, Switzerland, and Japan. Donni and Fecher (1997) analyze 15 OECD countries. Both authors were restricted to using aggregated economic information instead of individual-company data. Diacon et al. (2002) and Fenn et al. (2008) use individual-company data, but concentrate on European countries (15 and 14, respectively). Rai (1996) takes a look at nine European countries, Japan, and the US, but considers a relatively small dataset of 106 companies. What is missing is a broad comparison of efficiency at the international level that incorporates a large number of countries and companies.

The aim of this paper is to contribute to the growing body of literature on frontier efficiency at the international level by answering key research questions based on a large number of countries and companies. Our cross-country analysis uses data on 6462 insurers from 36 countries, which gives our study one of the largest samples ever analyzed for the insurance industry. We consider five main aspects: (1) methodologies, (2) countries, (3) organizational forms, (4) lines of business, and (5) company size. These five aspects allow us to address many of the economic questions set out in existing efficiency studies and to compare our results with the existing evidence. Another important contribution of this paper is that we determine and compare efficiency for 12 countries that have not been considered in the literature to date: Barbados, Bermuda, Brazil, Hong Kong, Indonesia, Lithuania, Mexico, Norway, Poland, Russia, Singapore, and South Africa. Our empirical analysis thus provides a broad evaluation of efficiency in the international insurance industry, including many emerging markets from all over the world.

Our four main empirical findings are as follows: (1) there is steady technical and cost efficiency growth in international insurance

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markets during the sample period (2002–2006), with large efficiency differences between the 36 countries. The highest efficiency scores are found for Denmark and Japan, the lowest for the Philippines. (2) Our analysis provides no evidence in support of the expense preference hypothesis, as the efficiency of insurers organized as mutuals is not lower than the efficiency of insurers organized as stock companies. (3) In line with most other empirical studies, we find that larger companies are in general more efficient than smaller companies; we also uncover evidence for economies of scale. (4) There is very little difference in the results of the two frontier efficiency methodologies – data envelopment analysis (DEA) and stochastic frontier analysis (SFA).

The remainder of the paper is organized as follows. Section 2 contains an overview of 14 studies on efficiency measurement in the international insurance industry. Data and methodology is presented in Section 3. Section 4 contains the empirical results. We conclude in Section 5.

2. Literature

Efficiency comparisons at the international level have received significant attention in the insurance literature. Table 1 provides a detailed overview of 14 international studies, including their sample periods, lines of business covered, and types of efficiency analyzed. The 14 studies can be subdivided into three groups (see second column): worldwide surveys, which start with Weiss (1991), studies with a focus on the European Union (Delhausse et al., 1995, among others), and studies with a focus on Asia (Boonyasai et al., 2002).

Weiss (1991) is the first cross-country comparison of efficiency and covers the US, Germany, France, Switzerland, and Japan. She finds high productivity for the US and Germany. Japan shows the weakest productivity growth for the period 1975–1987. Rai (1996), in a broader cross-country study (11 OECD countries), concludes that firms in Finland and France have the highest efficiency and firms in the United Kingdom have the lowest. Donni and Fecher (1997) show for a sample of 15 OECD countries for the period 1983–1991 that average efficiency levels are relatively high, but vary across countries. Growth in productivity is observed for all countries, which is attributed to improvements in technical progress.

The introduction of the single European Union (EU) insurance license in 1994 raised concerns over international competitiveness among EU insurers. Consequently, there have been quite a few efficiency studies that focus on competition in the EU. For a sample of 450 companies from 15 European countries and for the period 1996–1999, Diacon et al. (2002) find striking international differences in average efficiency. According to their study, insurers doing long-term business in the United Kingdom, Spain, Sweden, and Denmark have the highest levels of technical efficiency. However, UK insurers seem to have particularly low levels of scale and allocative efficiency compared to the other European countries in the sample. Interestingly, and in contrast to the literature finding increasing levels of efficiency over time, these authors find decreasing technical efficiency.

Boonyasai et al. (2002) study efficiency and productivity in Asian insurance markets. Their results show increasing productivity in Korea and Philippines due to deregulation and liberalization, but liberalization had little effect on productivity in Taiwan and Thailand. The most recent stream of efficiency literature, however, again focuses on EU markets and includes Klumpes (2007) and Fenn et al. (2008). Fenn et al. (2008) find increasing returns to scale for the majority of EU insurers. The results indicate that mergers and acquisitions, facilitated by liberalized EU markets, have led to efficiency gains.

Overall, the empirical evidence is quite consistent in finding that efficiency in developed countries is on average higher than that in emerging markets and that technical progress has increased productivity and efficiency around the world. However, empirical findings are not unambiguous. An example is the United Kingdom, where many studies have consistently indicated relatively low efficiency levels compared to other countries (around 60%; see Rai, 1996; Fenn et al., 2008; Vencappa et al., 2008). On the other hand, however, Diacon (2001) finds higher efficiency for the United Kingdom – 77%, which is higher than that found for competing European countries in their study. Donni and Fecher (1997) and Diacon et al. (2002) also find the United Kingdom among the most efficient countries. Moreover, recent empirical evidence (Hussels and Ward, 2006; Vencappa et al., 2008) suggests that the efficiency increase after the EU deregulation is very limited. On the other hand, however, the merger activity that was facilitated by liberalized EU markets have led to efficiency gains (Fenn et al., 2008).

It is possible, however, that external shocks, such as the capital market plunge from 2000 to 2003, might influence efficiency. Therefore, regarding the empirical studies discussed above, the differences in sample periods might be important in explaining inconsistent results. Moreover, comparability of the studies is limited by differences in the subject of investigation and the methodology employed. Thus, the major contribution of this paper is to extend existing literature as to the number of countries analyzed, and also with regard to the methodologies used, with the aim of shedding a brighter light on efficiency in international insurance markets.

3. Data and methodology

Our main data source is the 2007 edition of the AM Best Non US database (Version 2007.3). It contains information on 4683 life and non-life insurance companies from 99 countries.[1] The database has five years of data, covering the period 2002–2006. Companies were included in our analysis if they had positive values for all the inputs and outputs described in Table 2, however, they were not required to have data for all years; we thus consider unbalanced panel data. This reduces our sample to 3831 companies from 91 countries. Furthermore, in order to appropriately compare the different countries we require each country to have at least a total of 30 firm years and to have data for each of the five years that we analyze. This reduces our sample to 3522 companies from 35 countries. The remaining 309 companies from 56 countries were included in the analysis as "other" countries.[2] We complement this database with data on 2940 US insurers operating in life and non-life derived from the AM Best database. Our combined database thus consists of 6462 insurers from 36 countries plus the residual category "other" (a total of 26,505 firm years).

There is widespread agreement in literature with regard to the choice of inputs (see Cummins et al., 2004). We thus use *labor*,

[1] The database also contains information on 659 insurance groups with 2,381 firm years that we did not include in our analysis.

[2] These countries are: Antigua and Barbuda (1 company/3 firm years), Argentina (4/15), Bahamas (10/43), Bahrain (4/18), Bolivia (14/37), British Virgin Islands (3/8), Bulgaria (5/14), Cayman Islands (14/57), Chile (50/144), China (8/19), Croatia (4/12), Cyprus (5/17), the Czech Republic (7/28), the Dominican Republic (1/4), Ecuador (40/106), Egypt (6/27), El Salvador (7/16), Estonia (12/47), Greece (3/6), Guernsey (2/6), Hungary (2/3), Iceland (7/21), India (12/52), the Isle of Man (3/9), Israel (10/28), Jamaica (3/12), Jordan (2/6), Kazakhstan (1/5), Kenya (4/14), Kuwait (4/17), Latvia (8/29), Lebanon (1/5), Macau (4/19), Malta (2/8), Monaco (1/1), Montserrat (1/2), Nigeria (2/9), the Northern Mariana Islands (1/4), Oman (3/8), Pakistan (4/14), Panama (3/13), Peru (9/27), Qatar (3/14), Romania (3/6), Saudi Arabia (1/5), Slovakia (10/23), Slovenia (4/15), South Korea (9/45), Tanzania (5/16), Thailand (17/45), Trinidad and Tobago (6/27), Tunisia (2/10), the Ukraine (3/9), the United Arab Emirates (3/7), Uruguay (12/34), and Venezuela (46/192). For many South American countries, there are no data available for 2006; we thus excluded these from the country-specific analysis even though the number of companies is relatively large. We also did tests to ensure data consistency, e.g., for Denmark and Hong Kong; we are grateful to Steve Diacon and Xiaoying Xie for highlighting the specifics of these countries.

