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# A Luenberger Index for the Greek Life Insurance Industry

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***Abstract:***

*This paper uses the Luenberger productivity index to evaluate the productivity changes of Greek Life insurance companies between 1994 and 2003, combining operational and financial variables. It is found that the average annual productivity change was about 19% and was due to technological progress, whereas the impact of efficiency was minimal. It seems that deregulation, established by the Third Insurance Directive in 1994, provoked investments in new technologies which were not matched by superior managerial practices. For comparative purposes, a Malmquist productivity index is estimated.*

**Keywords:** *Greek life insurance companies, productivity changes, Luenberger indicator.*

## 1. Introduction

Efficiency in insurance industry is a theme that has attracted considerable research in recent past. A review of the relevant literature shows that two main approaches have been used: the DEA-Data Envelopment Analysis applied in insurance, and the stochastic frontier models. The aim of this paper is to extent previous research by analyzing the efficiency and productivity of Greek life insurance companies in the period 1994 to 2003, with the use of a directional distance function and the Luenberger productivity indicator.

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Whereas productivity may be estimated by parametric techniques, the most popular approaches employ non-parametric methods: DEA and the Malmquist productivity index. The advantage of using non-parametric frontier technologies is that they impose no a priori functional form on technology, nor any restrictive assumptions regarding input remuneration. Yet, differences exist between productivity measures based on ratios (indices) and differences (indicators). Recently, difference-based indicators, such as the Luenberger indicator, have been introduced. A key advantage of this indicator is that it allows the evaluation of organizations that can be assumed to be profit maximizing. Then, the Luenberger productivity indicators encompass the Malmquist productivity approach and they can also specialize to an output- or input-oriented perspective, corresponding to the revenue maximization and cost minimization cases when necessary (Boussemart et al., 2003).

In this paper we innovate in the field of insurance performance studies with an application of the directional distance and of the Luenberger productivity indicator to the analysis of Greek life insurance market for the period 1994 -2003. In order to show the value of the use of the Luenberger productivity indicator, we adopt also the Malmquist productivity index, which is a more traditional productivity measure, and we make a comparison.

The paper is organized as follows. In the second section, we describe the institutional setting. In the third section, we survey the literature on the topic and in the fourth section we present the theoretical framework. In the fifth section, the data and results are presented and the managerial implications of the study are considered. In the final section, we draw our conclusions.

## 2. Overview of the Greek Insurance Market

The Greek insurance market is the least developed in the group of EU-15 countries. For this group of insurance markets, the relative share of the Greek market has increased from 0.3% in 1994 to 0.4% in 2003, in terms of total premiums. From Table 1 we observe that the volume o total premium in the Greek market has increased from €1050 million to €3235 million between 1994 and 2003. In the same period, the inflation-adjusted average annual growth rate was 6.8%, while in EU-15 was 4.8%. For the Life sector, the inflation-adjusted average annual growth rate was 6.0% (EU-15: 7.3%), whereas for the Non-Life sector it was 7.5% (EU-15: 2.3%). That is, most of the growth in the volume of business in the Greek insurance market in the period 1994-2003, has come from the faster growth of the Non-Life sector. This is explained by the fact that Greece has not completed yet the reform of its pensions system. This reform process has contributed substantially to the rapid growth of the Life insurance sector in most European insurance markets. It is not strange, therefore, that the “life/non-life” mix was 48/52 in 1994 (EU-15: 44/56) and 44/56 (EU-15: 57/43) in 2003.

The number of insurance companies has decreased from 161 in 1994 to 100 in 2003, a decrease of about 38%, when the respective decrease in the EU area was 6.5%. Most of the exits of insurance companies were due to insolvencies, while the rest were taken over in M&A projects. The reduction in the number of insurance companies has led to the beneficial effect of increasing the average firm size by five times in the period 1994-2003. The size of the employment in the insurance sector has decreased from 10.000 in 1994 to about 9.500 in 2003; a decrease of 0.5% on an annual basis (EU-15 decrease: 0.3%).

Moreover, we observe from Table 1 that concentration has been very high in the life sector, much higher than the corresponding ratios in the EU-15 area whereas, concentration in the non-life sector is comparable to EU standards.

