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Working Paper

The effects of liberalization and deregulation on the performance of financial institutions: The case of the German life insurance market

Thünen-Series of Applied Economic Theory - Working Paper, No. 93

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Suggested Citation: Trigo Gamarra, Lucinda (2008) : The effects of liberalization and deregulation on the performance of financial institutions: The case of the German life insurance market, Thünen-Series of Applied Economic Theory - Working Paper, No. 93, Universität Rostock, Institut für Volkswirtschaftslehre, Rostock

This Version is available at:

<https://hdl.handle.net/10419/39756>

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Thünen-Series of Applied Economic Theory

Thünen-Reihe Angewandter Volkswirtschaftstheorie

Working Paper No. 93

**The Effects of Liberalization and Deregulation on the
Performance of Financial Institutions: The Case of the German
Life Insurance Market**

by

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2008

The Effects of Liberalization and Deregulation on the Performance of Financial Institutions: The Case of the German Life Insurance Market

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This version: July 2008

Abstract

The German insurance market was liberalized in 1994 by the introduction of the ‘single passport’ allowing European insurers to operate throughout the entire European Union. The European directive put also an end to price and insurance contract terms regulation. These measures were meant for removing the obstacles to competition within and between the insurance markets of the member states aiming at an increased efficiency of the European insurance markets. We analyze to which extent this aim has been achieved in the German life insurance market. The development of market performance is measured by changes in technical cost and profit efficiency levels since the liberalization, as well as a measurement of technological change. Technical cost efficiency levels are estimated by applying a stochastic “true” fixed effects distance frontier (Greene, 2005). Non-standard profit efficiency is derived in a second step following Kumbakhar (2006). According to our results, the industry experienced positive total factor productivity (TFP) growth during the observation period, which is mainly driven by substantial positive technological change. Technical cost efficiency and profit efficiency remained stable on average, but significant positive scale efficiency change can be found indicating that market consolidation in the presence of increasing returns to scale led to efficiency gains of the firms.

Keywords: Insurance Markets, Total factor productivity growth, Stochastic Frontier Analysis

JEL Codes: D24, G 22, G 28

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Thanks are due to Christian Growitsch and Doris Neuberger for helpful comments and suggestions.

1 Introduction

In 1994, European life insurance markets were liberalized by the Third Life Insurance Directive. Since then, insurance firms have been able to operate freely throughout the member states, either by establishing their own branches and agencies throughout the European Union, or by direct cross-border trade. Market consolidation has increased as a consequence of intense (cross-border) M&A activities, and the main part of the existing product and price regulations were abolished. By this, the European Union aims to enhance the efficiency of the national insurance markets through increased competition and consolidation. As a result, insurance customers should benefit from an increased product variety at more competitive prices.

As a consequence of the Third Life Insurance Directive, the German insurance market has undergone major changes in the past decade. Before European market liberalization, the market was characterized by severe price and product regulation, which allowed inefficient insurers to stay in the market. Competition was also highly limited because of regulations that restricted foreign insurance firms' access to the market. The stepwise liberalization of the market which resulted in a changed regulatory regime and an increased level of competition was accompanied by two other factors that have strongly affected the insurance environment. First, technological progress in information technologies has led to considerable changes in internal administrative and communication processes and has strongly influenced the structure and choice of distribution channels in most insurance firms. Most significantly, electronic distribution channels have simplified direct contact with the customer without the involvement of intermediaries. Second, changes in the statutory pension systems have resulted in increased demand for private and occupational old-age provision. This development is backed by state-run promotion of certain old-age provision products, with life insurance firms facing strong competition by banks in this field.

This study analyzes whether the aims of the liberalization process have been achieved in the German life insurance market, i.e., whether increased competition as a consequence of the liberalization has resulted in better market performance. To accomplish this analysis, we analyze possible effects of the liberalization process on market performance by applying the revised SCP paradigm. The traditional SCP paradigm addresses the relationship between market structure and performance via the conduct of the firms in an industry (e.g., Mason, 1949, and Bain, 1951). The revised SCP paradigm also accounts for possible feedback effects of market performance on the structure and conduct of firms (e.g., Demsetz, 1973) so, in this

study, it is used to analyze the effects of liberalization and the corresponding changes in the regulatory regime. Market performance is analyzed by measuring the total factor productivity (TFP) change of the industry, which is composed of technical change and changes in (technical) cost and scale efficiency. We also measure profit efficiency change in the industry after market liberalization.

