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Article

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Efficiency and Convergence in the European Life Insurance Industry

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This article employs a flexible stochastic frontier to estimate revenue efficiency and efficiency convergence for 22 European Union insurance markets during the financial crisis and after. It also looks at firm-specific factors that might affect inefficiency. Revenue efficiency falls with the beginning of the financial crisis but remains relatively stable over the examined period. The average revenue efficiency is found to be 57.4% indicating a 42.6% possible increase in revenue efficiency on average. The results on the issue of convergence are mixed; β-convergence has taken place but not σ-convergence. In fact, σ-divergence occurred during the financial crisis period. Size and diversification seem to negatively affect efficiency. (JEL: G15, G22, F36)

Keywords: revenue efficiency; β-convergence; σ-convergence; European life insurance industry; stochastic frontier

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I. Introduction

In the last twenty years significant changes and reforms occurred in the

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European financial industry that have affected the structure and performance of financial markets and institutions. The purpose of removing legal and administrative obstacles was to foster integration in the provision of insurance services across the EU's landscape. This paper examines the issue of efficiency and convergence in the European insurance market.

According to Baele et al. (2004), a financial market is integrated if all its potential participants with the same relevant characteristics: (a) face a single set of rules when they decide to invest in this market, (b) have equal access to financial instruments and/or services in this market, and (c) are treated equally when they are active in this market. Based on the spirit of the law of one price, several measures of financial integration are suggested in the literature and many of them are based on the cross-sectional variation of several relevant variables such as interest rate spreads or return divergences (Baele et al., 2004). In the most recent literature, however, the concepts of β-convergence and σ-convergence are used in order to see if the financial markets are integrating (Mamatzakis, Staikouras and Koutsomanoli-Filippaki, 2008; Weill, 2009; Casu and Girardone, 2010). With regard to efficiency, β-convergence means that countries with initial lower levels of efficiency experience faster growth rates than countries with higher initial levels of efficiency. The speed of convergence is captured by the σ-convergence which occurs if each country's level of efficiency is converging to the average level of the group of countries.

Measuring convergence towards a European average efficiency frontier is important in the context of the single market for financial services since a satisfying level of convergence would indicate a reduction in the level of variation among the EU countries. This possible reduction in variation of efficiency level in EU in turn would be expressed as progress in the real economy since the financial institutions form the basis of an economy by bringing into contact the redundant and the deficient entities. Given that the level of convergence in the financial markets is the key issue to the creation of a single European insurance market, it is surprising that only two studies deal with the issue of convergence. Cummins and Rubio-Misas (2016) look at the issue of convergence using a sample of ten European countries and the Data Envelopment Analysis (DEA) method. Apergis et al. (2012) employ a sample of 16 insurance companies within the European Monetary Union (EMU) and they base the analysis on certain financial ratios.

During the examined sample period of this paper the world economy has experienced a global financial turmoil that has been characterized as the worst financial crisis since the Great Depression of the 1930s. This crisis began as a crisis in the subprime mortgage market in the United States and evolved into an international banking crisis. At the end of 2009 and at the beginning of 2010 this financial crisis caused the so called European debt crisis since several member states were unable to repay or refinance their government debts. Did the financial crisis affect efficiency and integration in the European insurance sector? One might argue that at difficult economic times firms should try to become more efficient in order to reduce the impact of the bad economic environment.

This paper contributes to the existing literature in three important aspects. First, it provides revenue efficiency estimates for 22 European countries based on a flexible stochastic frontier. To the best of our knowledge, there is no other previous work to measure revenue efficiency for the European life insurance industry that includes European countries entered the Union with the Fifth Enlargement Part I and II (2004 and 2007 respectively). Only one study (Cummins and Rubio-Misas, 2016) examines revenue efficiency for ten European insurance markets using a different methodology than ours.

Second, it examines the level of efficiency convergence of the European life insurance industry by estimating β-convergence and σ-convergence, and it looks at the effect of the financial crisis of 2007 on efficiency and convergence. To our knowledge, there are only two studies - Cummins and Rubio-Misas (2016) and Apergis et al. (2012)- that have examined the convergence of the European insurance industry but with different methodologies and different data set. Third, it considers the role of certain firm-specific characteristics on inefficiency.

The next section presents a brief review of the relevant literature. In section III, we outline our method, describe the data and report the estimated model. Section IV contains the empirical results. The final section includes a summary of our findings and some concluding observations.

II. Review of the relevant literature

According to Wise (2017) there are about 200 studies that examine life insurance efficiency around the world. The early studies that began in the 1990s examined the efficiency of life insurers for individual countries, initially for the United States and then for Germany. Since the early 2000s there is a growing number of papers for multiple nations, such as of Europe, Asia and worldwide.

Following the Third Generation Directives several studies were undertaken in an effort to examine how this deregulation has affected the efficiency and productivity of the European insurance market. These studies can be grouped into two categories: One category looks only at individual European insurance markets and another looks at a group of countries. Some studies of the first category, in chronological order, include the following. Mahlberg and Url (2003) analyzed the Austrian insurance market, Barros et al. (2005) examined the Portuguese insurance market, Cummins and Rubio-Misas (2006) looked at the Spanish insurance market. Mahlberg and Url (2010) used the long-run economic growth literature (β- and σ-convergence) in order to analyze convergence in efficiency and productivity for the German insurance industry for the period 1991-2006. They found σ-convergence for cost efficiency among German insurance companies while dispersion in revenue efficiency diminishes only in year 2003.

Bikker and Gorter (2011) examined the Dutch non-life insurance industry. Biener et al. (2016) examined efficiency and productivity for the Swiss insurance companies in the life, non-life, and reinsurance sectors. A general conclusion that emerges from the above studies is that the deregulation has led to productivity gains in the individual European insurance markets.