Table 1
Cross-country efficiency studies.

Authors	Country focus	Selected countries	No. insurers	Sample period	Lines of business	Method	Types of efficiency	Main findings (1. Country ranking 2. Efficiency over time 3. Other findings)
Weiss (1991)	World	Five OECD countries: France, Germany, Japan, Switzerland, US	Aggreg. economic data	1975–1987	Property–liability	Index-numbers	Total factor productivity	1. US and Germany with overall high productivity 2. Productivity increase for France, Germany, and Switzerland, no clear results for US; Japan worse than average
Delhausse et al. (1995)	EU	Belgium, France	191 (BE) 243 (FR)	1984–1988	Non-life	DEA, SFA	Technical, scale	1. Efficiency French > Belgium 2. Overall low efficiency levels 3. Nonprofit companies are more efficient than for-profit companies
Rai (1996)	World	11 OECD countries: Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Sweden, Switzerland, UK, US	106	1988–1992	Life incl. health, non-life	SFA, Distr. Free Approach	Cost	1. Efficiency Finland and France > UK 2. No result with regard to eff. over time 3. Small firms (specialized firms) more efficient than large firms (combined firms)
Donni and Fecher (1997)	World	15 OECD countries: Belgium, Canada, Finland, France, Germany, Iceland, Italy, Japan, Netherlands, New Zealand, Portugal, Switzerland, Turkey, UK, and US	Aggreg. economic data	1983–1991	Life, non-life	DEA	Technical	1. US, UK, France, and Germany best, Portugal worst 2. Efficiency levels high and dispersed; growth in productivity in all countries due to technical progress
Mahlberg (1999)	EU	Austria and Germany	36 (AT) 118 (DE)	1992–1996	Life, health, property–liability	DEA	Technical	1. Efficiency Austria > Germany 2. Inefficiencies in both markets
Diacon (2001)	EU	Six European countries: France, Germany, Italy, Netherland, Switzerland, and UK	431	1999	General insurance	DEA	Technical	1. Efficiency UK > Germany > Netherlands > France > Switzerland > Italy 2. No result with regard to eff. over time (only one year considered)
Kessner (2001)	EU	Germany and UK	78 (GE) 87 (UK)	1994–1999	Life	DEA	Technical	1. Efficiency UK > Germany 2. Increasing efficiency in both markets
Diacon et al. (2002)	EU	15 European countries: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Switzerland, and UK	454	1996–1999	Life incl. pension, and health	DEA	Pure technical, scale, mix	1. Striking international differences 2. Decreasing levels of average technical efficiency
Boonyasai/ Grace/ Skipper (2002)	Asia	Four Asian countries: Korea, Philippines, Taiwan, and Thailand	33 (KR) 33 (PH) 31 (TW) 13 (TH)	1978–1997	Life	DEA	Technical, pure technical, scale	1. Productivity Korea and Philippines > Taiwan and Thailand 2. Efficiency increases 3. Welfare gains only minimal if deregulation does not closely follow liberalization
Hussels and Ward (2006)	EU	Germany and UK	31 (GE) 47 (UK)	1991–2002	Life	DEA, Distr. Free Approach	Cost, technical, allocative, scale	1. Efficiency UK > Germany 2. Limited evidence of improvement in post deregulation efficiency 3. Limited influence of deregulation on eff.
Klumpes (2007)	EU	Seven European countries: France, Germany, Italy, Netherlands, Spain, Switzerland, and UK	1183	1997–2001	Life, general insurance	DEA	Cost, technical, alloc., pure technical, scale, revenue	1. No country ranking in this study 2. No result with regard to eff. over time 3. Acquiring firms achieve greater efficiency gains than target firms or firms not involved in mergers
Fenn et al. (2008)	EU	14 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, Switzerland, and UK	Not specified	1995–2001	Life, non-life, composite	SFA	Cost	1. Life: Portugal and Austria best, Netherlands and UK worst; Non-life: UK best, Luxembourg worst 2. No improvement in cost efficiency 3. Increasing returns to scale for most EU insurers operating; larger firms with high market shares less cost efficient
Vencappa/ Fenn/ Diacon (2008)	EU	14 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, Switzerland, and UK	Not specified	1995–2001	Life, non-life	SFA	Technical	1. Life: Italy best, UK among the worst; Non-life: Convergence of efficiency scores for France, Germany, Italy, and Spain 10 points above UK (worst) 2. Non-life: no improvement (except Spain); Life: no improvement (except for Germany), decrease for Spain 3. Total factor productivity growth decomposition indicates some growth from scale economies (particularly life), and improvements in technical efficiency
Davutyan and Klumpes (2008)	EU	Seven European countries: France, Germany, Italy, Netherlands, Spain, Switzerland, and UK	472	1996–2002	Life, non-life	DEA	Technical, pure technical, scale	1. Life: France best, Netherlands worst; Non-life: Switzerland best, Spain worst 2. Very low efficiency scores 3. In life insurance, after mergers, business inputs replace labor for both targets and acquirers; mergers do not significantly impact acquirer behavior

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Table 2
Inputs and outputs.

Inputs	Proxy
Panel A: Overview	
Labor and business service	AM best operating expenses/ILO October Inquiry wage per year
Debt capital	AM best total liabilities
Equity capital	AM best capital and surplus
Input prices	
Price of labor	ILO October inquiry wage per year
Price of debt capital	Long-term government bond rates
Price of equity capital	20-Year-average MSCI stock market return indices
Outputs	
Non-life claims + additions to reserves	AM best net incurred claims + additions to reserves
Life benefits + additions to reserves	AM best net incurred benefits + additions to reserves
Investments	AM best total investments

Variable	Unit	Mean	St. Dev.	Min.	Max.
Panel B: Summary statistics for variables used					
Labor and business service	Quantity	2862	13,417	0.02	409,472
Debt capital	Million $	1509	7564	0.00	393,159
Equity capital	Million $	369	1971	0.00	82,010
Price of labor	$	29,753	23,504	227.18	113,300
Price of debt capital	%	5.09	5.52	0.00	57.96
Price of equity capital	%	12.84	15.56	0.01	104.17
Non-life claims + additions to reserves	Million $	250	1687	0.00	111,614
Life benefits + additions to reserves	Million $	1,251	4893	0.00	119,084
Investments	Million $	1566	7499	0.00	432,088
Operating expenses	Million $	100	465	0.00	26,984
Costs	Million $	251	1033	0.01	75,488
Assets	Million $	2782	15,456	0.03	439,691
ILO consumer price index	%	3.74	5.23	−3.07	44.96

business services and material, *debt capital*, and *equity capital* as inputs. Due to data availability, it is necessary to simplify this scheme by combining labor and business services as only operating expenses (including commissions) are available in the AM Best Non US database. This simplification is a common practice in many international efficiency comparisons (see Diacon et al., 2002; Fenn et al., 2008), usually for reasons similar to ours. Furthermore, Ennsfellner et al. (2004) argue that the operating expenses should be treated as a single input in order to reduce the number of parameters that will need to be estimated. We thus use operating expenses to proxy both labor and business services and handle these as a single input in the following analysis.

Cummins and Weiss (2000) showed in their analysis of operating expenses in the US insurance market that these are mostly labor related, i.e., in both life and non-life insurance, the largest expenses are employee salaries and commissions. We therefore concentrate on labor to determine the price of the operating-expenses-related input factor. The *price of labor* is determined using the ILO October Inquiry, a worldwide survey of wages and hours of work published by the International Labor Organization (ILO; see http://laborsta.ilo.org/) and used in a variety of efficiency applications (see, e.g., Fenn et al., 2008). The *price of debt capital* is proxied using country-specific one-year treasury bill rates for each year of the sample period. The *price of equity capital* is determined using the 20-year-average of the yearly rates of total return of the country-specific MSCI stock market indices (all data were obtained from the Datastream database; see Cummins and Rubio-Misas (2006) for a comparable selection and a discussion on selection depending on the insurer's capital structure and portfolio risk). To ensure that all monetary values are directly comparable, we deflate each year's value by the *consumer price index* to the base year 2002 (see Weiss, 1991; Cummins and Zi, 1998). Country-specific consumer price indices were obtained from the ILO.