The relative importance of the Greek insurance market in the domestic economy is not significant. The underdeveloped condition of the Greek insurance market on the one hand may imply inefficiency and low competition, but on the other hand offers significant opportunities for development and growth. Along the period analyzed the ratio of total premiums to GDP has increased from 1.5% (EU-15: 5.9%) in 1994 to 2.1% (EU-15: 7.7%) in 2003. The respective ratios for total investments to GDP have been 1.8% (EU-15: 24%) and 4.5% (EU-15: 44%).

**TABLE 1: Basic Characteristics of the Greek Insurance Market.**

| Characteristic of the Insurance Market | 1994 | 2003 |
|---|---|---|
| Number of insurance Companies | 161 | 100 |
| Employment | 10.000 | 9.500 |
| Total Premium | 1.050 million € | 3.235 million € |
| Life | 506 million € | 1435 million € |
| Non-Life | 544 million € | 1800 million € |
| Average Size of Firm | 1050/161=6.5 | 3235/100=32.3 |
| Mix(Life/Non-life) | 48/52 | 44/56 |
| Market Concentration | | |
| 1. Life: | | |
| Big 5 | 68.7% (EU-15: 45%) | 62.5% (EU-15: 54%) |
| Big 10 | 82.9% (EU-15: 63%) | 88.9% (EU-15: 75%) |
| Big 15 | 90.6% (EU-15: 72%) | 97.2% (EU-15: 84%) |
| 2. Non-Life: | | |
| Big 5 | 39.3% (EU-15: 32%) | 42.8% (EU-15: 46%) |
| Big 10 | 50.9% (EU-15: 48%) | 58.4% (EU-15: 62%) |
| Big 15 | 59.1% (EU-15: 59%) | 70.8% (EU-15: 71%) |

**Source:** European Insurance in Figures, CEA (various issues).

## 3. Literature Survey

In the United States as well as in European countries, studies about efficiency in the insurance industry have emerged, using both parametric and non parametric approaches, during the eighties and nineties.

Research about efficiency in insurance employs frontier models. Two contemporary scientific methods to analyze efficiency quantitatively are the econometric frontier and data envelopment analysis (DEA). Both have advantages and drawbacks. Under the econometric approach, a functional form for the cost, profit or production frontier is specified. Firms that are found to be below the efficient frontier may be due to inefficiency, but also it may result of random shocks or measurement errors, due to the stochastic nature of the approach. Thus, the function error term is hypothesized to consist of an inefficiency component and a purely random component. Unlike the econometric stochastic frontier approach, the DEA (a non-parametric method) allows the use of multiple inputs and outputs and does not impose any functional form on the data; neither does it make distributional assumptions for the inefficiency term[1]. Both methods assume that the production function of the fully-efficient decision unit is known. In practice, this is not the case and the efficient isoquant must be estimated from the sample data. Under these conditions, the frontier is defined relative to the sample considered in the analysis.

Cummins and Zi (1998) apply these two methodologies and also some variants of each, to explore the efficiency of US life insurance companies and conclude that the choice of the efficiency estimation method can make a significant difference. They find that average efficiency is higher for econometric models than for DEA models. Although, efficiency rankings for the DMUs included in the sample are well preserved in the econometric methods and less well preserved between econometric methods and programming methods. Other studies on the US insurance markets include Cummins and Weiss (1993), Gardner and Grace (1993), Cummins, Weiss and Zi (1999) and Cummins and Weiss (2000).

In Europe, there was a growth in research about efficiency in the insurance sector during the nineties, stimulated by a radical change in the sector, after the implementation of the single market in European financial services in 1993, which increased competition in state members and put additional pressure on less efficient insurers. The studies by Fecher et al. (1993), Cristea and Cingula (2008) and Cummins, Turchetti and Weiss (1996) reflect this environment.

Fecher et al. (1993) use both a parametric approach (a stochastic Cobb-Douglas frontier) and a non-parametric approach (DEA) to construct the efficient frontier. The sample consists on 84 life and 243 non-life French insurance companies. The authors observe that the results are not very sensitive to the

[1] Coelli, Rao and Battese (1998) provide a detailed comparison between parametric and non-parametric methodologies.

approach used, and that there is a great dispersion of efficiency levels between companies. In life insurance, average efficiency is only 30% and for non-life it is 50%. Another important conclusion is a positive correlation between the size of the company and efficiency.