Cross-country studies on efficiency and productivity of European insurance markets are growing over the years. Table 1 gives a brief summary of these studies and below we present them in chronological order. Diacon, Starkey and O'Brien (2002), using a sample of insurers from 15 European countries for the period 1996-1999, found important international differences concerning the average efficiency. Their results show that the technical efficiency has declined since 1996, and insurers transacting long-term business in the United Kingdom, Spain, and Sweden have the highest levels of technical efficiency. Hussels and Ward (2007) examined the impact of insurance market deregulation by comparing the UK and German markets. They found that in an inter-industry analysis the German industry dominates UK cost efficiency both before and after deregulation.

Fenn et al. (2008), using Stochastic Frontier Analysis (SFA), estimated separate Flexible Fourier cost functions for life, non-life, and composite insurers operating in 14 major European countries for the period 1995-2001. They found that company size and domestic market share are significant factors determining X-efficiency and that the cost efficiency for firms in the non-life and composite sectors was relatively stable over the period 1995-2001 while the cost efficiency of life insurers declined, particularly between 1997 and 2000.

Davutyan and Klumpes (2008) examined the relationship between mergers and acquisitions, efficiency and scale economies in seven European insurance markets for the period 1996-2002. They found that: a) post consolidation technical efficiency generally improved whereas scale efficiency deteriorated; b) as asset size increases scale efficiency goes up but technical efficiency declines; c) results for the non-life sector tend to be stronger than for the life sector.

Zanghieri (2009) assessed to what extent the large differences in insurance markets across EU countries explain differences in individual firms' X-efficiency. He estimated cost and profit frontiers using balance sheet data on a sample of European insurance companies for the period 1997-2006 from 14 countries. The results show that national markets characteristics play a significant role in explaining cost and profit efficiency. Moreover, life and non life insurance businesses differ substantially in what drives technical efficiency. While in non life insurance cost and profit efficiency are positively related to size, hinting at economies of scale, in the life insurance industry large firms tend to be relatively less efficient.

Berry-Stolzle, Weiss and Wende (2011) tested the structure-conduct performance (SCP) hypothesis, the relative market power hypothesis and the efficient structure hypothesis in twelve European property-liability insurance markets over the years 2003-2007. Their results strongly support the efficient structure hypothesis. Kasman and Turgutlu (2011) analyzed the cost efficiency and scale economies in the insurance industries of 19 European countries and Turkey over the period 1995-2005. Their results show a wide range of cost inefficiency scores across countries and across different size groups. The estimated average inefficiency for the whole sample is 11.8%. They also found significant economies of scale especially for the small and medium-size insurance firms.

Apergis et al. (2012) investigated convergence through certain financial ratios of 16 insurance companies operating within the European Monetary Union (EMU). Their results indicate limited convergence within the insurance sectors across the EMU countries.

TABLE 1. Cross-country studies on efficiency and productivity of European insurance markets

Authors and title of the paper	Countries, Sample period, Method	Type of efficiency	Average efficiency results
Diacon, S. R. (2001). The efficiency of UK general insurance companies.	6 EU countries 1999 DEA	Technical efficiency	67.50%
Diacon, S. R., Starkey, K. and O'Brien, C. (2002). Size and Efficiency in European Long-Term Insurance Companies: An International Comparison.	15 EU countries 1996-1999 DEA	Technical efficiency	55.73%
Hussels, S., and Ward, D.R. (2007). The Impact of Deregulation on the German and UK Life Insurance Markets: An Analysis of Efficiency and Productivity between 1991-2002.	Germany and UK 1991-2002 DEA	Technical and Cost efficiency	Technical: 77.60% Cost:65.90%
Davutyan, N., and Klumpes, P. J. M., (2008). Consolidation and Efficiency in the Major European Insurance Markets: A Non Discretionary Inputs Approach.	7 EU countries 1996-2002 DEA	Technical efficiency	For life: 28.80% For nonlife: 35.20%
Zanghieri, P., (2009). Efficiency of European Insurance Companies: Do Local Factors Matter?	15 EU countries 1997-2006 SFA	Cost and profit efficiency	National market characteristic have a strong influence on efficiency.
Fenn, P., Vencappa, D., Diacon, S., Klumpes, P. and O'Brien, C. (2008). Market Structure and the Efficiency of European Insurance Companies: A Stochastic Frontier Analysis.	14 EU countries 1995-2001 SFA	Cost efficiency	For life: 79.60% For nonlife: 93%
Kasman, A., and Turgutlu, E. (2011). Performance of European Insurance Firms in the Single Insurance Market.	19 EU+Turkey 1995-2005 SFA	Cost efficiency	88.20%

(*Continued*)

TABLE 1. (Continued)

Authors and title of the paper	Countries, Sample period, Method	Type of efficiency	Average efficiency results
Berry-Stolzle, T., Weiss, M., and Wende, S., (2011). Market structure, Efficiency, and Performance in the European P-L Insurance Industry.	12 EU countries 2003-2007 DEA	Cost and Revenue efficiency	Cost eff: 36.80% Revenue eff: 49.10%
Vencappa, D., Fenn, P., and Diacon, S. (2013). Productivity growth in the European Insurance Industry: Evidence from Life and Nonlife Companies.	14 EU countries 1995-2008 SFA	Total Factor Productivity	For life: 4.02%, For nonlife: –19.23% Productivity change is volatile.
Jarraya B., and Bouri A., (2014). Optimal Production Plan and Profit Efficiency in European Non-Life Insurance Companies.	9 EU countries 2002-2008 SFA	Profit efficiency	54.11%
Cummins, J. D., and Rubio-Misas, M., (2016). Integration and Efficiency Convergence in European Life Insurance Markets.	10 EU countries 1998-2007 DEA	Cost and Revenue efficiency	Evidence of integration in the EU life insurance market
Cummins, J. D., Rubio-Misas, M., and Vencappa, D., (2017). Competition, efficiency and soundness in European life insurance markets.	10 EU countries 1999-2011 Boone indicator		Competition increases the soundness of EU life insurance markets.
Eling, M., and P. Schaper. (2017). Under Pressure: How the Business Environment Affects Productivity and Efficiency of European Life Insurance Companies.	14 EU countries 2002-2013 DEA	Technical and Cost efficiency	Technical eff: 91% Cost eff: 60% Business environment is important in affecting productivity and efficiency

Vencappa, Fenn and Diacon (2013) estimated productivity growth for a sample of insurance companies from 14 EU countries over the 1995-2008 years. Their results question the ability of the EU insurance industry to generate positive technical change since liberalization in the early 1990s.