As done in most studies on efficiency in the insurance industry, we use the value-added approach (also called the production approach; see Grace and Timme, 1992; Berger et al., 2000) to determine the outputs.[3] We thus distinguish between the three main services provided by insurance companies – risk-pooling/-bearing, financial services, and intermediation. According to Yuengert (1993), a good proxy for the amount of risk-pooling/-bearing and financial services is the value of real incurred losses, defined as current losses paid plus additions to reserves. As different types of services are provided by life and non-life insurance firms, we need separate output measures for each type of firm (see Choi and Weiss, 2005; Weiss and Choi, 2008). We use the present value of *net incurred claims plus additions to reserves* as a proxy for the output for non-life insurance and the present value of *net incurred benefits plus additions to reserves* for life insurance. The output variable, which proxies the intermediation function, is the real value of *total investments*. To obtain present values we again deflate each year's value using the consumer price indices.

Panel A of Table 2 presents an overview of the inputs, outputs, and prices used in this analysis. Panel B of Table 2 contains summary statistics on the variables employed. The cost variable, necessary for the calculation of SFA cost efficiency, is calculated as operating expenses plus cost of equity capital, following Choi and Weiss (2005). For comparative purposes, all numbers were deflated to 2002 using the ILO consumer price indices and converted into US dollars using the exchange rates published in the AM Best database. Note that the efficiency comparison thus depends on exchange rate assumptions and the consumer price index.

In the next section, we analyze technical and cost efficiency considering two methodologies (DEA, SFA; we only briefly describe these two approaches; readers interested in more details are referred to the referenced work), 36 countries (see Table 3 for a list), two organizational forms (stocks, mutuals), two branches (life, non-life), and three company sizes (large, medium, small). Company-specific information on domiciliary country, organization type, and lines of business is extracted from the AM Best database. Total assets are a widespread measure of insurer size (see, e.g., Cummins and Zi, 1998; Diacon et al., 2002). For comparison of different company sizes, we subdivide all companies by their total assets into large (total assets larger than $239 million in non-life/$1,655 million in life), medium, and small (total assets smaller than $39 million in non-life/ $121 million life) insurers. Although the comparability of findings from different efficiency studies is limited, e.g., due to different sample compositions and time horizons, we try to integrate our empirical results into the existing literature whenever possible.

[3] Another approach to measure output in the insurance industry is the intermediation approach (see, e.g., Brockett et al., 2004, 2005). Cummins and Weiss (2000) argue that this approach is not optimal because insurers provide many services in addition to financial intermediation. Leverty and Grace (in press) show that the value added approach is consistent with traditional measures of firm performance and inversely related to insurer insolvency. The intermediation approach is only weakly related to traditional performance measures and firms recognized as highly efficient have a higher probability to fail.

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4. Empirical results

4.1. Data envelopment analysis

For data envelopment analysis, we calculate efficiency values assuming input orientation and variable returns to scale. As the standard DEA approach is sensitive to problems of measurement error, we use the bootstrapping procedure presented in Simar and Wilson (1998). Table 3 sets out the bias-corrected DEA efficiency scores.[4] The results of the data envelopment analysis are presented at different levels of aggregation so as to focus on different aspects of efficiency. The first focus is on countries, see Panel A, the second on organization, see Panel B, the third on lines of business, see Panel C, and the fourth on size, see Panel D. For comparison purposes, the average values are presented in the last line of the table. The left part of Table 3 shows technical efficiency; cost efficiency is shown on the right. Note that the DEA results in Table 3 always show combined effects, e.g., the efficiency of a country given the line of business, the size, or the organizational form.

4.1.1. Technical efficiency

The last line of Table 3 shows that technical efficiency in life insurance is, on average, 0.71, and 0.50 in non-life insurance.[5] Large efficiency differences can be found between countries, both for life and non-life. In non-life, Japanese companies have the highest average efficiency (0.63), followed by those in Denmark (0.62) and Switzerland (0.57). The country with the highest efficiency in life insurance is Denmark (average efficiency 0.89), followed by Luxembourg (0.89) and Norway (0.88). Diacon et al. (2002), as well as Fenn et al. (2008), also find Denmark to be among the most efficient European insurance markets. Japanese insurance companies are usually found to be not very efficient (see Donnie and Fecher, 1997; Weiss, 1991), but the empirical evidence on the Japanese market is relatively old. In this context, it is important to recognize that the Japanese insurance industry experienced severe industrial reorganization starting from the beginning of the 1990s. The high efficiency values found in our data might thus indicate efficiency improvements as a result of this reorganization process over the last 15 years (see Lai and Limpaphayom, 2003; Souma and Tsutsui, 2005 for the development of the Japanese insurance market; Amel et al. (2004) report corresponding evidence for the Japanese banking market). The lowest efficiency values are found for the Philippines (average efficiency 0.22 in non-life).

Developed countries in Asia and Europe on average achieve higher efficiency scores than do emerging market countries. We subdivided our countries into 22 developed and 12 not developed countries, based on the advanced economy list of the International Monetary Fund (see IMF, 2008). On average, companies from developed countries have a technical efficiency of 0.51 in non-life (0.72 in life) compared to 0.39 for the other countries (0.58 in life). The efficiency of the largest economies, however, fall in the middle of the field. Taking non-life as an example, Germany is in 15th place (average efficiency 0.46), France is in 19th place with a score of 0.45 on average, and the United Kingdom is in 18th place with an efficiency of 0.45. The United States ranks high in non-life (7th place; average efficiency 0.54), but is in 18th place for life insurance. In general, however, the country rankings in non-life and life look very similar, e.g., for Denmark (no. 2 in non-life and no. 1 in life), Finland (no. 6 and no. 4), or Australia (no. 18 and no. 16).

As to the 12 countries in our sample that have never been previously analyzed, Norway turns out to be highly efficient (5th in non-life and 3rd in life insurance). Indeed, we find high efficiency values for all northern European countries (Norway, Finland, Sweden, and Denmark), a result that confirms previous findings for these countries (see, e.g., Rai, 1996). The results for the other "new" countries fall in the lower half, e.g., in non-life Poland is 28th, South Africa 29th, and Brazil 30th.

The second focus of our analysis concerns different organizational forms and their effects on efficiency, which is a quite well-developed field of frontier efficiency analysis. The two principal hypotheses in this area are the expense preference hypothesis (see Mester, 1991) and the managerial discretion hypotheses (see Mayers and Smith, 1988). The expense preference hypothesis states that mutual insurers are less efficient than stock companies due to unresolved agency conflicts (e.g., higher perquisite consumption of mutual managers). The managerial discretion hypothesis claims that the two organizational forms use different technologies (also known as the efficient structure hypotheses) and that mutual companies are more efficient in lines of business with relatively low managerial discretion (see Cummins and Weiss, 2000).[6] In Panel B of Table 3, we cannot confirm the expense preference hypothesis, as the average technical efficiency values of stock companies (0.49 in non-life and 0.70 in life) are lower than those of mutual insurers (0.55 in non-life and 0.80 in life).[7] A detailed analysis (available upon request) shows that this finding is robust among different countries, lines of business, and company sizes. We conducted significance tests (parametric *t*-test, nonparametric Wilcoxon test), which confirm that the difference between stocks and mutuals is significant at the 1% level for both life and non-life.