If market liberalization has been successful, cost and profit efficiency will have increased as competition forces firms to reduce costs and to realize unused profit potentials. An increase in profit efficiency might also result from firms' undertaking innovations in services and products which raise costs but also lead to higher prices and profits, even though cost efficiency decreases. Increased competition may also induce firms to exploit formerly unused scale economies by moving to the most productive production size, i.e., the point of minimum average costs. It is also important to analyze changes in scale efficiency, as an increased scale efficiency and market consolidation may reduce competition. Thus, in a second step, cost and profit efficiency might decrease as a feedback effect. Finally, an analysis of market performance would not be complete without taking into account technical change; it is expected that increased competition provides incentives for firms to adopt new technologies and increase productivity, so we expect positive technical change in the industry. This is supported by a technology-pull effect resulting from important innovations in information technologies. Analysis of both the effects of efficiency and technical change provides evidence of the main drivers of TFP growth after market liberalization.

Previous evidence from the German industry is limited. Hussels and Ward (2004) analyzed cost efficiency and technical change using a small sample of German life insurance firms over the period 1991-2002, applying a non-parametric Malmquist DEA analysis to a randomly chosen, balanced panel of 31 German life insurers which persisted in the industry over the entire period. However, they neglected the possible effects of firms which entered or exited the market as a consequence of the liberalization of the market. In addition, the random choice of insurance firms in the sample may have resulted in biased data. Mahlberg and Url (2007) conducted a non-parametric Malmquist DEA for the whole German insurance industry using a balanced panel containing only firms which remained in the sample over the whole observation period 1991-2002.

Our data set contains information about the German life insurance industry for the years 1995-2002. We use an unbalanced panel in order to account for possible effects on market performance resulting from firms' entering or exiting the market during the observation period and extend the research by incorporating profit efficiency change into the analysis,

which has not been done by previous studies. It is important to account for changes in profit efficiency, in addition to changes in cost efficiency, because, as a consequence of the liberalization process, life insurance firms have innovated by creating new products and services. These innovations may raise costs, but they may also lead to increased revenues. In contrast to cost efficiency measurement, which takes only the cost side into account, profit efficiency measurement also considers firms' revenues and, thus, allows a more complete analysis of changes in market performance (e.g., Berger and Mester, 2003). Thus, this paper provides new and extended evidence on the effects of liberalization in the German life insurance industry.

To obtain measures of cost efficiency, scale efficiency, and technical change, we use a stochastic distance frontier panel approach recently developed by Greene (2005) to disentangle inefficiency and firm-specific heterogeneity. Profit efficiency is derived by applying a novel approach developed by Kumbakhar (2006), which accounts for possible price-setting power of the firms. In contrast to the standard profit function, where firms take output prices as given, the non-standard profit function takes account of the increasing product competition in the market that may enable firms temporarily to achieve price-setting power.

The paper is structured as follows. Section 2 gives an overview of past and present regulation of the German life insurance market. Section 3 derives the hypotheses to be tested in the study and gives an overview of previous evidence on the effects of market liberalization and deregulation on insurance markets. Section 4 presents the methodology. The data set and the chosen variables are described in section 5. Section 6 presents the results of the stochastic frontier analysis (SFA), and the measurement of changes in TFP growth and efficiency, and section 7 concludes the study.

2 The Regulatory Regime in the German Life Insurance Industry

Before the liberalization of the European insurance markets in 1994, the German regulatory concept encompassed all elements of the supervisory system which prevailed in the United Kingdom, the Netherlands, and Ireland, but extended the regulation to a prior approval system in which every tariff and every product had to be accepted before the insurance firm could conduct its business (e.g., Everson, 1996). The entry of a new insurance firm into the market was subject to various requirements. In addition, contract conditions were largely harmonized, as new contract types had to be submitted to the regulatory agency, and some contract elements were standardized. Price competition was highly restricted, as premiums were regulated according to a cost-plus price regulation. Based on a standardized calculation of expected loss common for all insurers, insurers could calculate their premiums by adding to them an amount unique to themselves that depended on the insurer's costs.

As a consequence of the prescribed minimum price levels, German life insurers pursued a revenue-maximizing, rather than a profit-maximizing objective, focusing on increasing their sales strength to maximize their turnover. Because price competition was restricted, insurance firms competed for new business by increasing selling and advertising costs and based competition mainly on service (e.g., Hess and Trauth, 1998; Rees and Kessner, 1999). Thus, German life insurers engaged heavily in selling activities by large, exclusive sales forces, the most important distribution channel in life insurance, keeping independent agents and direct sale to a minor role. Commissions paid to agents were restricted to 11 percent of the premiums, and total marketing expenditures could not exceed 30 percent of total premiums. Finally, German life insurers were also profit-regulated, as 90 percent of any amount of insurers' profits which exceeded 3 percent of premium income had to be redistributed to policyholders and shareholders (e.g., Rees and Kessner, 1999). Thus, ex post price competition was possible but, from the customers' point of view, it was difficult to obtain a market overview over rebates. For their part, German life insurers were limited in their investment activities and in the types and amounts of assets they could hold; as a consequence, insurers held a substantial amount of fixed-interest assets.