Cummins and Rubio-Misas (2016) examined the impact of integration on the efficiency of ten European Union (EU) life insurance markets for the post-deregulation period 1998-2007. To assess the effects of deregulation, they first estimated cost and revenue efficiencies by applying the metafrontier data envelopment analysis (DEA) approach. In the second stage, they tested the degree of inter-country convergence as well as cross sectional dispersion by using panel data models. Their results show that efficiencies have converged and that the dispersion of mean efficiency scores across countries has been reduced, providing evidence of integration in the EU life insurance market. Results also show the β-convergence and σ-convergence in metatechnology efficiency ratios suggesting that technological discrepancy among the life insurance markets of major EU countries has decreased. Cummins, Rubio-Misas, and Vencappa (2017) provided cross-country evidence on the association between soundness and competition in the life insurance industry. They analyzed 10 European Union life insurance markets over the post-deregulation period 1999-2011. Their results show that competition increases the soundness of the EU life insurance markets and the soundness-enhancing effect of competition is greater for weak insurers than for healthy ones.

Eling and Schaper (2017) considered a sample of 970 life insurers from 14 European countries in order to estimate technical and cost efficiency for the period 2002-2013 by using multi-stage DEA. Although they found no technical change, they observed an efficiency increase in this period that leads to an increase in total factor productivity. Their results show that that the general economic, capital market and insurance market conditions are important drivers of efficiency.

It should be clear from the above literature presentation that only two papers examine convergence in the European insurance sector, the others basically deal with the evolution of efficiency during the sample periods while trying to determine the factors affecting efficiency levels. We extend this segment of the literature in three ways. Our analysis includes 22 EU countries over 10 countries that were used before, we use stochastic frontier analysis over data envelopment analysis, and our sample period is different.

III. Data and Methodology

A. The Data

The data source of this paper is the Orbis database that includes data for over 200 million companies worldwide with all information standardized for easy cross-border comparisons. The European insurance market is characterized by the existence of large, multinational groups of insurers selling both life and nonlife insurance services through a range of subsidiaries, which may themselves specialize in one particular product line. These groups of insurers coexist with a large number of fully independent (unaffiliated) insurance companies which may choose to specialize in life or non-life business, or indeed, to engage in both (Fenn et al., 2008; Vencappa, Fenn and Diacon, 2013).

The Decision Making Unit (DMU) includes both these groups of insurers and the unaffiliated single insurers specialized in life or engaged in both life and nonlife activities. Consolidated statements for group of insurers and unconsolidated data for single unaffiliated insurance companies are used. Companies are included in our analysis if they have positive values for all the inputs and outputs. Companies are not required to have data for all years of the research period but those with less than three years of data are excluded. Thus, in this paper an unbalanced panel data sample containing 771 companies with 6,321 firm-year data operating in 22 European countries is used.

Inputs and their prices

There is a widespread agreement in insurance efficiency literature concerning the determination of the inputs utilized by the insurers. For a good discussion on inputs and outputs in the insurance industry see Wise (2018). According to this literature, expenses for labor, business services and materials, debt capital, and equity capital are used as inputs (e.g., Diacon, Starkey and O'Brien, 2002; Eling and Luhnen, 2010a,b). However, it is common for researchers to combine labor and business services as one input (operating expenses including commissions) due to data restrictions (e.g., Fenn et al., 2008). Ennsfellner, Lewis and Anderson (2004) advocated for this simplification and claimed that the operating expenses should be treated as a single input in order to reduce the number of parameters that is needed to be estimated. Cummins and

Weiss (2012) showed in their analysis of operating expenses in the US insurance market that these are mostly labor related. They found that employee salaries and commissions constitute the largest expenses in both life and property-liability insurance industry.

Following the literature, this paper uses three inputs: labor (including business services and materials), debt capital, and equity capital. Operating expenses are used to proxy both labor and business services and tackle these as a single input in the efficiency estimations. Debt capital is proxied by total liabilities reported in the database used. Equity capital is proxied by capital and surplus item reported in the Orbis database. Labor is used to determine the price of the operating-expenses-related input factor (Eling and Luhnen, 2010a). The price of labor is determined using OECD and EUROSTAT databases and it is proxied by the average annual wage in each life insurance sector. The price of debt capital is proxied by using country specific ten-year bond rates for each year of the sample period (Fenn et al., 2008) obtained from the European Central Bank data warehouse. The price of equity capital is determined by using the 10-year-rolling-average of the yearly rates of total return of the country-specific MSCI stock market indices (e.g., Eling and Luhnen, 2010a) obtained from Bloomberg database.

Outputs

Despite the widespread agreement in insurance efficiency literature concerning the determination of the inputs utilized, there is an open debate concerning output selection (see Cummins and Weiss, 2012; Vencappa, Fenn and Diacon, 2013; Wise, 2017, 2018). According to Wise (2017) the debate in the insurance literature is about two basic sets of prevalent output proxies used: (a) reserves (or their change) and claims and (b) premiums and investments. Some authors (e.g., Yuengert, 1993) use incurred benefits plus additions to reserves to measure the insurance output and criticize the use of premiums as output stating that premiums represent price times the quantity of output but not output alone. Other authors (e.g., Greene and Segal 2004) express their reservations stating that the use of the incurred benefits/losses plus additions to reserves is not accurate since reserves change when policies age and the change in reserves measures the change in liabilities rather than the output of the selling effort. Net premiums written are used as an output that proxies the risk pooling/risk bearing function of insurers.