The finding that mutuals are more efficient than stocks is not in accordance with much of the literature and so we looked into how these differences might have occurred. An aspect that might account for the efficiency advantage of mutuals is that in our sample stocks and mutuals of comparable size produce approximately the same output volume, but the input usage is lower, especially with the non-US mutuals. For example, the expense ratio, i.e., operating expenses divided by premiums, is on average 25% lower for the non-US mutuals. This finding is again contrary to the expense preference hypothesis, which states that mutuals should fail to minimize costs. Furthermore, we found that this advantage is especially prevalent among small mutuals, i.e., the difference between stocks and mutuals in input usage increases with decreasing size. Overall, these findings suggest that the efficiency advantage of mutual insurers might be related to country

[4] The DEA results in Table 3 are based on a one-world frontier and estimated separately for all years, while we present results for an unbalanced panel for the SFA analysis (Table 4). Our DEA implementation only allows a pooled estimation using balanced panel data and we did that to check the robustness of our results. We find comparable results considering the pooled sample and the results for separate years. However, for methodological consistency, our estimation on time trend is presented with the SFA results. The bias-corrected efficiency scores are on average 3% lower than standard DEA scores. Confidence intervals for the measurement values are available upon request.

[5] Note that we cannot conclude from this result that life insurers are more efficient than non-life insurers because we estimated separate efficient frontiers for these two branches. Nevertheless, the lower efficiencies for non-life suggest that there is more opportunity for firms to make mistakes that degrade efficiency when operating in non-life, as the degree of competition is lower. While non-life insurance remains a traditional insurance market, life insurance has become part of the financial services market in recent years, and life insurers increasingly compete with banks and other financial institutions in providing asset accumulation products (see Cummins et al., 2004).

[6] The empirical evidence for these two hypotheses with regard to insurance companies is mixed. Most studies find that stock companies are more efficient than mutuals, confirming the expense preference hypothesis (see, e.g., Cummins et al., 1999a,b; Brocket et al., 2004, 2005; Erhemjamts and Leverty, 2007) or are equally efficient. However, other studies have found mutuals to be more efficient than stocks (see, e.g., Diacon et al., 2002). Fukuyama (1997) and Greene and Segal (2004) find that mutual life insurers in Japan and the United States are as cost efficient as stock companies.

[7] A small group of other organizational types (i.e., public companies) is not analyzed in Table 3. For that reason the firm years in Panel B do not add up to our total sample size of 17,832 (non-life)/8673 (life).

Table 3
Results of the data envelopment analysis.

	Technical efficiency				Cost efficiency			
	Non-life		Life		Non-life		Life	
	No. of firm years	Average	No. of firm years	Average	No. of firm years	Average	No. of firm years	Average
Panel A: Comparison of countries								
Australia	276	0.44	130	0.69	276	0.29	130	0.62
Austria	52	0.42	14	na	52	0.26	14	na
Barbados	40	0.46	1	na	40	0.31	1	na
Belgium	210	0.48	83	0.73	210	0.33	83	0.58
Bermuda	287	0.56	41	0.53	287	0.36	41	0.44
Brazil	111	0.36	88	0.61	111	0.28	88	0.50
Canada	830	0.53	391	0.57	830	0.36	391	0.47
Denmark	389	0.62	210	0.89	389	0.46	210	0.70
Finland	98	0.56	154	0.84	98	0.42	154	0.71
France	467	0.45	239	0.77	467	0.32	239	0.64
Germany	1098	0.46	1003	0.79	1098	0.32	1003	0.63
Hong Kong	67	0.41	8	na	67	0.27	8	na
Indonesia	42	0.28	3	na	42	0.22	3	na
Ireland	303	0.36	164	0.70	303	0.25	164	0.57
Italy	242	0.42	221	0.78	242	0.26	221	0.67
Japan	110	0.63	172	0.82	110	0.40	172	0.76
Lithuania	68	0.35	18	na	68	0.27	18	na
Luxembourg	51	0.51	40	0.89	51	0.34	40	0.67
Malaysia	113	0.37	28	na	113	0.26	28	na
Mexico	93	0.30	54	0.64	93	0.25	54	0.48
Netherlands	745	0.49	269	0.76	745	0.39	269	0.65
New Zealand	79	0.35	22	na	79	0.28	22	na
Norway	167	0.56	42	0.88	167	0.40	42	0.82
Other	668	0.38	314	0.55	668	0.27	314	0.45
Philippines	46	0.22	10	0.51	46	0.20	10	na
Poland	44	0.37	30	0.63	44	0.28	30	0.56
Portugal	58	0.48	39	0.78	58	0.30	39	0.64
Russia	64	0.39	5	na	64	0.23	5	na
Singapore	47	0.39	7	na	47	0.25	7	na
South Africa	72	0.36	57	0.65	72	0.22	57	0.56
Spain	672	0.50	284	0.82	672	0.42	284	0.59
Sweden	274	0.49	116	0.82	274	0.35	116	0.76
Switzerland	348	0.57	84	0.81	348	0.41	84	0.67
Taiwan	44	0.46	19	na	44	0.27	19	na
Turkey	32	0.32	7	na	32	0.18	7	na
UK	933	0.45	501	0.74	933	0.30	501	0.67
US	8592	0.54	3805	0.67	8592	0.43	3805	0.57
Panel B: Comparison of organizational types								
Mutual	3850	0.55	1265	0.80	3850	0.48	1265	0.65
Stocks	13929	0.49	7389	0.70	13929	0.35	7389	0.59
Panel C: Comparison of lines of business								
One line	1063	0.48	659	0.73	1063	0.33	659	0.60
More than one line	3472	0.44	1478	0.75	3472	0.31	1479	0.65
Panel D: Comparison of company size								
Large	5944	0.54	2891	0.77	5944	0.38	2891	0.70
Medium	5944	0.49	2892	0.72	5944	0.38	2891	0.57
Small	5944	0.49	2890	0.65	5944	0.38	2891	0.51
	1521	0.70	1521	0.70	1521	0.70	1521	0.70
Total	17832	0.50	8673	0.71	17832	0.38	8673	0.59

or size effects, but regression tests (see Section 4.3) show that mutuals are also more efficient than stocks when controlling for country effects and company size. One explanation for the lower operating expenses may be that many mutuals are specialized insurers active in regional markets with small staffs, no supraregional sales and marketing, and good knowledge of their market.[8] According to the managerial discretion hypothesis, these markets are characterized by standardized policies and good actuarial tables and there is thus not much need for individualized pricing and underwriting. In these predictable lines, mutuals can take advantage of the lack of owner–policyholder conflict and provide price stability as well as high service quality (see Cummins et al., 2004).[9]

We compare companies that are active in only one line of business with companies that are active in more than one line of business (see Panel C of Table 3).[10] Technical efficiency is

[8] Cummins et al., 1999a,b find that the geographic Herfindahl index is significantly higher for mutuals than for stocks. Furthermore, stocks are on average larger than mutuals.

[9] We need to be cautious when interpreting the results with regard to organizational form because the literature suggests that mutuals and stocks operate at distinct frontiers, which would require a cross-frontier analysis (see Cummins et al., 1999a,b). We therefore focus on the expense preference hypotheses and do not interpret our results with regard to the managerial discretion hypotheses. Future research is needed to provide a better interpretation on the relationship between organizational form and efficiency.

[10] Some insurers in the Non US database only indicate whether they are operating in life or non-life and do not offer detailed information on the lines of business covered. Furthermore, we have no information on lines of business covered available for the US insurers. For these two reasons, the number of firm years in Panel C does not add up to our total sample size of 17,832 (non-life)/8673 (life).

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comparable in both groups, with a slight advantage for specialized firms (those active in only one line) in non-life insurance (0.48 vs. 0.44). In life insurance, however, multi-line firms are more efficient than specialized firms. These results give only a rough indication of the (non-) existence of economies of scope in international insurance markets. However, our finding is in line with Cummins et al. (2007), who conclude that diversifying in different lines of business is not always better than a strategic focus on one line. Further research on scope economies in different lines of business is needed, e.g., considering companies that change from single- to multi-line during the investigation period or considering mergers of single-line companies from different lines of business (see Cummins and Xie, 2008).