The European Union aims at the establishment of a Single Market for Financial Services because integrating Europe's financial markets should foster competition between financial firms and lead to higher efficiency in these markets, and customers should benefit from an increasing variety of financial products at more competitive prices (e.g., Hogan, 1995). The Third Directive on Life Insurance (92/96/EEC) (ECC, 1992) completed the freedom of

establishment and services. Life insurance firms need only a single license, issued by the regulatory agency of their home country, to operate throughout the European Union, either under the principles of freedom of establishment or under the principle of freedom of services. However, if a subsidiary is established in a foreign country, the host country principle remains. Finally, the principle of minimum harmonization was established, requiring insurance firms to meet the minimum principles established in the Third Directive. The national regulatory agency is free to impose more stringent standards on its domestic insurance firms, but foreign insurers must be allowed to conduct their business according to the minimum principles (e.g., Hogan, 1995). The directive abolished price and product regulation in those member countries where these elements of material regulation still existed (e.g., Germany) and made price competition possible, as minimum price levels were no longer prescribed (Schmidt, 2002). The Third Directive also removed restrictions on distribution and marketing expenditures.

Despite the liberalization process, which was completed by the Third European Directives, the insurance business in Germany is still limited, to an extent, by the remaining regulatory requirements regarding the amount of technical liability and solvency capital. To date, it remains the main objective of insurance regulation to provide the insurance company with a high level of credibility as a firm able to meet its actual and future (contingent) obligations by reducing the insolvency risk of an insurance firm.

To sum up, the regulation and supervision of German life insurance firms has changed from a very strict material regulation before 1994 to a very detailed but less intrusive regulation centering on the supervision of insurance firms and preventing insurers' insolvency. The next section describes how these changes in regulatory regime together with the liberalization of the market may affect the industry's structure, firms' conduct and market performance.

3 Theoretical Background and Previous Evidence

In this section, the regulatory changes connected with the liberalization of the European insurance markets are analyzed within the framework of the SCP paradigm (e.g., Mason, 1949; Bain, 1951). The revised SCP paradigm takes account of the fact that all variables are endogenous as a result of interactions between market structure, conduct, and performance (e.g., Demsetz, 1973). In section 3.1, the paradigm is applied to insurance markets to describe and analyze the possible effects of changed regulations on the structure, the conduct, and particularly the performance of the German life insurance market. Section 3.2 derives our hypotheses concerning the evolution of cost and profit efficiency in the market, as well as changes in technical and scale efficiency. Section 3.3 gives an overview of existing literature on the effects of market liberalization on insurance markets.

3.1 Effects of Liberalization and Deregulation within the (Revised) SCP-Paradigm

The traditional SCP paradigm addresses the relationship between market structure and performance via the conduct of the firms in an industry, where the *performance* of a market depends on the *conduct* of the market participants. Conduct, in turn, depends on the *market structure*, which is affected by *the basic conditions* of the industry and the prevailing *public policy* regime. The SCP paradigm can be used to analyze the effects of liberalization and the corresponding changes in the regulatory regime on market performance in the German life insurance industry. Possible feedback effects of market performance on the structure and conduct of firms are accounted for by the revised SCP paradigm. Figure 1 presents the structure of the revised SCP paradigm for the German life insurance market.¹

[Figure 1 about here]

Public policy includes the main actions of the liberalization process in the German market: implementation of the principles of freedom of services and establishment and the abolition of price and product regulation. The *basic conditions* of the market changed during the period of interest for this study (1995-2002), particularly because important technological changes occurred in the field of information technology, which led to changed supply and demand conditions in insurance markets (e.g., Cummins et al., 1999). Insurance firms implemented new technologies for pricing, underwriting, policyholder services and distribution. Operating

¹ Only those aspects relevant to this study have been included in the SCP framework in figure 4.1. Thus, the figure makes no claim to be complete but serves as a guideline for the following analysis. For a more detailed description of the revised SCP paradigm, see, e.g., Schwalbach (1994). For an application to banking markets, see Neuberger (1998).

procedures and the communication channels within the company also changed as a consequence of technical change in information technologies (e.g., Köhne and Kopp, 2007). On the demand side, because of the internet, customers became increasingly able to inform themselves about insurance products and to purchase their products online.

Another basic condition which influences the demand side is that insurance markets are characterized by large information asymmetries and high complexity, so insurance customers face difficulties in assessing the content and quality of insurance products and the financial stability and solvency of insurers.² These information asymmetries are of special importance in life insurance markets, as most life insurance products are both highly complex and long-term (e.g., Finsinger et al., 1985). As a consequence, trust and reputation of firms play an important role in insurance markets, and customers often prefer to purchase their products from established, well known suppliers (e.g., Beckmann et al., 2002). The high information asymmetries also help to explain the importance of distribution channel choice for insurance firms: In most cases, especially for long-term and complex life insurance products, insurance services are still provided by intermediaries (insurance agents or brokers) who help the customer to assess and choose suitable products. The supply and the demand side of life insurance products have also been affected by changes in the statutory pension systems, and by newly created opportunities for employees to contribute to pension plans (e.g., Maurer and Somova, 2007).