TABLE 2. Descriptive statistics for the European life insurance sector

Variable	Mean	St. Deviation	Minimum	Maximum
Labor and Business Services Expenses (in thousands €)	689,088.9	2,359,723	55	36,864,675
Debt Capital (total liabilities in thousands €)	14,700,845	55,287,295	0.0	1,060,431,000
Equity Capital (capital and surplus, in thousands €)	891,625.9	3,259,355	0.0	60,747,000
Price of Labor (average annual wage, in thousands €)	33.616	10.932	3.681	59.946
Price of Debt Capital (country specific ten-year bond rates for each year)	3.7518%	0.0168	1.2%	22.5%
Price of Equity Capital (the 10-year-rolling-average of the yearly rates of total return of the country-specific MSCI stock market indices)	10.294%	0.0771	0.3%	55.7%
Investments (in thousands €)	14,372,642	50,968,754	4,038.076	70,9567,631
Premiums Written (in thousands €)	1,194,191	4,120,902	176	65,501,443
Total Assets (in thousands €)	15,522,311	58,163,004	3,717	1,110,081,000

Investments are used as a second output by life insurance firms and proxy their intermediation process (Eling and Luhnen, 2010b).

Table 2 presents the descriptive statistics of the variables used in this study. For comparative analysis, all monetary values for each year were deflated by the Harmonized European Consumer Price Index to the base year 2014 obtained from the Eurostat database.

B. The model

There are two distinct approaches- parametric and non-parametric- for estimating efficient frontiers. Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) are the most commonly used methods for each approach respectively. In the literature there is a controversy concerning the advantages and disadvantages of each approach, with some researchers arguing for the parametric approach (e.g., Berger, 1993; Greene, 2008). The basic advantage of the parametric approach over the non- parametric approach is that the first allows firms to be off the frontier due to both random noise and inefficiency and, consequently it does not count purely random divergence from the frontier as inefficiency only. The primary disadvantage of the parametric approach is that it requires the adoption of a functional form in order to estimate the respective model. However, the selection of an inappropriate functional form will produce unreliable results. In our case SFA was preferred to DEA because we have a multi-national sample and one has to account for country-specific differences in order to make a common European frontier meaningful. These country-specific differences were taken into account in the banking efficiency literature (e.g., Fiordelisi and Molyneux, 2010), but were neglected in most insurance studies that use cross-country data. Only Eling and Luhnen (2010a), Kasman and Turgutlu (2011), and Gaganis, Hasan and Pasiouras (2013) used the Battese and Coelli (1995) model that allows for exogenous effects in a single and common frontier.

Revenue efficiency reflects how efficiently an insurer sells its outputs and it is measured as the deviation from the maximum possible amount of revenue on the relevant revenue frontier. Despite its importance, revenue efficiency estimation has not attracted satisfactorily the interest of the researchers. Under the standard revenue frontier approach, output prices are taken as exogenous and the inefficiency comes from the improper mix of input or output quantities. In this study, the alternative revenue approach is adopted that takes outputs as exogenous and allows for price setting behavior by the insurers since output markets are not perfectly competitive and insurers have some market power in the pricing of their outputs (Berger and Mester, 1997; Berger et al., 2000; Fiordelisi and Molyneux, 2010).

The model employed in this paper is the one of the Battese and Coelli (1995) which permits the estimation of efficiency in a single stage while considering the impact of environmental variables on efficiency. In the general form, the alternative revenue equation can be expressed with the following form:

$$TR_{it} = TR(q_{it}, p_{it}; \beta) + v_{it} - u_{it} \tag{1}$$

where:

TR_{it} represents total revenue of the *i*-th insurer (i=1,2,…,N) in the *t*-th period (t=1,2,…,9) which are given by our database and include premium and investment income less losses and loss adjustment expenses,

q_{it} is a vector of output quantities of the *i*-th firm in the *t*-th period,

p_{it} is a vector of input prices of the *i*-th firm in the *t*-th period,

β is the vector of coefficients needed to be estimated,

v_{it} is the random noise component which is assumed to be independent and identically distributed, with zero mean and constant variance and independent of the u_{it}.

u_{it} resents revenue inefficiency and is assumed to be independently (but not identically) distributed, such that u_{it} is obtained by truncation at zero point of the $N\left(m_{it},\sigma_u^2\right)$ distribution, where the mean, m_{it}, is assumed as (e.g., Battese and Coelli, 1995):

$$m_{it} = \delta z_{it} \qquad (2)$$

where:

z_{it} is a vector of variables that affect the efficiency of the *i*-th insurer in the *t*-th time period, and δ is a vector of coefficients to be estimated.