In Panel D of Table 3 the sample is subdivided by total assets into three size categories – large, medium, and small insurers. In agreement with most research, we find that large life insurers have higher efficiency than small companies. Average efficiency for large companies is 0.77, whereas it is only 0.72 for medium-sized companies, and 0.65 for small companies. In non-life the efficiency for small and medium insurers is comparable, while that of large-sized insurers is a bit higher. An additional analysis on returns to scale shows that many small insurers exhibit increasing returns to scale, whereas most large insurers operate under decreasing returns to scale. For example, in life insurance, 65.60% of the small insurers operate under increasing returns to scale and 7.09% under decreasing returns to scale. Only 0.05% of the large firms, however, operate under increasing returns to scale and 68.18% under decreasing returns to scale (these numbers are comparable to other results in the literature, see, e.g., Cummins and Zi, 1998; Amel et al., 2004). This finding indicates that merger activity with small insurers might improve efficiency, but not with large companies.

4.1.2. Cost efficiency

Cost efficiency is on average lower than technical efficiency, with a value of 0.38 in non-life and 0.59 in life insurance. Cost efficiency is the product of technical efficiency and allocative efficiency and allocative efficiency is bounded between zero and one. For that reason, cost efficiency is, by definition, equal to or lower than technical efficiency.

Depending on allocative differences, we might observe differences in country and firm rankings. However, the cost efficiency results are very similar to the technical efficiency results. For example, in non-life, Japan, Denmark, and Switzerland have the highest values, while the Philippines has the lowest (Panel A), mutuals are more cost efficient than stock companies (Panel B), companies operating in one line are not too different from multi-line firms (Panel C), and in life insurance large companies are more efficient than small ones (Panel D).

4.2. Stochastic frontier analysis

Overall, the DEA efficiency values in our international dataset are relatively low compared to those of other studies. A possible explanation might be that the sample is relatively heterogenous.[11] It thus might be promising to complement the mathematical programming method (data envelopment analysis) with an econometric frontier efficiency method (stochastic frontier analysis) that is able to distinguish between random departures from efficiency and departures due to inefficiency.

For the calculation of *technical efficiency*, we specify a translog stochastic input distance function. The distance function formulation is chosen so as to accommodate multiple outputs and multiple inputs (see, e.g., Coelli and Perelman, 1996; Coelli, 2005). To calculate *cost efficiency*, a translog stochastic cost function is specified. The inefficiency term is assumed to follow a truncated normal distribution. The random error term is assumed to be normally distributed. For more details on the SFA specification (which follows Battese and Coelli, 1995), the reader is referred to the Appendix A of the paper.

4.2.1. Technical efficiency

As expected, and consistent with literature (see Berger and Humphrey, 1997, for an overview), the efficiency values from SFA are higher than those from DEA. This is because the nonparametric DEA measures all departures from the frontier as inefficiency, whereas the parametric SFA allows for a random error term (see Cummins and Weiss, 2000). However, like other studies employing both DEA and SFA (see, e.g., Fecher et al., 1993), the implications that can be drawn from our SFA results are generally consistent with those that can be drawn from the DEA results. Average technical efficiency in life insurance (0.84) is again higher than in non-life insurance (0.81), although the difference is smaller compared to DEA. The rank correlation of the efficiency scores received by SFA and DEA is 0.84 for non-life and 0.71 for life. These numbers are relatively high, but generally consistent with other estimators in literature; e.g. De Borger and Kerstens (1996) find a rank correlation of 0.83 comparing DEA and SFA, while the rank correlation reported by Cummins and Zi (1998) is a bit lower at 0.58. Hjalmarsson et al. (1996) find rank correlations in the range of 0.65–0.73.

Considering the *country analysis* (Panel A), Japan (0.85), Denmark (0.88), and Switzerland (0.86) are again among the most efficient in non-life insurance. Additionally, Finland and the United States rank high in non-life insurance. In life insurance, Portugal (0.96), Norway (0.94), and Denmark (0.93) are the most efficient countries, which again confirms the high levels of efficiency found for northern European countries. The lowest efficiency values are found for the Philippines in non-life and for Bermuda in life insurance.

In regard to the different *organizational forms* (Panel B in Table 4), the SFA results do not support the expense preference hypothesis. Mutual insurers show higher efficiency (0.86 in non-life and 0.88 in life) than stock insurers (0.80 in non-life and 0.83 in life). As for different *lines of business* (Panel C in Table 4), specialized non-life insurers have a slight efficiency advantage compared to non-life insurers operating in more than one line of business (0.75 vs. 0.73). In life insurance, however, multi-line insurers seem to be more efficient than insurers focused on a single line (0.86 vs. 0.81).

In contrast to the DEA results, the SFA results reveal no clear evidence for size advantages of large insurers (Panel D in Table 4). For non-life, there is little difference in average efficiencies. For life, medium-sized companies are more efficient than large and small companies. Looking at Panel E, there is steady technical *efficiency growth* for non-life (+7.6%), but only limited growth for life firms from 2002 to 2006.

4.2.2. Cost efficiency

Cost efficiency has increased over the sample period for both non-life (+8.2%) and life insurers (+3.3%). The increase in cost efficiency is larger than the increase in technical efficiency, indicating that the insurers in our sample improved their allocative skills from 2002 to 2006. This might be the effect of rationalization efforts and cost savings that many insurers accomplished in these years. Singapore is the most cost efficient in non-life and Portugal in life. Turkey and the Philippines are among the least cost efficient. Mutuals are more efficient than stocks (see Panel B) and large companies are more efficient than small ones, especially for life (see Panel D). For different lines of business, we again find that

[11] Another effect that degrades the DEA efficiency scores is that we present bias-corrected efficiency scores following Simar and Wilson (1998). Moreover, the larger the sample, the lower, ceteris paribus, the average efficiency scores (see Zhang and Bartles, 1998).

Table 4
Results of the stochastic frontier analysis.

	Technical efficiency				Cost efficiency			
	Non-life		Life		Non-life		Life	
	No. of firm years	Average	No. of firm years	Average	No. of firm years	Average	No. of firm years	Average
Panel A: Comparison of countries								
Australia	276	0.68	130	0.86	276	0.66	130	0.45
Austria	52	0.67	14	n/a	52	0.70	14	n/a
Barbados	40	0.77	1	n/a	40	0.92	1	n/a
Belgium	210	0.76	83	0.87	210	0.80	83	0.80
Bermuda	287	0.78	41	0.61	287	0.83	41	0.35
Brazil	111	0.74	88	0.85	111	0.21	88	0.79
Canada	830	0.82	391	0.68	830	0.71	391	0.37
Denmark	389	0.88	210	0.93	389	0.79	210	0.91
Finland	98	0.87	154	0.89	98	0.92	154	0.91
France	467	0.74	239	0.88	467	0.75	239	0.80
Germany	1098	0.76	1003	0.85	1098	0.82	1003	0.70
Hong Kong	67	0.76	8	n/a	67	0.80	8	n/a
Indonesia	42	0.66	3	n/a	42	0.59	3	n/a
Ireland	303	0.57	164	0.82	303	0.70	164	0.65
Italy	242	0.73	221	0.90	242	0.81	221	0.82
Japan	110	0.85	172	0.92	110	0.79	172	0.75
Lithuania	68	0.66	18	n/a	68	0.68	18	n/a
Luxembourg	51	0.76	40	0.88	51	0.85	40	0.92
Malaysia	113	0.78	28	n/a	113	0.92	28	n/a
Mexico	93	0.62	54	0.83	93	0.48	54	0.62
Netherlands	745	0.79	269	0.88	745	0.74	269	0.73
New Zealand	79	0.67	22	n/a	79	0.57	22	0.29
Norway	167	0.82	42	0.94	167	0.91	42	0.82
Other	668	0.69	314	0.84	668	0.65	314	0.34
Philippines	46	0.53	10	n/a	46	0.62	10	n/a
Poland	44	0.69	30	0.88	44	0.73	30	0.78
Portugal	58	0.83	39	0.96	58	0.92	39	0.94
Russia	64	0.61	5	n/a	64	0.70	5	n/a
Singapore	47	0.76	7	n/a	47	0.94	7	n/a
South Africa	72	0.66	57	0.86	72	0.58	57	0.32
Spain	672	0.84	284	0.88	672	0.79	284	0.91
Sweden	274	0.75	116	0.91	274	0.77	116	0.88
Switzerland	348	0.86	84	0.83	348	0.75	84	0.83
Taiwan	44	0.80	19	n/a	44	0.92	19	n/a
Turkey	32	0.64	7	n/a	32	0.38	7	n/a
UK	933	0.67	501	0.76	933	0.64	501	0.59
US	8592	0.87	3805	0.83	8592	0.75	3805	0.49
Panel B: Comparison of organizational types								
Mutual	3903	0.86	1284	0.88	3903	0.79	1284	0.73
Stocks	13929	0.80	7389	0.83	13929	0.73	7389	0.57
Panel C: Comparison of lines of business								
One line	1063	0.75	659	0.81	1063	0.73	659	0.67
More than one line	3472	0.73	1479	0.86	3472	0.75	1479	0.71
Panel D: Comparison of company size								
Large	5944	0.80	2891	0.80	5944	0.75	2891	0.65
Medium	5944	0.81	2891	0.86	5944	0.74	2891	0.62
Small	5944	0.82	2891	0.84	5944	0.73	2891	0.51
	1521	0.70	1521	0.70	1521	0.70	1521	0.70
Panel E: Comparison of efficiency over time								
2002	3932	0.79	1867	0.83	3932	0.73	1867	0.60
2003	3915	0.80	1946	0.84	3915	0.73	1946	0.59
2004	3781	0.81	1905	0.84	3781	0.72	1905	0.58
2005	3409	0.82	1621	0.84	3409	0.75	1621	0.58
2006	2795	0.85	1334	0.83	2795	0.79	1334	0.62
Total	17832	0.81	8673	0.84	17832	0.74	8673	0.59