Market liberalization has had an important effect on the *market structure*. First, the size of the market has changed as a consequence of the establishment of freedom of services and establishment. German life insurers now face potential competition from the whole European market, although competition by foreign insurers occurs mainly via M&A activities and only to a lesser extent via direct cross-border trade or the establishment of agencies (Beckmann et al., 2002). Farny (2002) pointed out that M&A activities by foreign insurers are not a direct consequence of market liberalization, as they were already possible before 1994; however, these activities have certainly increased since then.

Second, entry barriers to the market may have decreased because technological progress in information technology has eliminated the need for a large sales force and eased market entry for new direct insurers which offer their products exclusively via the internet. Still, certain barriers to entry persist because of remaining differences in regulation (e.g., differing tax

² The information asymmetries in insurance markets are two-sided, as insurance firms also face difficulties in evaluating the individual risk of potential insurance customers (e.g., Finsinger et al., 1985). Though, possible information asymmetries to the burden of the insurer are not in the focus of this study, and are not further considered in the following.

regimes) and the large, exclusive sales forces still common in the German life insurance market. These may represent a barrier to entry to foreign insurers, as building up an own sales force would be very costly (e.g., Regan and Tennyson, 2000). Further barriers to entry may be due to economies of scale or reputation (or lack thereof). For example, the actual market share via direct distribution in life insurance markets remains small despite of technological progress. The overall effect is that potential competition has increased as a consequence of market liberalization, but that effect is still limited because of customer loyalty to domestic, well established insurers and because of the large sales forces of domestic insurance firms (e.g., van den Berghe, 2001; Schmidt, 2002).

Third, cost structures have changed because technological changes allow insurance services to be provided at lower costs and because the abolition of price regulation provides incentives for insurance firms to minimize their costs (Rees and Kessner, 1999). The market after liberalization is also characterized by increased product differentiation, since the abolition of ex ante product approvals has made room for an increasing variety of life insurance products. This development is supported by an increasing demand for private and occupational old-age provision and by new insurance products offering private old-age provision. In the German market, the so-called Riester pension reform (established in 2002) and the Rürup pension plans (established in 2004) are thought to encourage private old-age provisions by enabling individuals to invest part of their income into individual pension accounts. The investment occurs on a pretax basis and is subsidized by the government. (For more details, see Maurer and Somova, 2007.)

As a consequence, *market conduct* has also been affected. The abolition of price regulation may have increased price competition in certain insurance lines, particularly standardized life insurance products, like term life insurance. Since price competition is more likely in standardized, less complex insurance lines, insurance customers are better able to compare prices, and direct insurers work to attract customers with lower premiums. On the other hand, quality variables may also influence competition in a liberalized market as insurers introduce new products or innovate on existing products or services to improve their own market position.

A final part of market structure is the possible scale effects resulting from increased M&A activities in a liberalized market. Insurance firms are likely to realize increasing economies of scale because they have relatively large fixed costs from investments in computer systems and financial capital, and because the industry operates on the basis of the law of large numbers. The larger the policy portfolio of similar risks, the better the insurance firm's ability to assess

the risks and the lower the risk volatility (e.g., Cummins and Rubio-Misas, 2006). The establishment of the single market was expected to lead to increasing M&A activities from intensified competition and the possible realization of scale economies (e.g., Hogan, 1995). This process may be enforced by increasing integration of the European insurance markets. Foreign life insurers most often rely on M&A activities to enter new markets, while the establishment of branches or agencies, as well as the direct cross-border trade, is much more infrequent (Beckmann et al., 2002). The realization of economies of scale would result in an increased scale efficiency, but M&A activities may also bring high coordination and adjustment costs, including difficulties in integrating data-processing systems (Rhoades, 1998) and product portfolios (Diacon et al., 2005). High costs may also arise as a consequence of the coordination of the different distribution systems after a merger or acquisition.

The possible effects of these presented variables on *market performance*, i.e. on the performance of the German life insurance industry, lead to the hypotheses to be tested in our study. We also take into account possible feedback effects of changes in market performance on the other variables. The development of the market performance of an industry may be analyzed by changes in the levels of cost, scale and profit efficiency. Cost efficiency describes a firm's ability to produce a given output at minimum costs, whereas scale efficiency describes how far away a firm operates from its optimal size, i.e., from the production size where minimum average costs are reached. Profit efficiency encompasses firms' revenues and describes the relationship of actual to potential firm profits. An industry's market performance may also be analyzed by the measure of technical change, which turns positive if an improvement in technology occurs which alters the production function, i.e. if technological changes allow the industry to produce a given output with a smaller amount of inputs (e.g., Färe et al., 2008). Changes in cost efficiency, technical change, and scale efficiency combine and lead to TFP growth (e.g., Coelli et al., 2003).³

3.2 Hypotheses

According to the above analysis, market liberalization has induced changes in market structure, and correspondingly, in firms' conduct, which affects market performance. If the aimed effects of liberalization are fulfilled, the increase in potential competition should lead to higher efficiency levels among the firms in the industry (e.g., Rees and Kessner, 1999).