This paper estimates the revenue frontier using the translog functional form in order to assess the level of efficiency. Most of the empirical studies in the financial institutions' efficiency literature assume the translog form followed by the flexible Fourier form. As Berger and Mester (1997) showed, these two functional forms give the same average level and dispersion of efficiency, and rank the individual firms in almost the same order. Accordingly, the translog form is used in order to reduce the number of parameters needed to be estimated and to increase the degree of freedom for our model estimates. The translog revenue function takes the following form:

$$\ln\left(\frac{TR_{it}}{p_{Kit}}\right) = \alpha_0 + \sum_{m=1}^{M} \alpha_{mi} \ln(q_{mit}) + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M} \alpha_{mn} \ln(q_{mit}) \ln(q_{nit})$$

$$+ \sum_{k=1}^{K-1} \beta_k \ln\left(p_{kit}^{*}\right) + \frac{1}{2}\sum_{\kappa=1}^{\mathrm{K}-1}\sum_{l=1}^{L-1} \beta_{kl} \ln\left(p_{kit}^{*}\right) \ln\left(p_{lit}^{*}\right)$$

$$+ \sum_{k=1}^{K-1}\sum_{m=1}^{M} \phi_{km} \ln\left(p_{kit}^{*}\right) \ln(q_{mit}) + z_1 TREND \tag{3}$$

$$+ \frac{1}{2} z_{11} TREND^2 + \sum_{m=1}^{M} \gamma_{1m} TREND \ln(q_{mit})$$

$$+ \sum_{k=1}^{K-1} \omega_{1k} TREND \ln\left(p_{kit}^{*}\right) + \upsilon_{it} - u_{it}$$

where:

TREND is a time factor and is included as a regressor in the revenue function to account for possible technological change over our sample period. In the summations above M=N=2 represent the number of outputs produced while K=L=3 represent the number of inputs used by the insurers. In order to ensure linear homogeneity of degree one in input prices, one input price (p_{Ki}, the price of equity capital in our case) is randomly chosen and the dependent variable and all the other input prices are divided by this input price. Thus, $p_{kit}^{*} = p_{kit} / p_{Kit}$. This is why all summations in (3) involving p_{kit}^{*} are over K–1 and not K. The other symbols of equation (3) were described above in equation (1). The random error υ_{it} is assumed to be distributed normally and inefficiencies u_{it} are assumed to follow a truncated normal distribution with the mean m_{it} of u_{it} varying depending on a vector of firm-specific variables as:

$$m_{it} = \delta_0 + \delta_1 STOCK_{it} + \delta_2 LNL_{it} + \delta_3 SIZE_{it}$$
$$+ \delta_\theta COUNTRY_{i\theta} + \delta_\gamma T_{i\gamma} \tag{4}$$

where:

STOCK is a dummy variable taking the value of one if the insurer follows the stock organizational form and zero if it follows the mutual form.

LNL is a dummy variable taking the value of one if the insurer provides both life and non-life services and zero if it provides only life services.

SIZE equals the natural logarithm of total assets.

$COUNTRY_i$ are 21 country dummy variables with θ=Austria, Belgium,...,United Kingdom (France is used as a reference category). T_i are eight year dummy variables with γ=2007,...,2014 (2006 is used as a reference year).

The parameters of equations (3) and (4) are estimated in one step using maximum likelihood.

This article estimates revenue efficiency of the European life insurers operating in 22 countries for the period 2006-2014, which includes the years of the financial crisis and after. Estimating the level of convergence, the concepts β-convergence and σ-convergence are used which were firstly used in the growth literature (Barro and Sala-i-Martin, 1992; Barro and Sala-i-Martin, 1995). Since the factors of production and their prices (costs of debt, equity and labor) underlie the law of one price, they are expected to converge across their European average.

C. Convergence estimations

Convergence has been mainly modeled using time-series, cross sectional, and panel data methods with respect to economic growth models (Murinde, Agung and Mullineux, 2004). In the growth literature σ-convergence occurs when the dispersion of real per capita income across a group of economies falls over time, and β-convergence occurs when the partial correlation between growth in income over time and its initial level is negative (Young, Higgins and Levy, 2008). Thus, the notion of convergence in economics (catch-up effect) means that the per capita income of poorer economies tends to grow at faster rates than that of richer ones. Young, Higgins and Levy (2008) demonstrated that β-convergence is a necessary but not sufficient condition for σ-convergence.

The notions of β- and σ-convergence used in this paper were originally proposed by Barro and Sala-i-Martin (1992, 1995) for measuring convergence in economic growth rates across different countries following a neoclassical approach. Quah (1996) criticized the β-convergence test on two grounds. First, he stressed the fact that when countries with low initial levels grow faster than those with high initial level, this can lead to a situation where the former overpass the latter, meaning the absence of convergence. Second, he stated that β-convergence tests provide no information on the evolution of the dispersion over a sample of countries. The σ-convergence test does not suffer from these limits as it investigates the evolution of dispersion and convergence exists if dispersion diminishes over time (Quah, 1996). Thus, the σ-convergence notion captures how quickly each country's level (e.g., efficiency, GDP, interest rates) is converging to the average level of the countries in the group investigated.

In the existing literature, some papers use the recently developed panel convergence methodology by Phillips and Sul (2007) for convergence estimations. This test is superior to the beta and sigma panel convergence tests because it gives an estimate of the speed of convergence and clusters panels into club convergence groups. Hence, in addition to detecting panel convergence, if present, the Phillips and Sul (2007) clustering algorithm test reveals whether club formation is also present. This methodology also allows for the calculation of each country's relative transition parameter. Matousek et al. (2015) used both approaches and found the same results.

In this paper, the work of Casu and Girardone (2010) and Weill (2009) is used in order to investigate the convergence of insurance efficiency levels across the EU countries over the period of analysis. In order to estimate the unconditional β-convergence (catch-up effect), we define the following model:

$$\Delta y_{j,t} = \alpha + \beta\left(\ln y_{j,t-1}\right) + \rho \Delta y_{j,t-1} + \varepsilon_{j,t} \tag{5}$$

where j=1, 2,..,22 and t=2007, 2008,…,2014; $y_{j,t}$ and $y_{j,t-1}$ is the mean efficiency of the insurance market of country j at year t and year t–1 respectively, $\Delta y_{j,t} = \ln\left(y_{j,t}\right) - \ln\left(y_{j,t-1}\right)$, α, β, and ρ are the parameters needed to be estimated, and $\varepsilon_{j,t}$ is assumed to be the random error term, which is independently and identically distributed $\sim IID\left(0, \sigma_{\varepsilon}^{2}\right)$, catching up the effects of the factors not included in (5). A negative value for the β parameter implies convergence with the higher the coefficient in absolute terms the greater the tendency for convergence.