diversified insurers are more efficient than specialized insurers in life insurance (see Panel C).

4.3. Conditional mean analysis

To verify the results displayed in Table 4, which shows combined efficiency effects, we implemented an analysis that is able to isolate the impact of different firm and country-specific effects on efficiency. A one-stage approach is implemented that models the mean of the inefficiency term from the stochastic frontier analysis dependent on a vector of firm and country-specific variables (so called "conditional mean approach;" see Battese and Coelli (1995) and Greene and Segal (2004), for an application to the insurance industry).[12] One assumption of the conditional mean approach is the homoscedasticity of the random error and inefficiency terms, an assumption that simplifies computation and in standard regression problems usually provides adequate estimation results

[12] We also conducted a Tobit regression analysis (see Tobin, 1958), a methodological alternative building on data envelopment analysis. The Tobit analysis has been criticized in the literature, e.g., because it incorporates serial correlation problems due to its two-step nature. As a one-step approach, the conditional mean approach does not suffer from these problems. We thus decided to restrict our presentation to the conditional mean analysis. However, we also implemented a methodologically improved alternative to the Tobit regression that addresses the serial correlation problems – the truncated regression and bootstrapping approach presented by Simar and Wilson (2007). The results are available upon request.

Table 5
Results of the conditional mean analysis.

	Technical efficiency				Cost efficiency			
	Non-life		Life		Non-life		Life	
	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic	Coefficient	*t*-Statistic
Intercept	−2.23	−13.58***	−6.24	−25.24***	−1.83	−8.15***	−2.23	−9.74***
Organization	0.78	27.27***	0.48	12.73***	0.48	12.86***	0.53	11.50***
Solvency	−1.71	−37.48***	−0.59	−20.20***	−0.18	−8.35***	0.43	11.90***
Small	0.44	18.66***	−1.55	−23.16***	0.13	3.44***	−0.03	0.63***
Medium	0.27	15.02***	−1.97	−44.33***	0.08	2.68***	−0.19	4.90***
Civil law	0.03	0.22***	0.01	0.21***	0.61	3.88***	−0.06	−0.93***
Mixed law	0.01	0.05***	−3.27	−12.97***	0.39	2.77***	0.38	3.81***
2003	−0.18	−8.12***	0.00	0.05***	0.04	0.91***	0.08	1.81***
2004	−0.40	−15.88***	−0.01	−0.22***	0.05	1.05***	0.12	2.54***
2005	−0.73	−25.22***	0.01	0.16***	−0.10	−1.91**	0.08	1.52*
2006	−1.03	−32.98***	0.02	0.50***	−0.44	−7.63***	−0.25	−4.50***
Australia	1.03	6.71***	−0.55	−2.38***	1.23	6.20***	2.09	10.09***
Austria	0.71	3.76***	−1.09	−6.76***	0.40	1.57**	0.08	0.08***
Barbados	−0.75	−2.63***	−0.31	−0.31***	−2.57	−12.73***	1.12	0.92***
Belgium	−0.32	−3.43***	0.80	2.59***	−0.40	−1.92**	0.20	0.68***
Bermuda	0.18	1.12***	6.48	25.88***	−0.14	−0.64***	2.53	10.63***
Brazil	0.08	0.57***	1.44	5.48***	2.94	9.31***	−0.18	−0.38***
Canada	−1.55	−9.76***	5.93	31.06***	1.01	5.24***	2.48	12.31***
Denmark	−3.49	−36.10***	−0.10	−0.67***	−0.12	−0.71***	−3.35	−13.83***
Finland	−3.42	−28.47***	−0.12	−0.71***	−3.17	−23.43***	−3.28	−17.70***
Germany	−0.13	−2.00***	0.71	4.94***	−0.65	−5.41***	1.30	7.20***
Hong Kong	−0.46	−1.38*	3.03	8.74***	−0.36	−0.91***	−2.42	−2.38***
Indonesia	1.22	4.27***	3.55	11.14***	1.08	4.45***	1.73	2.43***
Ireland	2.07	13.39***	3.17	18.46***	1.01	5.03***	1.55	7.25***
Italy	−0.27	−3.10***	−0.61	−3.22***	−0.73	−3.18***	−0.48	−1.98**
Japan	−3.02	−10.18***	2.69	9.01***	−0.08	−0.36***	0.44	1.99**
Lithuania	0.79	5.12***	−1.00	−6.01***	0.48	2.14**	2.04	6.70***
Luxembourg	0.02	0.10***	−0.57	−3.09***	−1.46	−3.30***	−3.63	−19.48***
Malaysia	−0.81	−3.78***	2.92	8.76***	−3.33	−12.82***	1.13	3.29***
Mexico	1.62	13.36***	3.24	13.02***	1.32	8.87***	1.65	6.88***
Netherlands	−0.56	−7.76***	0.38	2.22**	0.27	2.53***	0.85	4.47***
New Zealand	1.50	8.66***	−0.38	−2.02**	1.67	7.68***	2.75	11.11***
Norway	−0.99	−6.81***	−1.11	−4.94***	−2.76	−5.88***	−0.43	−0.97***
Other	0.82	9.73***	3.41	19.72***	0.82	6.47***	2.34	11.74***
Philippines	2.11	10.35***	3.89	7.63***	0.86	3.29***	2.73	8.57***
Poland	0.11	0.43***	0.88	2.59***	0.01	0.04***	0.07	0.16***
Portugal	−2.73	−7.30***	−1.03	−6.32***	−3.49	−21.70***	−3.64	−19.85***
Russia	0.98	7.29***	4.15	4.18***	0.30	1.16***	2.36	5.79***
Singapore	−0.06	−0.15***	2.11	6.79***	−3.42	−20.81***	−4.08	−18.57***
South Africa	1.45	7.44***	3.18	8.19***	1.22	6.29***	2.15	9.22***
Spain	−2.02	−23.05***	−0.48	−2.69***	−0.33	−2.56***	−3.10	−16.00***
Sweden	0.67	8.19***	−0.09	−0.56***	0.11	0.82***	−2.28	−3.60***
Switzerland	−3.08	−21.05***	3.15	12.95***	0.04	0.28***	−0.04	−0.11***
Taiwan	−0.43	−1.25***	2.10	6.69***	−3.41	−2.92***	1.22	3.46***
Turkey	1.20	4.45***	0.52	0.53***	1.66	9.22***	3.32	9.67***
United Kingdom	1.40	9.48***	3.62	20.40***	1.50	7.75***	1.70	8.52***
United States	−3.05	−17.74***	3.11	20.53***	0.76	4.13***	1.97	10.05***