³ A detailed and formal analysis of these concepts can be found in section 4.

We analyze cost efficiency change, as increased competition may force firms to minimize costs: inefficient insurers have a strong incentive to improve their efficiency; otherwise, they would be forced to leave the market (e.g., Cummins, 2002). Insurance firms aim at realizing cost reductions by internal reorganizations, the reduction of overhead costs, and the restructuring of distribution channels (Muth, 1993). Hess and Trauth (1998) also point out that the liberalization of services and establishment throughout Europe allows insurance firms to better diversify their risks and by this, to lower costs.

However, increased competition may also force firms to realize potential profits, either by competing through prices or quality of services (e.g., Kumbakhar et al., 2001; Weiss and Choi, 2008). Hence, we additionally take into account profit efficiency, which measures the ratio of actual to potential profits. If the aims of the liberalization process have already been achieved, profit efficiency change in the industry should also be positive. As has been explained in section 2, the German life insurance market before market liberalization was characterized by price and product regulation leading to excessive sales activities (e.g., Finsinger et al., 1985). The existing cost-plus price regulation set incentives for firms to inflate costs and to maximize revenues, thus firms were not induced to act profit efficient. In contrast to that, firms now are induced to maximize profits.

It is important to measure profit efficiency besides cost efficiency due to the following: The introduction of new insurance products and additional services by firms may raise customers' willingness to pay, enabling innovative insurance firms to charge higher prices and realize higher profits. However, the introduction of these innovations may raise firms' costs, and consequently, lower their cost efficiency (e.g., Berger and Mester, 2003). Increases in cost levels may be caused by the implementation of new technologies, additional services, and changed distribution structures. Distribution structures have undergone major restructuring in the German life insurance market, which heavily relied on exclusive sales forces before its liberalization. Most multi-channel insurance firms, which represent over 80 percent of all life insurers, have added additional distribution channels like independent brokers, direct channels and sales via bank branches, reducing their own sales forces at the same time. Thus, an exclusive analysis of cost efficiency change might lead to misleading results, disregarding the possibility that an increase in costs may be accompanied by increasing revenues, resulting in an overall positive effect on profit efficiency. An ongoing process of innovations may explain why these higher profits are not competed away. Though extraordinary innovation profits are competed away over time, subsequent innovations permit the anew realization of innovation rents (Berger and Mester, 2003). Boone (2001) further

showed in a formal model that increasing competition in an industry may set incentives for the firms to innovate. If above all the market leaders innovate, they may increase their market share further by innovating, leading to an increased market power of the industry leaders and an increased concentration in the industry. Thus, as a consequence of increased competition, prices and profits in the industry may rise. Finally, eased investment rules may lead to increased investment income of insurers after the liberalization of the market (e.g., Rees and Kessner, 1999).

Summarizing, the following main hypotheses should hold if the liberalization of the market has enhanced competition and thus, increased efficiency:

H 1: Cost and profit efficiency in the German life insurance industry increased during the observation period.

However, as has been explained, service and product innovations may have raised costs, although to a lesser extent than revenues have increased. Thus, we additionally formulate the following hypothesis:

H 2: Cost efficiency decreased, and profit efficiency increased during the observation period.

We now turn to possible scale effects: As has already been explained, market liberalization followed by increased competition in the German life insurance market may foster the exploitation of economies of scale by a growing firm size, mainly by M&A activities. Especially less profitable insurance firms which used to be protected by the former regulatory regime may become M&A targets. Thus, we derive the following hypothesis:

H 3: Scale efficiency in the German life insurance industry increased during the observation period.

Finally, we analyze technical change: As has been argued, technological changes in the information technologies have had a major influence on the supply of insurance services. In the long run, technical progress in the information technology should have a positive effect on technological change in the life insurance industry. This development may be reinforced by the liberalization of the market, as increased competition increases incentives for firms to improve productivity and innovate (e.g., Cummins et al., 1999; Cummins, 2002).

H 4: Technical change has been positive.

3.3 Previous Evidence

An overview of existing studies which analyze the effects of regulatory changes and market liberalization on insurance markets reveals only two extant studies which analyze the effects of market liberalization on the German insurance market.