In order to estimate the cross-section dispersion or σ-convergence, that is to estimate how quickly each country's efficiency level is converging to the European average, the following autoregressive distributed lag model (Casu and Girardone, 2010; Weill, 2009) is determined:

$$\Delta E_{jt} = \alpha + \sigma E_{j,t-1} + \rho \Delta E_{j,t-1} + \varepsilon_{j,t} \tag{6}$$

where $E_{j,t} = \ln(y_{j,t}) - \ln(\overline{y_t})$; $E_{j,t-1} = \ln(y_{j,t-1}) - \ln(\overline{y_{t-1}})$; $y_{j,t}$ and $y_{j,t-1}$ as defined above in (5); $\overline{y_t}$ and $\overline{y_{t-1}}$ are the mean efficiencies of the EU insurance market at time t and t–1 respectively; $\Delta E_{jt} = E_{j,t} - E_{j,t-1}$; α, σ, and ρ are coefficients to be estimated. $\varepsilon_{j,t}$ is assumed to be the random error term, which is independently and identically distributed $\sim IID(0, \sigma_{\varepsilon}^{2})$, catching up the effects in the model. The coefficient $\sigma<0$ represents the rate of convergence of $y_{j,t}$ towards $\overline{y_t}$. The larger the value of σ in absolute terms, the faster the rate of efficiency convergence will be (Casu and Girardone, 2010).

Following Casu and Girardone (2010), equations (5) and (6) are estimated by using the two-step system Generalized Method of Moments (GMM) in order to introduce dynamic behavior in the time series and cross-sectional variation. This approach is adopted against the conventional random and fixed effects panel data approaches since GMM technique corrects potential endogeneity, heteroskedasticity, and autocorrelation in the model estimated, it uses the lagged dependent variable and the exogenous variables as instrumental variables in order to account for simultaneity, and it captures possible correlations among the independent variables (Arellano and Bond, 1991; Blundell and Bond, 1998; Blundell and Bond, 2000).

IV. Results

A. Determinants of efficiency results

Table 3 presents the estimated coefficients of the translog revenue function and of the inefficiency term given by equations (3) and (4). The net premium written output has the expected positive sign (1.8225) which is statistically significant at the 1% level. The coefficient of total investments has an unexpected negative sign (–1.3005) something that might be due to the large variations in invested income that were caused

TABLE 3. Parameters of the stochastic frontier

Variable	Parameter estimate	Variable	Parameter estimate
Constant	4.1266***	$\ln(p_1/p_3) \times \ln q_1$	0.1010***
$\ln q_1$	–1.3005***	$\ln(p_1/p_3) \times \ln q_2$	–0.1041***
$\ln q_2$	1.8225***	$\ln(p_2/p_3) \times \ln q_1$	–0.1010***
$0.5 \times \ln q_1 \times \ln q_1$	0.1616***	$\ln(p_2/p_3) \times \ln q_2$	0.1026***
$0.5 \times \ln q_2 \times \ln q_2$	–0.1737***	*TREND*	–4.1077***
$\ln q_1 \times \ln q_2$	0.1823***	0.5 × *TREND* × *TREND*	0.0102***
$\ln(p_1/p_3)$	2.7140**	*TREND* × $\ln q_1$	0.0074***
$\ln(p_2/p_3)$	–2.4665**	*TREND* × $\ln q_2$	–0.0095***
$0.5 \times \ln(p_1/p_3) \times \ln(p_1/p_3)$	0.0659***	*TREND* × $\ln(p_1/p_3)$	–0.0128**
$\ln(p_1/p_3) \times \ln(p_2/p_3)$	–0.1016***	*TREND* × $\ln(p_2/p_3)$	0.0120*
$0.5 \times \ln(p_2/p_3) \times \ln(p_2/p_3)$	0.1142***		
Inefficiency term			
Constant	–0.0593	NETHERLANDS	0.0495
STOCK	–0.1074***	POLAND	0.0066
SIZE	0.3125***	PORTUGAL	0.0142
LNL	0.2960***	ROMANIA	0.0452
AUSTRIA	–0.0715	SLOVAKIA	–0.1075
BELGIUM	0.1487	SLOVENIA	0.0229
CROATIA	–0.0929	SPAIN	–0.0617
CZECH REBUBLIC	–0.1759	SWEDEN	0.0526
DENMARK	0.3747***	UNITED KINGDOM	0.0277
FINLAND	0.0172	*T*1	0.0732
GERMANY	–0.4490***	*T*2	0.5397***
GREECE	0.1332	*T*3	–0.2188*
HUNGARY	–0.0181	*T*4	–0.2856**
IRELAND	0.2468**	*T*5	0.3160***
ITALY	–0.1192	*T*6	–0.2471*
MALTA	0.0227	*T*7	0.0100
		*T*8	0.0216

Sigma–squared (σ^2): 0.7115***
Gamma (γ): 0.9234***
Log–likelihood function: –4,325.7474

Note: ***, **, * indicate significance at 1%, 5%, 10% level. Software NLOGIT 5 was used for executing these estimations. ln: Natural logarithm; q_1: Total investments; q_2: Net premium written; p_1: Price of debt capital; p_2: Price of labor; p_3: Price of equity capital; *TREND*: time variable. *STOCK* is a dummy variable taking the value one when the insurer follows the stock organizational form and zero if it follows the mutual form. *LNL* is a dummy variable equal to one if the insurer provides both life and non-life services and zero if it provides only life services. *SIZE* equals the natural logarithm of the total assets of each insurer. AUSTRIA, BELGIUM,…, UNITED KINGDOM are 21 country dummy variables (France is used as a reference category). Finally, *T*1,*T*2,…,*T*8 are eight year dummy variables for the years 2007,…,2014 respectively (2006 is used as a reference category). The value of γ being close to one indicates that a large proportion of the variation in the composite error term is due to the inefficiency component $\left(\gamma = \sigma_u^2 / \sigma_v^2 + \sigma_u^2\right)$.

by the financial turmoil. The input price of debt does not have the expected negative sign (2.7140) while the input price of labor has the expected negative sign (–2.4665) and it is statistically significant at the 5% level. The negative coefficient of the *TREND* variable indicates that total revenues have declined over the nine years period.