Cummins, Turchetti and Weiss (1996) study the Italian market, considering a sample of 94 companies (life, non-life and mixed) between 1985 and 1993. They use a DEA distance function to estimate the technical efficiency and a Malmquist index to analyse changes in technical efficiency. Their results show that technical efficiency in the Italian insurance industry ranges from 70% to 78%, during the sample period.

Hardwick (1997) analyses the cost inefficiency of the United Kingdom life insurance companies using a stochastic frontier approach, between 1989 and 1993. The author concludes that the life insurance industry is very inefficient, namely, that it is possible to produce the same level of output with less 30% of costs. The author also observes that larger life insurance companies are less inefficient than smaller, which he attributes to exploitable scale economies.

Noulas et al. (2001) investigates efficiency of non-life insurance companies in Greece applying a DEA methodology. The sample includes 12 companies for the period 1991 to 1996. The results show an average efficiency of 65%, with a great dispersion between companies. The authors conclude that non-life insurance firms are very inefficient, and their survival in the market implies reduction in costs and an improvement in productivity; that is, an improvement in efficiency.

Mahlberg and Url (2003) and Ennsfellner, Lewis and Anderson (2004) study the Austrian insurance market. These studies use different methodologies to study the impact on efficiency of the single market and of the deregulation in the insurance industry. The former measures the effects of liberalization on technical efficiency and on productivity between 1992 and 1999, using DEA for the estimation of efficient frontiers and also construct a Malmquist index for the transition period. The authors find that, despite the full implementation of the financial single market in 1994, the Austrian insurance industry is inefficient, with an average score of about 75%, and that it is possible to reduce costs adjusting the size of the companies. They also observe a reduction in the dispersion of the efficiency scores and in productivity over time, which they explain by an increase in competition. The later study uses a Bayesian stochastic frontier (a parametric approach) and analyses a similar period, 1994 to 1999. Their conclusions are consistent with the Mahlberg and Url (2003), showing that efficiency increased in the period, from 61.7% in 1944 to 84.8% in 1999.

There are three studies about Spanish insurance industry. Fuentes et al (2001), analyze the change in productivity in the period 1987 to 1994, and find that deregulation had little impact on productivity growth. Cummins and Rubio-Misas and Zi (2004) study the period between 1989 and 1998 and conclude that industry consolidation was efficiency-enhancing.

Barros, Borges and Barroso (2005) study the efficiency and productivity of the Portuguese insurance market in the period 1995 to 2001, using a Malmquist index, and find that a large proportion of companies experienced productivity growth while some experienced a decrease in productivity. They argue that, for a significant number of the companies, there is still room for improvement of managerial skills, which would translate as an increase in technical efficiency.

Finally, we must refer to Diacon, Starkey and O'Brien (2002), a paper that provides comparisons among European countries, which is relevant in the context of globalisation. Using Standard & Poor's Eurothesis database for the years 1996 to 1999, they analyze technical efficiency of European insurers in different countries, and find striking differences in efficiency. The higher levels of technical efficiency are found in UK, Spain, Sweden and Denmark[2].

## 4. Methodological Framework

The paper adopts the efficient frontier approach by using the directional distance function and the Luenberger productivity indicator. In the 1990s, Chambers, Chung and Färe (1996, 1998) proposed new, more flexible, measures involving production theory. They introduced the "directional distance function" which is the transposition in production theory of the Luenberger's (1992) "benefit function" in a consumer context. As its name indicates, the directional distance function determines a shortcut in one direction, which permits an observed production unit to reach the production frontier. In more economic terms, this function makes it possible to evaluate the scale of the economies which can be achieved and the possible improvements in production. It also provides a "benchmark" by defining a reference point to be reached. The principal advantage of this function lies in its capacity to take account simultaneously, and in a broader context, of both inputs and outputs. This function therefore measures the smallest changes in inputs and outputs in a given direction which are necessary in order to reach the production frontier. This distance function can therefore be considered as an indicator of the performance of each observed entity.