Hussels and Ward (2004) analyzed changes in cost efficiency and TFP growth in the German life insurance industry for the years 1991-2002. They concluded that the expected gains in efficiency were not achieved; a TFP growth of 2.6 percent occurred in the industry, but the observed time span included both years of productivity increases and years of productivity decreases. Mahlberg and Url (2007) examined the development of the German insurance industry for the years 1991-2001, using DEA and Malmquist analysis. They found that TFP increased during the observation period, although the liberalization process did not lead to converging efficiency scores. The authors further reported important improvements in scale efficiency and less pronounced gains in technical and cost efficiency.

Several other studies conducted similar analyses for other European countries. Hardwick (1997) examined the effects of market liberalization on the development of the UK life insurance industry by employing a stochastic cost frontier approach. He found evidence for increasing returns to scale and significant cost inefficiencies and concluded that large and inefficient insurers are most likely to benefit from the European Single Market. Fuentes et al. (2001) employed a parametric distance function approach to estimate a Malmquist productivity index for Spanish insurance companies from 1987-1994. The authors found a very low rate of growth in productivity and that technical efficiency did not improve as a consequence of market deregulation. Diacon et al. (2002) focused on European specialist and composite insurers for the years 1996-1999. Employing non-parametric DEA, the authors found evidence for declining technical efficiency over time, which they attributed to high costs incurred in the restructuring and M&A processes.

Campbell et al. (2003) examined the impact of the Second and Third Life and Non-Life Directives on the stock returns of insurance firms in 14 European Union countries, plus Norway, and Switzerland. They found positive effects on wealth for European life insurance firms, the highest effects of which were in formerly highly regulated countries. Ennsfellner et al. (2004) employed Bayesian SFA to analyze the productive efficiency of the Austrian insurance industry for the years 1994-1999 and found evidence for an increase in productive efficiency over time, which they attributed to market deregulation. Cummins and Rubio-Misas (2006) analyzed the effects of deregulation and market consolidation for the Spanish

insurance market from 1989-1998. Using non-parametric DEA and Malmquist analysis, and paying special attention to M&A activities in this market, they found significant TFP growth, which was due primarily to an increase in cost efficiency among Spanish insurance firms. Further, Spanish firms experienced efficiency gains as a consequence of liberalization and market consolidation. Fenn et al. (2008) employed SFA to analyze the market structure and efficiency of European insurance companies between 1995 and 2001 and found evidence of increasing returns to scale among European life insurance firms. The authors also found the mean cost efficiency for German life insurance firms remained unchanged over time, which they explained as the result of M&A activities that annulled the efficiency gains from market liberalization. Bikker and Gorter (2008) examined the performance of the Dutch non-life insurance industry. The authors estimated a stochastic cost frontier and found that increasing economies of scale persisted in the market despite the consolidation process after the liberalization of the European markets. They also reported large differences in firms' cost efficiency levels, suggesting that competitive pressure might be insufficient to force insurance firms to improve their cost levels.

4. Methodology

This section describes our methodology and the estimation approach we follow to obtain technical cost and profit efficiency scores of German life insurers and a measure of TFP growth during the observation period. In section 4.1, we introduce the input distance function and describe the way it will be constructed in our analysis. Section 4.2 describes our estimation methodology, the parametric SFA. In section 4.3, we illustrate how individual technical cost and profit efficiency scores for firms may be obtained from the estimation of a stochastic input distance frontier. Finally, section 4.4 shows how TFP growth will be measured and decomposed in our study.

4.1 Parametric Input Distance Functions

In this study, a parametric input distance function, rather than a cost function, is used to obtain firm-individual measures of firm's technical cost efficiency, i.e., measures of the over-usage of costs by firms.⁴ We are able to use an input distance function approach because the inputs used in this study represent the relevant cost categories of insurance firms, so the input distance function can derive firm-individual efficiency scores which represent cost over-usage. We have chosen the input distance function approach in this study because direct estimation of a cost frontier is not practical since data is limited and there is insufficient variation in some of the input prices. In these cases, a distance function approach proves superior to the direct estimation of a cost function (Coelli, Singh and Fleming, 2003). Although the econometric estimation of distance functions is a fairly recent concept, an increasing number of applications can be found in the literature, including some which use distance functions for the measurement of TFP growth, as will be done in this study (e.g., Atkinson and Primont, 2002; Orea, 2002; Coelli and Rungsuriyawiboon, 2006). Applications of the distance function approach to efficiency and TFP growth measurement to the field of financial services can be found in Fuentes et al. (2001) and Orea and Cuesta (2002).

Distance functions, a concept introduced by Shepard (1953), can be differentiated into input and output distance functions. While an input distance function characterizes the production technology by seeking the minimal proportional contraction of the input vector, given an output vector, the output distance function gives information about the maximum proportional expansion of the output vector, given an input vector. This study uses an input

⁴ In the following, the efficiency scores obtained from the estimation of the input distance function are labelled *technical cost efficiency* in order to differentiate this concept of efficiency measurement from the cost efficiency estimates obtained from a cost function.

distance function because the output of an insurance firm, as measured in this study, is largely exogenously determined by the incurred benefits of a firm. (See section 5 for additional details.)