* Significance level of 10%.
** Significance level of 5%.
*** Significance level of 1%.

even if the assumption is not true (see Verbeek, 2008). However, in our context, the assumption could be implausible and result in inconsistent estimates, especially because the variability of incurred claims and costs depends on the size of the insurer and these scale differences might bias the efficiency scores (for more details, see Fenn et al., 2008). There are some approaches that model the variance of the random error and inefficiency term to address potential violations of homoscedasticity (see Kumbhakar and Lovell, 2000; Fenn et al., 2008), but we follow the widely used standard conditional mean approach.[13]

The following explanatory variables are used in our regression model: (1) *Organization:* 1 if the insurer is a stock company; 0 otherwise. (2) *A solvency variable:* 1 if the company's ratio of equity capital to total assets is above the median in the respective branch; 0 if not. (3) *Company size:* dummy variables are included according to the three size classes "small," "medium," and "large." The size category "large" is excluded to avoid singularity. It serves as the reference category for the other two categories. (4) *Legal systems:* each country is assigned to one of the two main legal systems relevant to our sample: civil law, also called "continental European law," and common law, which originated in England and later spread through the British Commonwealth. Since some countries have pluralistic legal systems that either mix elements of civil and common law with each other or with other systems, such as religious law, we added a third category – "mixed." Again, one category ("common law" in this case) is

[13] In our empirical application, the standard conditional mean approach leads to results consistent with those of nonparametric modeling approaches. We used the Fenn et al. (2008) methodology on a cross-sectional basis as an additional test and found that our main results are not affected by the choice of methodology. The results are available upon request. We are grateful to Dev Vencappa for helping us implement this approach.

excluded to avoid singularity.[14] (5) *Time:* dummy variables for each year 2003–2006 are chosen to capture time effects; 2002 is excluded. (6) *Country:* country dummies are included to take country effects into consideration. France, a country with mid-level efficiency, is chosen as the reference category and is omitted from the regressions.[15]

Table 5 shows results of the conditional mean analysis by branch (life vs. non-life) and efficiency type. Since the conditional mean approach models the inefficiency term, a negative coefficient indicates a decrease in inefficiency, i.e., an increase in efficiency, and a positive coefficient indicates an increase in inefficiency, i.e., a decrease in efficiency. The likelihood-ratio test for all analyses rejected the null hypothesis that the inefficiency term is not significantly different from 0 at the 1% level.

The results of the conditional mean analysis confirm for both life and non-life that mutual insurers have higher cost and technical efficiencies than stocks: coefficients are positive and significant, indicating higher inefficiency of insurers operating as stocks. This is an important finding because it shows that the efficiency advantage for mutuals also holds when controlling for country effects and for firm characteristics such as solvency and size.

For the impact of the equity to total assets ratio on efficiency ("solvency"), we find a negative coefficient for life (with technical) and non-life (with technical and cost efficiency) insurers, indicating that a high equity to assets ratio is in line with higher efficiency. This finding is in agreement with those of Diacon et al. (2002), who also observe a positive link between capitalization and efficiency. An exception in our sample is cost efficiency for life insurers, where a high equity to assets ratio is accompanied by lower efficiency, possibly indicating that equity capital is not used cost efficiently in life insurance.[16]

The positive coefficients of the size variables with non-life show that small and medium-sized insurers are less efficient than large insurers, which are the reference category. The relative disadvantage for large life insurers is also confirmed in the regressions, i.e., small and medium-sized insurers are more efficient than large insurers. Under the conditional mean approach the size advantage of large insurers is thus only confirmed for non-life, while we find size advantages both for life and non-life under DEA.

With regard to legal systems, there is no clear technical efficiency difference between countries with civil, mixed, or common law for non-life insurance. However, the results suggest that non-life insurers from countries with common law are more cost efficient than those from countries with either mixed or civil law as coefficients are positive and significant. Overall, the legal variable has relatively low significance levels. Compared to the other variables considered in the model, it thus seems that the legal system is not an important driver of efficiency.

The coefficients of the time dummies for non-life technical efficiency confirm a steady efficiency increase over time compared to the year 2002: all coefficients are negative, significant, and decrease with time. For non-life cost efficiency, a significant increase in efficiency between 2002 and 2005, and 2006 is confirmed. For life insurance, there is no significant efficiency increase in any of the years compared to 2002, except for cost efficiency in 2006. The efficiency increase is thus higher in non-life compared to life insurance.

Finally, the coefficients of the country dummy variables confirm the DEA and SFA results. Interpreting the country dummy variables we also have to keep in mind that these have to be related to the reference category, which is in this case France, a country with mid-level efficiency. For example, for non-life technical efficiency, Denmark, Finland, and Switzerland display high negative and significant coefficients, indicating that these countries are more efficient than the reference country, whereas the Philippines is assigned a high positive and significant coefficient as this country is much less efficient than the reference country.

5. Conclusion

The contribution of this paper is to provide a broad evaluation of efficiency in the international insurance industry. We extend existing cross-country comparisons by analyzing a broad international dataset that has not yet been the subject of an efficiency study (the AM Best Non US database). We complement this database with US data so that our cross-country analysis covers data on 6462 insurance companies from 36 countries. To our knowledge this is the largest dataset ever analyzed in insurance-related efficiency literature. A total of 26,505 firm years is analyzed using both data envelopment analysis and stochastic frontier analysis, allowing us to glean a broad range of new insights into the efficiency of the international insurance industry:

- During the sample period from 2002 to 2006, there is a steady growth in efficiency in the international insurance markets, although there are large differences between countries. Denmark and Japan have the most efficient insurance companies, whereas insurers in the Philippines have the lowest efficiency values.
- We are the first to determine technical and cost efficiency for 12 countries. Among these, Norway turns out to be highly efficient, while many emerging markets such as Brazil, Indonesia, Mexico, Poland, Russia, and South Africa have relatively low efficiency. In general, developed countries in Asia and Europe on average achieve higher efficiency scores than do emerging market countries, indicating significant improvement potential for insurers operating in emerging markets. The results are in line with other cross-country comparisons in the insurance literature (Rai, 1996; Diacon et al., 2002; Fenn et al., 2008), and also agree with findings from studies in the financial services sector, e.g., banking (see, e.g., Amel et al., 2004 for Japanese banking).
- The results of data envelopment analysis and stochastic frontier analysis and the economic insights that can be derived from them turn out to be very similar, both for technical efficiency and cost efficiency. This result agrees with the few other studies that have considered multiple frontier efficiency methodologies.
- In our analysis, mutual insurers are consistently more efficient than stock insurers. Therefore, we cannot confirm the expense preference hypothesis. This result adds to the mixed evidence regarding the effect of organizational form on efficiency in

[14] Information on the legal systems in effect in the different countries came from the Faculty of Law at the University of Otawa (http://www.droitcivil.uottawa.ca/world-legal-systems/eng-monde.php). We use this variable to capture international differences in legal practices that might be substantial, e.g., in the field of legal protection and indemnities.

[15] An earlier version of this paper contained a second regression model with country-specific variables such as real GDP, corruption, insurance density, and regional dummy variables. The results of this second model (available upon request) broadly confirm the analysis presented here. We tried to select variables according to other studies (e.g., Gardner and Grace, 1993; Cummins et al., 2004), but our decision to include variables in the regression is also driven by data availability. For example, more detailed information on the lines of business covered would be interesting (as used, e.g., in Cummins et al., 2004). However, we only have such information for a relatively small portion of our firm years (see note 10), which is the reason why we did not include it in the regressions. Other useful information that we do not have available are agency vs. direct distribution systems (Gardner and Grace, 1993), geographical Herfindahl (Cummins et al., 1999a,b), or liquidity (Diacon et al., 2002).

[16] For the United States, Cummins and Nini (2002) find that the large increases in capitalization between 1989 and 1999 represent an inefficiency in so far as equity capital is significantly over-utilized. However, they consider property-liability, not life, insurers.