Let the technology be described by a set, $T \subseteq R_+^N \times R_+^M$ , defined by

$$T_t = \{(x_t, y_t) : x_t \text{ Can produce } y_t\} , \qquad (1)$$

where $x_t \in R_+^N$ is a vector of inputs and $y_t \in R_+^M$ is a vector of outputs at the time period *t*.

Throughout this paper, technology satisfies the following conventional assumptions:

A1: $(0,0) \in T_t, (0, y_t) \in T_t \Rightarrow y_t = 0$ i.e., no free lunch;

[2] A previous study on the efficiency and productivity of the insurance industry in the OECD countries is Donni and Fecher (1997).

A2: the set $A(x_t) = \{(u_t, y_t) \in T_t; u_t \leq x_t\}$ of dominating observations is bounded $\forall x_t \in R_+^N$, i.e., infinite outputs are not allowed with a finite input vector;

A3: $T_t$ is closed;

A4: $\forall (x_t, y_t) \in T_t, (x_t, -y_t) \leq (u_t, -v_t) \Rightarrow (u_t, v_t) \in T_t$, i.e., fewer outputs can always be produced with more inputs, and inversely (strong disposal of inputs and outputs);

A5: $T_t$ is convex.

The directional distance function generalizes the traditional Shephard distance function (1970) and plays a meaningful role in production theory. Directional distance functions project input and/or output vector from itself to the technology frontier in a pre-assigned direction. In the case of a radial direction out of the origin, we retrieve the classical Shephard distance function. The directional distance function is defined as follows.

The function $D_t : R^{n+p} \times R^{n+p} \rightarrow R \cup \{-\infty\} \cup \{+\infty\}$, defined by

$$D_t(x_t, y_t; g) = \begin{cases} \sup\{\delta : (x_t - \delta h; y_t + \delta k) \in T_t\} & \textit{if } (x_t - \delta h; y_t + \delta k) \in T_t, \delta \in R \\ -\infty & \textit{otherwise} \end{cases} \quad (2)$$

is called directional distance function in the direction of $g = (h, k)$.

In order to make this approach more operational, it is necessary to take an appropriate direction. We do this by considering the direction $g = (x, y)$. Then, the directional distance function is similar to the proportional distance function introduced by Briec (1997). This distance function is based on simultaneous proportional modifications of inputs and outputs. It therefore generalizes Debreu's and Farrell's measure and is equally straightforward to interpret.

To estimate the proportional distance function, we use a non-parametric approach (Banker and Maindiratta, 1988; Varian, 1984). Then, the technology can be written as:

$$T_t = \left\{(x_t, y_t), x_t \geq \sum_k \theta_k x_t^k, y_t \leq \sum_k \theta_k y_t^k, \sum_k \theta_k = 1, \theta_k \geq 0, k = 1, \ldots, K\right\}. \quad (3)$$

The linear program that calculates the values of the directional distance function is given by[3]:

$$D_t(x_t, y_t) = \max \delta_t$$
$$\text{s.t. } x_t - \delta_t x_t \geq \sum_k \theta_k x_t^k , \quad (4)$$
$$y_t + \delta_t y_t \leq \sum_k \theta_k y_t^k ,$$
$$\sum_k \theta_k = 1,\ k = 1 \ldots K .$$

Suppose now that an individual firm is represented by a production vector $(x_t, y_t)$ with corresponding technology $T_t$, and then the production vector is changed to $(x_{t+1}, y_{t+1})$ with corresponding technology $T_{t+1}$. In order to assign a cardinal measure to the productivity change it is natural to use the directional distance function. There are two ways to do this, corresponding to using either the initial technology at *t* or the final technology at *t+1* as reference. Along this line, the Luenberger productivity indicator was proposed in Chambers (1996) to evaluate productivity change. This productivity indicator is constructed as the arithmetic mean between two components reflecting the productivity change with respect to the production frontier in base year $T_t$ and $T_{t+1}$.