An input distance function which summarizes all economically relevant characteristics of the production technology can be defined as:

$$D^I(x, y) = \max \{ \rho : (x/\rho) \in L(y_0) \}, \quad (1)$$

where the input set $L(y)$ represents the set of all input vectors x that can produce the output vector y .

Färe and Primont (1995) showed that the following properties hold for an input distance function: $D^I(x, y)$ is

- non-decreasing in x and non-increasing in y
- linearly homogeneous in x
- concave in x and quasi-concave in y , and, finally,
- if $x \in L(y_0)$, then $D^I(x, y) \geq 1$, with $D^I(x, y) = 1$, if x belongs to a firm on the frontier of the input set.

Figure 2 shows an input-oriented distance function for the two-input (x_1, x_2), one-output (y) case. The isoquant shows the frontier of the technology for a given output vector y_0 . The area $L(y_0)$ represents all input quantity vectors x which can produce the output quantity vector y_0 . $L(y_0)$ is bounded below by the isoquant, which represents the minimum input quantities which are necessary to produce a given output vector y_0 . The value of the distance function at B , then, is equal to the ratio $\rho = OB/OQ > 1$, as the firm could reduce its input usage and still produce the given output vector.

[Figure 2 about here]

Thus, we are able to derive a measure of input-oriented technical efficiency in terms of the input-distance function. According to Farrell (1957), the efficiency at the production point B is measured by

$$TE = OQ/OB = 1/D^I(x, y), \text{ where } 0 \leq TE \leq 1. \quad (2)$$

Technical efficiency, then, represents the reciprocal of the value of the distance function. A fully efficient firm which operates on the frontier obtains an efficiency score of 1, and the value of the input distance function also equals 1. In this study, the efficiency scores obtained

from the estimation of an input distance function are denoted as technical cost efficiency, as all input categories used represent firm's costs.

In order to estimate a parametric input distance function, a functional form has to be chosen for $D^I(x,y)$. The translog function chosen for this study was introduced by Christensen et al. (1973), and represents a generalization of the Cobb-Douglas functional form. Compared to the Cobb-Douglas function, the translog function is a second-order flexible form, i.e., it has enough parameters to provide a second-order approximation of a Taylor series. By taking the logarithm of both sides of the function, the translog function can be estimated in a linear framework. Finally, homogeneity is easily imposed, as shown below.

A translog input distance function is parametrized as follows in the K ($k = 1, \dots, K$) input (x), one-output (y) case:

$$\begin{aligned} \ln D_i^I(x, y) = & \alpha_0 + \beta_1 \ln y_{it} + \frac{1}{2} \beta_{11} \ln y_{it}^2 + \sum_{k=1}^K \gamma_k \ln x_{kit} + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \gamma_{kl} \ln x_{kit} \ln x_{lit} \\ & + \sum_{k=1}^K \delta_k \ln x_{kit} \ln y_{it} + \sum_{k=1}^K \phi_k \ln x_{kit} t + \kappa_1 \ln y_{it} t + \eta_1 t + \frac{1}{2} \eta_{11} t^2, \end{aligned} \quad (3)$$

where t represents a time trend to approximate technical change. The subscripts i ($i = 1, 2, \dots, N$) and t ($t = 1, 2, \dots, T$) index firm and time period, respectively, while the parameters to be estimated are β , γ , δ , ϕ , κ , and η .

To ensure that the first-order translog parameters can be directly interpreted as the production elasticities at the sample mean, every series is divided by its geometric average, a process which does not change the results (e.g., Coelli et al., 2003). Homogeneity of degree 1 in inputs is imposed by the following constraints:

$$\sum_{k=1}^K \gamma_k = 1; \sum_{l=1}^K \gamma_{kl} = 0; \sum_{k=1}^K \delta_k = 0; \sum_{k=1}^K \phi_k = 0. \quad (7)$$

4.2 Estimation Methodology – Stochastic Frontier Analysis

In this study, a parametric approach is used to derive the “best practice” input distance frontier and to measure technical cost efficiency in the German life insurance industry. In contrast to non-parametric approaches to efficiency measurement (e.g., DEA), which rely on mathematical programming techniques to obtain the “best practice” frontier, the econometric approach requires that a functional form of the underlying production function be specified and that the “best practice” frontier using econometric methods be estimated. In this study, a parametric approach is chosen in order to accommodate the derivation of profit efficiency

scores, in keeping with Kumbakhar (2006), who chose a parametric approach for deriving profit efficiency measures.