We now turn to the results concerning the effect of certain variables on inefficiency given by the equation (4). Positive coefficients indicate an increase in inefficiency (decrease in efficiency) and negative coefficients indicate a decrease in inefficiency (increase in efficiency). It is observed that stock insurers are more revenue efficient than mutuals as this coefficient is negative (–0.1074) and statistically significant at the 1% level. This result might be due to the fact that the management of the stock companies is under the continuous scrutiny of the stockholders to produce profits. In general, the policyholders of the mutual companies are less concerned about the short-term financial results than the stock holders of stock companies. While most of the studies in the literature find that stock insurers are more efficient than mutuals, Eling and Luhnen (2010a) examining the cost efficiency for 36 countries found that insurers operating as mutuals are more efficient. The size has a positive and statistically significant effect on revenue inefficiency (0.3125), indicating that the size tends to increase revenue inefficiency in the European life insurance market, a result which is in line with the study by Fenn et al., (2008). The effect of the *LNL* variable on revenue inefficiency is positive and statistically significant (0.2960) indicating that diversified insurers are less revenue efficient than those that focus only on life insurance. This result is in line with the study of Cummins et al. (2010) where they found that strategic focus is superior to diversification in the insurance industry. The country effects appear to be statistically significant only for three countries. Specifically, positive country effects on revenue inefficiency exist for insurers operating in Denmark and Ireland that are statistically significant at the 1% and 5% level respectively, while for Germany the coefficient is negative and statistically significant at 1% level. Given that France is the reference country the above results indicate that insurers in Denmark and Ireland experience higher revenue inefficiency than insurers in France, while insurers in Germany experience lower revenue inefficiency. Finally, the coefficients of the time dummies indicate a reduction in revenue inefficiency for the years 2009, 2010 and 2012 compared to 2006. For the years 2008 and 2011 it is observed an increase in revenue inefficiency compared to 2006.

B. Efficiency results

Table 4 presents the revenue efficiency results for the European life insurance sector by year and country. Three conclusions emerge: First, the average revenue efficiency score for all the 22 EU life insurance markets over the whole sample period 2006-2014 is 57.4%, indicating a 42.6% possible increase in revenues on average. The average revenue efficiency result of this paper differs from that found by the Cummins and Rubio-Misas (2016) study. These authors report three measures of revenue efficiency: metafrontier 22%, own-country 54,4% and metachronology 41% for a sample of ten European countries using DEA technology. Thus, we find a higher level of average revenue efficiency than Cummins and Rubio-Misas (2016) which it might be due to the different sample, different technology and different time period used.

Second, the average revenue efficiency for the firms in the EU life insurance sector remains relatively stable over the period 2006-2014 with a noticeable reduction between 2006-2008 with the year 2008 to be the worst of all, something that might be due to the global financial crisis that broke out during that time. Although the global financial crisis of 2007 was primary a banking crisis, insurance companies' revenue efficiency has been affected primarily through their investment portfolios since they were directly exposed to the US mortgage market (e.g., Marovic, Njegomir and Maksimovic, 2010). Third, considering the country ranking, Croatia (0.684), Czech Republic (0.683), and Slovakia (0.669) appear to have the most revenue efficient life insurance sectors in EU. On the other hand, Greece (0.448), Belgium (0.498), and Romania (0.501) are among the least revenue efficient life insurance markets in EU. It is important to point out the dramatic drop in revenue efficiency of the Greek life insurers after the burst of the sovereign debt crisis in 2010. It is also interesting to note that the efficiency levels are very low for the years 2011, 2012 and 2013 for three countries- Greece, Ireland and Portugal- that faced serious economic problems at that time.

C. Convergence results

Table 5 reports the results concerning revenue efficiency convergence. The beta coefficient for the whole period 2007-2014 is negative and statistically significant (–0.8057) indicating that convergence in revenue efficiency has taken place in the EU-22 life insurance industry. Thus, the results indicate that the least efficient life insurance sectors in 2007 have experienced a higher improvement of revenue efficiency than the