The Luenberger productivity indicator can probably best be interpreted in the context of recent attempts to develop testing and economic approaches to index number theory based on differences rather than the more traditional ratios. While economics as a discipline has long been used to work with ratios, the business and accounting community is clearly more familiar with analyzing cost, revenue or profit differences. Apart from tradition, the ratio and difference approaches to index numbers also differ in terms of certain basic properties of great practical significance. While ratios are unit invariant, differences are not. But differences are invariant to changes in the origin, while ratios are not. Furthermore, ratios have difficulties coping with zero observations, while this poses little problem for differences. For a systematic discussion of both ratio and difference approaches to index number theory from both a test and an economic perspective, the reader is referred to Chambers (1996, 2002) and Diewert (1998, 2000), among others. See also Boussemart et al. (2003) for both theoretical and empirical comparisons between the Luenberger productivity indicator and the Malmquist productivity index. The Luenberger productivity indicator, as a generalization of the Malmquist

[3] All the computations are programmed in Mathematica language with the mathematica 5.0 software.

index, is required for evaluating organizations that can be assumed to be profit maximizing. Furthermore, this Luenberger productivity index can specialize to an output- or input-oriented perspective, corresponding to the revenue maximization and cost minimization cases when necessary. Clearly, the Luenberger productivity indicators encompass the Malmquist productivity index approach.

The Luenberger productivity indicator is defined as[4]:

$$L(z_t, z_{t+1}) = \frac{1}{2}\left[D_{t+1}(z_t; g) - D_{t+1}(z_{t+1}; g) + D_t(z_t; g) - D_t(z_{t+1}; g)\right]. \quad (5)$$

Growth (decline) is indicated by positive (negative) value. The Luenberger productivity indicator is additively decomposed as follows:

$$L(z_t, z_{t+1}) = \left[D_t(z_t; g) - D_{t+1}(z_{t+1}; g)\right] +$$

$$\frac{1}{2}\left[D_{t+1}(z_{t+1}; g) - D_t(z_{t+1}; g) + D_{t+1}(z_t; g) - D_t(z_t; g)\right], \quad (6)$$

where the first term (inside the first brackets) measures efficiency change between time periods *t* and *t*+1, while the arithmetic mean of the difference between the two figures inside the second brackets expresses the technological change component, which represents the shift of technology between the two time periods. This decomposition was inspired by the breakdown of the Malmquist productivity index in Färe et al. (1989).

The theoretical framework for the Malmquist productivity index (Malmquist, 1953) is well known and is not repeated here.

## 5. Data and Results

Frontier models require the identification of inputs (resources) and outputs (transformation of resources). The insurance literature contains an extensive discussion of the appropriate definition of inputs and outputs of insurance activity. In this paper, we adopt the methodology proposed by Cummins and Weiss (2000).

To estimate the production frontier, we used panel data for the years 1994 to 2003, obtained from the Association of Insurance Companies of Greece, on 16 Life insurance companies. Each company is observed for 10 years, allowing obtaining (10 years' × 16 companies) 160 observations. The insurance companies that are considered in this analysis represent almost 90% of the market, thus being adequately representative of the Greek life insurance market.

[4] We simplify the notations by posing $z_t = (x_t, y_t)$.

Determination of inputs and outputs was based on the conclusions of the review article by Cummins and Weiss (2000). Therefore we measured output by: (i) invested assets; (ii) losses incurred; (iii) reinsurance reserves and (iv) own reserves; and measured inputs by (v) labor cost, (vi) non labor cost and (vii) equity capital. The value of ‘‘losses incurred’’ is the sum of ‘‘life benefits’’ and ‘‘change in reserves’’. All variables have been deflated by the GDP deflator (1994=100). Table 2 provides the descriptive statistics of the sample values.

**TABLE 2: Characteristics of inputs and outputs of Greek Life Insurance Companies, 1994-2003 (units: Euros).**

| ***Variables*** | Minimum | Maximum | Mean | Stand. dev. |
|---|---|---|---|---|
| Outputs | | | | |
| Invested assets | 88.90 | 661664.19 | 53784.71 | 121004.81 |
| Losses incurred | 1.59 | 106494.47 | 8498.63 | 18888.64 |
| Reinsurance reserve | 0.67 | 8251.10 | 446.55 | 1397.65 |
| Own reserves | 0.18 | 33920.37 | 2643.37 | 6125.23 |
| Inputs | | | | |
| Labour cost | 1.15 | 43387.43 | 3829.14 | 8007.41 |
| Non-Labour cost | 0.58 | 24758.99 | 2283.64 | 4380.69 |
| Equity Capital | 64.04 | 197755.97 | 12516.61 | 30002.19 |

## 5. Productivity Changes Indicators

The Luenberger productivity indicators are calculated by using linear programming, a non-parametric approach. The results are presented in Table 3, with the Luenberger productivity indicator (L: productivity change) broken down into technically efficient change (EFFCH: the diffusion or catch-up component), and technological change (TECH: the innovation or frontier-shift component).