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insurance, where some studies, especially those covering the US market, have found stock companies more efficient than mutuals. However, other international comparisons have found mutuals to be more efficient than stocks. Further research is needed to solve this ambiguity over the relationship between organizational form and efficiency in international insurance markets.

- We find that diversifying in different lines of business is not always better than a strategic focus on one line. We recommend studying scope economies on an international level in order to find out when it would be best to employ a single product strategy as opposed to providing multiple products (see, e.g., Asaftei, 2008, with an analysis of US banking).
- Many small insurers exhibit increasing returns to scale, whereas most large insurers are operating under decreasing returns to scale, which indicates that merger activity might be efficiency enhancing for small insurers, but not for large insurers.
- The conditional mean analysis confirms the efficiency differences found under DEA and SFA. In general, there is a positive relationship between capitalization and efficiency. Furthermore, the efficiency advantage for mutuals also holds when controlling for country effects and for firm characteristics such as solvency and size. Legal systems are not a main driver of efficiency in the insurance industry.

Our results provide valuable insights into the competitiveness of insurers from different countries. At the country level, the results can be used to compare different insurance markets. This is especially interesting for regulators and politicians, as well as for the boards of national insurance associations. Apart from knowing how efficient their market is compared to others, they can direct their activities toward areas where efficiency needs to be improved, e.g., for small insurers. On a regional level (e.g., within the European Union), it might be of interest to monitor whether the efficiency levels of insurance markets converge as a result of deregulation and facilitated market entry for foreign companies.

At the individual-company level, the results can be used to compare performance with other firms in the industry, nationally and internationally. This can, for example, help managers in making decisions regarding international growth. A relatively efficient insurer from a country with an efficient insurance market might consider international growth opportunities (through new entry or acquisitions) in markets where it has a relative efficiency advantage.

A number of important issues regarding efficiency in international insurance markets still need to be addressed. Among these are an international analysis of efficiency of different distribution systems in order to verify whether the tendency toward increased independent agent distribution can also be supported by efficiency considerations. Also of interest would be a cross-frontier analysis (Cummins et al., 1999a,b) on an international level in order to provide more detailed insights with regard to the impacts of organizational form. Furthermore, there is no cross-country efficiency study that covers sublines of business (such as auto, homeowners, or liability insurance), which are expected to show largely different efficiency scores due to different competitive dynamics. Finally, more research can be done, e.g., at the individual country level and to better capture the heterogeneity of the sample analyzed in this paper. Moreover, there are recent modeling approaches in the literature (e.g., Fenn et al., 2008, based on Kumbhakar and Lovell, 2000) that refine the modeling of inefficiencies and thus might provide further insights into differences in efficiency across countries.

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Appendix A. Stochastic frontier analysis specification

For the calculation of *technical efficiency*, we specify a translog stochastic input distance function. The distance function formulation is chosen so as to accommodate multiple outputs and multiple inputs (see, e.g., Coelli and Perelman, 1996; Coelli, 2005). The translog functional form is selected due to its broad acceptance in stochastic frontier analysis in insurance (see, e.g., Cummins and Weiss, 2000). The technical efficiency SFA model is as follows:

$$\begin{aligned}-\ln(x_{Kit}) = {} & \alpha_0 + \sum_{m=1}^{M}\alpha_{mi}\ln(y_{mit}) + 0.5\sum_{m=1}^{M}\sum_{n=1}^{N}\alpha_{mn}\ln(y_{mit})\ln(y_{nit}) \\ & + \sum_{k=1}^{K-1}\beta_k\ln(x^*_{kit}) + 0.5\sum_{k=1}^{K-1}\sum_{l=1}^{L-1}\beta_{kl}\ln(x^*_{kit})\ln(x^*_{lit}) \\ & + \sum_{k=1}^{K-1}\sum_{m=1}^{M}\phi_{km}\ln(x^*_{kit})\ln(y_{mit}) + \varphi_1 t + 0.5\phi_{11}t^2 \\ & + \sum_{m=1}^{M}\gamma_{1m}t\ln(y_{mit}) + \sum_{k=1}^{K-1}\kappa_{1k}t\ln(x^*_{kit}) + v_{it} - u_{it},\end{aligned} \tag{A1}$$

where x_{kit} are the k inputs of insurer i at time t and y_{mit} are the m outputs of insurer i at time t. To ensure linear homogeneity of degree 1 in inputs, we randomly choose one input (such as x_{Ki} in our case) and divide all other inputs by this input. Thus $x^*_{ki} = x_{ki}/x_{Ki}$. This is also why all summations in Eq. (A1) involving x^*_{ki} are over $M-1$ and not M. To account for technological change over time, a time factor t is included as a regressor in the model. The random error is included in Eq. (A1) by v_{it}, which is assumed to be distributed normally. Inefficiencies are modeled by the term u_{it}, which is assumed to follow a truncated normal distribution. Using a one-stage approach, the mean m_{it} of u_{it} is assumed to vary depending on a vector of firm-specific variables ("conditional mean approach"; see Battese and Coelli, 1995, or Greene and Segal, 2004, following an approach similar to Huang and Liu, 1994):

$$m_{it} = \delta_0 + \delta_1 a_{it} + \delta_2 b_{it} + \delta_3 c_{it} + \delta_4 d_{it} + \delta_5 f_{it} + \delta_6 g_{it} + \delta_\theta h_{i\theta} + \delta_\gamma t_{i\gamma}, \tag{A2}$$

where a_{it} is a dummy variable reflecting organizational form (1 for stock companies and 0 for mutuals). b_{it} is the solvency variable (1 if the company's ratio of equity capital to total assets is above the median in the respective branch; 0 otherwise). c_{it} and d_{it} reflect firm size: c_{it} is equal to 1 if the company is in the "small" size class (0 otherwise); d_{it} is equal to 1 if the company is "medium" size (0 otherwise). The size category "large" is excluded to avoid singularity and serves as the reference category. f_{it} and g_{it} reflect legal systems: f_{it} is equal to 1 if the company is from a civil law country (0 otherwise) and g_{it} is equal to 1 if the company is from a country with pluralistic legal systems (0 otherwise). Again, one category is excluded to avoid singularity ("common law" in this case). $h_{i\theta}$ are country dummy variables with $\theta = 1, \ldots, 36$ (France is excluded). $t_{i\gamma}$ are four time dummy variables with $\gamma = 2003, \ldots, 2006$ (2002 is excluded).

The technical efficiency score TE_{it} is calculated by the following formula:

$$TE_{it} = \exp(-u_{it}) \tag{A3}$$

For the calculation of cost efficiency, we specify a translog stochastic cost function:

$$\begin{aligned}\ln\left(\frac{C_{it}}{p_{Kit}}\right) &= \alpha_0 + \sum_{m=1}^{M}\alpha_{mi}\ln(y_{mit}) + 0.5\sum_{m=1}^{M}\sum_{n=1}^{N}\alpha_{mn}\ln(y_{mit})\ln(y_{nit}) \\ &+ \sum_{k=1}^{K-1}\beta_k\ln(p^*_{kit}) + 0.5\sum_{k=1}^{K-1}\sum_{l=1}^{L-1}\beta_{kl}\ln(p^*_{kit})\ln(p^*_{lit}) \\ &+ \sum_{k=1}^{K-1}\sum_{m=1}^{M}\phi_{km}\ln(p^*_{kit})\ln(y_{mit}) + \varphi_1 t + 0.5\phi_{11}t^2 \\ &+ \sum_{m=1}^{M}\gamma_{1m}t\ln(y_{mit}) + \sum_{k=1}^{K-1}\kappa_{1k}t\ln(p^*_{kit}) + v_{it} + u_{it}\end{aligned} \tag{A4}$$

where C_{it} are total cost of insurer i at time t. p_{kit} are the k input prices of insurer i at time t and y_{mit} are the m outputs of insurer i at time t. To ensure linear homogeneity of degree 1 in input prices, we randomly choose one input price (such as p_{Ki} in our case) and divide the dependent variable (C_{it}) and all other input prices by this input price. The rest of the model specification, including the distributional assumptions of the random error v_{it} and the inefficiency term u_{it}, are analogous to the technical efficiency SFA model.

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