TABLE 4. Revenue efficiency scores by year and country, 2006-2014

Country	Years									
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2006-2014
Austria	0.609	0.609	0.511	0.634	0.692	0.503	0.698	0.633	0.693	0.620
Belgium	0.546	0.538	0.450	0.547	0.511	0.462	0.495	0.481	0.452	0.498
Croatia	0.814	0.652	0.564	0.518	0.710	0.821	0.640	0.745	0.609	0.684
Czech Republic	0.620	0.736	0.604	0.758	0.756	0.769	0.694	0.590	0.621	0.683
Denmark	0.475	0.343	0.289	0.617	0.618	0.471	0.653	0.434	0.528	0.492
Finland	0.634	0.524	0.603	0.725	0.400	0.694	0.628	0.578	0.398	0.576
France	0.660	0.615	0.465	0.629	0.654	0.505	0.617	0.615	0.549	0.590
Germany	0.653	0.631	0.540	0.678	0.696	0.641	0.730	0.640	0.658	0.652
Greece	0.599	0.633	0.454	0.668	0.377	0.260	0.280	0.358	0.401	0.448
Hungary	0.412	0.564	0.443	0.422	0.576	0.519	0.593	0.692	0.645	0.541
Ireland	0.621	0.509	0.454	0.599	0.543	0.346	0.542	0.514	0.532	0.518
Italy	0.689	0.656	0.518	0.588	0.630	0.605	0.604	0.497	0.491	0.586
Malta	0.495	0.575	0.405	0.745	0.758	0.697	0.631	0.606	0.433	0.594
Netherlands	0.617	0.587	0.419	0.594	0.605	0.587	0.608	0.508	0.547	0.564
Poland	0.502	0.589	0.460	0.625	0.598	0.501	0.704	0.589	0.578	0.572
Portugal	0.635	0.719	0.513	0.550	0.572	0.435	0.399	0.487	0.596	0.545
Romania	0.474	0.464	0.457	0.427	0.603	0.432	0.550	0.532	0.569	0.501
Slovakia	0.637	0.715	0.629	0.679	0.731	0.589	0.629	0.701	0.710	0.669
Slovenia	0.627	0.592	0.570	0.651	0.379	0.573	0.521	0.570	0.433	0.546
Spain	0.644	0.606	0.542	0.601	0.572	0.506	0.641	0.621	0.540	0.586
Sweden	0.606	0.455	0.421	0.660	0.703	0.467	0.689	0.535	0.565	0.567
United Kingdom	0.634	0.479	0.689	0.708	0.520	0.672	0.620	0.585	0.436	0.594
Average	0.600	0.581	0.500	0.619	0.600	0.548	0.598	0.569	0.548	0.574

TABLE 5. Results for *β*-convergence and *σ*-convergence

Period	β-convergence	σ-convergence
2007-2014	–0.8057***	–0.4632
2007-2010	0.0000	0.7780***
2010-2014	–2.4507***	0.3800

Note: *** Statistically significant at 1%.

most efficient ones in 2007. Sigma convergence indicates how quickly each country's efficiency levels are converging to the EU average with coefficient σ<0 representing the rate of convergence of the efficiency towards its average. The larger the value of σ in absolute terms the faster the rate of convergence. In our case sigma is negative but not statistically significant (–0.4632) and we cannot allege that the dispersion of the mean efficiency scores among the EU-22 countries has been reduced during the examined period. Cummins and Rubio-Misas (2016) found that the dispersion of mean efficiency scores across countries has been reduced in the EU life insurance market.

At the end of 2009 and at the beginning of 2010 the financial crisis led several European countries member states close to bankruptcy. To see the effect of the financial crisis on convergence, beta and sigma convergence are estimated separately for the periods 2007-2010 and 2010-2014.

The beta coefficient for the period 2007-2010 is zero and not statistically significant and it can be claimed that convergence has not been achieved during the period of the global financial crisis. Instead, this crisis halted back the integration process. The corresponding beta coefficient for the second sub period 2010-2014 is negative and statistically significant (–2.4507) indicating that convergence in the European life insurance efficiency has been achieved. The fact that revenue efficiency convergence was not achieved during the first period may be attributed to the fact that European authorities were caught unprepared when the global financial crisis broke out and national governments' responses were uncoordinated and heterogeneous creating a major challenge to the Single European Market. Only in June 2010 the European Financial Stability Facility (EFSF) was created as a temporary crisis resolution mechanism and the European Stability Mechanism (ESM) in October 2012 as a permanent firewall for the Eurozone countries. These coordinated initiatives possibly restored the confidence of the European insurers, increased their underwriting and investment revenues, and narrowed their differences in efficiency level.

The sigma coefficient for the first sub period is positive and statistically significant (0.7780) indicating that σ-divergence occurred during this period. The corresponding sigma coefficient for the second sub period is positive but not statistically significant (0.3800) and so there is no clue for sigma convergence concerning revenue efficiency. These results generally imply that the dispersion of the mean efficiency scores among the European life insurance sectors was not reduced during the whole period of this study. As Young, Higgins and Levy (2008) point out, β-convergence is a necessary but not sufficient condition for σ-convergence. Intuitively, insurers can be β-converging toward each other concerning their revenues efficiencies, but at the same time, random shocks such as the above mentioned financial crises are pushing them apart.

V. Conclusions

The results are some of the first to consider revenue efficiency and convergence for life insurance firms operating in 22 European Union countries during the 2006-2014 period. Employing a flexible stochastic revenue frontier and estimating a translog revenue function, the revenue efficiencies are found for the 22 insurance markets, then various factors that might affect revenue inefficiency are examined and last the issue of convergence is examined.

The average revenue efficiency is found to be relatively stable over the period 2006-2014 with a noticeable reduction for the period 2006-2008 due to the global financial crisis that broke out during this time. Croatia, Czech Republic, and Slovakia appear to have the most revenue efficient life insurance sectors, while Greece, Belgium, and Romania are among the least revenue efficient life insurance markets in EU.

The results show that insurance firms generally become less efficient with increasing size. Thus, the movement towards larger-sized insurers has important implications for the insurance industry. As the size of the insurance firms becomes larger, it might lead to higher levels of inefficiency. Stock insurers are found to be more revenue efficient than mutual insurers, while diversified insurers are less revenue efficient than those that focus only on life insurance.

Dynamic panel data models are employed to test β-convergence and σ-convergence in order to examine the speed of life insurance markets' integration after the removal of cross-country restrictions mentioned above. Evidence is provided for β-convergence for revenue efficiency but not for σ-convergence; instead σ-divergence is observed for the period 2007-2010. Cummins and Rubio-Misas (2016) find evidence for both β-convergence and σ-convergence.

This is the second study, to the best of our knowledge, which examines the effects of financial integration in EU on the revenue efficiency convergence for the EU life insurance markets. The study can be further extended by conducting an analysis of cost or profit efficiency or of productivity convergence over time. Last but not least, it would also be important to measure average efficiency scores by using different methods such as the non-parametric Data Envelopment Analysis (DEA).

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