**TABLE 3: Luenberger and Malmquist Productivity Indicators for Greek Life Insurance Companies, for the period 1994-2003.**

| | | Luenberger | | | Malmquist | | |
|---|---|---|---|---|---|---|---|
| No. | Name | EFFCH | TECH | L | EFFCH | TECH | M |
| 1 | AGROTIKI LIFE | 0.0000 | 0.4301 | 0.4301 | 1.087 | 1.367 | 1.488 |
| 2 | GENERALI LIFE | 0.0000 | 0.2745 | 0.2745 | 1.160 | 1.150 | 1.334 |
| 3 | IMPERIO LIFE | 0.0000 | 0.5886 | 0.5886 | 1.188 | 1.082 | 1.285 |
| 4 | ELLINOBRETANIKI LIFE | -0.7991 | 0.4148 | -0.3843 | 1.000 | 1.218 | 1.218 |
| | INTERAMERICAN INT. LIFE | -0.2718 | 0.1538 | -0.1180 | 1.074 | 1.121 | 1.204 |
| 6 | INTERAMERICAN LIFE | 0.0000 | -0.5407 | -0.5407 | 1.137 | 1.053 | 1.197 |
| 7 | NORDSTERN LIFE | 0.0000 | 0.2099 | 0.2099 | 0.997 | 1.184 | 1.180 |
| 8 | INTERSALONICA LIFE | 0.0000 | 0.0695 | 0.0695 | 1.074 | 1.092 | 1.173 |
| 9 | AKMI / EFG LIFE | 0.0000 | -0.2161 | -0.2161 | 1.007 | 1.159 | 1.167 |
| 10 | UNIVERSAL LIFE | 0.0915 | 0.1853 | 0.2767 | 1.010 | 1.112 | 1.123 |
| 11 | OLYMPIAKI VICTORIA LIFE | 0.3440 | 0.2517 | 0.5957 | 1.029 | 1.090 | 1.121 |
| 12 | ALLIANZ LIFE | 0.3791 | 0.3710 | 0.7501 | 1.000 | 1.104 | 1.104 |
| 13 | METROLIFE LIFE | 0.0565 | 0.5175 | 0.5740 | 1.000 | 1.027 | 1.027 |
| 14 | COMMERCIAL UNION LIFE | -0.1142 | 0.5932 | 0.4790 | 0.967 | 1.053 | 1.018 |
| 15 | SCOPLIFE | 0.3170 | 0.0563 | 0.3733 | 0.953 | 1.060 | 1.011 |
| 16 | INTERNATIONAL LIFE | -0.2567 | -0.0256 | -0.2823 | 0.921 | 1.078 | 0,993 |
| — | Mean | -0.0159 | 0.2084 | 0.1925 | 1.033 | 1.122 | 1.161 |
| — | Median | 0.0000 | 0.2308 | 0.2756 | 1.007 | 1.104 | 1.167 |
| — | Std. Deviation | 0.2783 | 0.3005 | 0.3946 | 0.075 | 0.080 | 0.127 |

In Table 3, we can see that the Luenberger productivity change score (L) is positive for 11 of the 16 life insurance companies, showing that a large proportion of the companies experienced gains in total productivity in the period considered. The mean Luenberger score is 0.1925, which indicates a simultaneous increase of outputs and decrease of inputs by 19.25%, on average annually. However, there are 6 companies with an indicator lower than the mean, signifying that these companies must improve their productivity.

The change in the technical efficiency score (EFFCH) is defined as the diffusion of best-practice technology and is attributed to investment planning, technical experience, and management and organization of insurance companies. Its mean value was –0.0159 implying that the average annual efficiency declined in the period 1994-2003. Moreover, we can see that EFFCH was positive for 5 life insurance companies, equal to zero for 7, while for 4 insurance companies the change in technical efficiency was negative. In other words, 7 out of the 16 life insurance companies were on the production frontier during the sample period. Thus, almost half of the Greek life insurance companies have been efficient.

It is observed, however, that technological change mainly explains productivity variations. Technological change (TECH) is the consequence of innovation, i.e. the adoption of new technologies by best-practice companies. Its mean value was 0.2084, and this indicator was higher than zero for almost every company, with the exception of only 3 companies out of the 16 analyzed. This indicates that innovation improved in the period for almost all companies, meaning that there was investment in new technologies (methodologies, procedures and techniques) and in the commensurate skills upgrades related to this. Overall, we observe six possible combinations of technical efficiency change and technological change:

(i) In the first group, we find five (5) companies in which improvements in technical efficiency co-exist with improvements in technological change. These are the best-performing insurance companies in the period, with improvements registered in technical efficiency, denoting upgraded organizational factors associated with the use of inputs and outputs, as well as the relationship between inputs and outputs.

(ii) In the second group, we find ten (10) insurance companies in which positive changes in technical efficiency co-exist with improvements in technology.

(iii) In the third group, we find no insurance companies in which improvements in technical efficiency co-exist with deterioration of technological change.

(iv) In the fourth group, three (3) companies are found in which deteriorating technical efficiency co-exists with improvements in technology.

(v) In the fifth group, we find two (2) insurance companies with zero technical efficiency and negative technological change.

(vi) In the sixth group, we find one (1) insurance company with deteriorating technical efficiency and deteriorating technological change.

Hence, our findings encompass several combinations of efficiency change, signifying that there is room for adjustment in almost all companies in order to achieve best-practice performance.

In Table 3, the Malmquist productivity index is also presented for comparative purposes. It is observed that the Malmquist scores display a similar view of the productivity change in the Greek life insurance market. It is again confirmed that the average annual productivity growth during the period 1994-2003 was about 16%, a similar figure with the Luenberger estimate. About 80% of this growth was due to improvements in technology and only 20% was due to technical change. It is useful to underline the different links between the Malmquist and the Luenberger indicators. Currently much research is going on concerning the relations between the different measures of productivity changes under different types of returns to scale (Grosskopf, 2003).

Table 4 shows the average annual Luenberger productivity scores for the period 1994-2003. The main conclusion is that the deregulation of the life insurance market in Greece, as a result of the implementation of the Third Insurance Directive in 1994, caused mixed results. Technical efficiency has been declining continuously. However, technological change has been increasing all the time, so the decline in efficiency is more than offset by technical progress. As a result, average annual productivity has been positive for most years.

**TABLE 4: Average productivity scores year by year.**

| YEAR | EFFCH | TECH | L |
|---|---|---|---|
| 1994-1995 | 0.0342 | -0.2755 | -0.2413 |
| 1995-1996 | 0.0356 | -0.2230 | -0.1874 |
| 1996-1997 | 0.0276 | 0.1323 | 0.1599 |
| 1997-1998 | 0.0121 | 0.1450 | 0.1571 |
| 1998-1999 | 0.0091 | 0.1578 | 0.1669 |
| 1999-2000 | 0.0036 | 0.1665 | 0.1701 |
| 2000-2001 | -0.0365 | 0.1734 | 0.1369 |
| 2001-2002 | -0.0495 | 0.1560 | 0.1065 |
| 2002-2003 | -0.0593 | -0.1142 | -0.1735 |

## 6. Conclusions

This article has introduced an innovative approach, which is used for the first time in insurance economics, the Luenberger Productivity Indicator, to estimate the efficiency and productivity in the Greek life insurance industry. It is shown that during the period 1994-2003 the productivity growth was about 16-19% and was mainly due to technological change, whereas the technical efficiency gains of this period were minimal. For comparative purposes, the Malmquist productivity indicators were estimated, with similar results. The sample period was associated with the implementation period of the Third Insurance Directive of 1994 that established deregulation in the Greek insurance market. It seems that deregulation provoked investment in new technologies which were not matched by advanced managerial practices.

Policy implications arising from the results are that benchmarking analysis is needed to provide upgraded managerial procedures for those insurance companies with nil or negative technical efficiency, and/or investment in new technologies for those insurance companies with negative technological change.

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