We employ a panel data model to estimate the stochastic input distance frontier, so that a firm's inputs and outputs vary freely through time and among firms. Recently, Greene (2004a, 2004b, 2005) suggested two different panel models, the true fixed and random effects models. These are intended to account for unobserved heterogeneity, which would otherwise enter the inefficiency term and bias the inefficiency estimates.

In the case of an input distance frontier, the true FE model is modeled as follows:

$$-x_{iK} = \alpha_i + g[(x_i - x_{iK}), y_i] + v_{it} - u_{it}, \quad (8)$$

where α_i represents firm-specific dummies which measure the firm-specific heterogeneity, v_{it} follows the standard normal distribution, and u_{it} may follow a half-normal, truncated-normal or exponential distribution.

In this study, we use the true FE model presented in equation (8) for two reasons: First, it accounts for unobserved heterogeneity, such that systematic differences between the insurance firms are considered by including a firm-specific fixed effect, α_i , which accounts for firm-specific characteristics not captured by the included variables.⁵ Second, efficiency varies freely through time. This is in contrast to most of the other models which allow for time-varying efficiency by assuming a given inefficiency u_i for every firm which varies through time in a given time path (e.g., Battese and Coelli, 1992) or because of the influence of additional variables in the inefficiency term (e.g., Battese and Coelli, 1995). Since this study is especially interested in the development of efficiency (and other TFP components) as a consequence of market liberalization, we prefer to let efficiency vary freely through time. Further, the true effects model allows for cross-firm variation in the efficiency of firms, since it is possible that some firms increase their efficiency while others decrease efficiency in a given year.

Summarizing, our estimation approach is as follows:

$$\begin{aligned} -\ln(x_{Ki}) = & \alpha_i + \beta_1 \ln y_{it} + \frac{1}{2} \beta_{11} \ln y_{it}^2 + \sum_{k=1}^{K-1} \gamma_k \ln \frac{x_{kit}}{x_{Kit}} + \frac{1}{2} \sum_{k=1}^{K-1} \sum_{l=1}^{K-1} \gamma_{kl} \ln \frac{x_{kit}}{x_{Kit}} \ln \frac{x_{lit}}{x_{Kit}} \\ & + \sum_{k=1}^{K-1} \delta_k \ln \frac{x_{kit}}{x_{Kit}} \ln y_{it} + \sum_{k=1}^{K-1} \phi_k \ln \frac{x_{kit}}{x_{Kit}} t + \kappa_1 \ln y_{it} t + \eta_1 t + \frac{1}{2} \eta_{11} t^2 + \varepsilon_{it}, \end{aligned} \quad (9)$$

⁵ We conducted a Hausman test to test the assumption of no correlation between the firm-specific random effects and the exogenous variables in the model. The result strongly rejected the assumption of no correlation between the variables. Thus, the estimation of a true RE model would not be appropriate in our case, and the true FE model was chosen.

where $\varepsilon_{it} = v_{it} - u_{it}$ represents the composed error term. Following Greene (2004a, 2004b, 2005), Maximum Likelihood estimation of the model yields the coefficients β , γ , δ , ϕ , κ , and η in the frontier. A normal-half normal distribution was chosen for the error terms, and the parameters associated with the K^{th} input were calculated using the estimated parameters and the restrictions presented in equations (4-7). The procedure also delivers estimates of the standard deviations of the error components, σ_u and σ_v , and the total error variance $\sigma^2 = (\sigma_u^2 + \sigma_v^2)$. Further, the parameter $\lambda = \sigma_u / \sigma_v$ is constructed. If $\lambda \rightarrow +\infty$, the deterministic frontier is the result because all variation in the error term is attributed to inefficiency. Conversely, if $\lambda \rightarrow 0$, there is no inefficiency in the disturbance, so the estimated function could be estimated by OLS.

Both inputs and outputs in this estimation approach appear as regressors in the distance function. Thus, concerns about a possible simultaneous equation bias might arise: When working with an input distance function, outputs should be treated as exogenous and inputs are endogenous. However, Coelli and Perelman (1996) argued that, as a consequence of the normalization by the K^{th} input, only input ratios will appear as regressors. These may be assumed to be exogenous, as the input distance function is defined for radial contraction of all inputs, given the output level; hence, by definition, the input ratios are held constant for each firm. Another problem discussed in connection with the application of distance functions is the possible correlation of the explanatory variables with the composite error term, which would signify a violation of one of the basic assumptions of the stochastic frontier model. However, Coelli (2000) showed that this may not be a problem for Cobb-Douglas and translog specifications.

4.3 Estimation of Technical Cost and Profit Efficiency

The estimation approach presented here does not allow direct observation of the inefficiency measure u_{it} because the estimation procedure delivers only an estimate of the composite error term $\varepsilon_{it} = v_{it} - u_{it}$. Thus, the efficiency scores are estimated following the procedure by Jondrow et al. (1982), who used the conditional distribution of u , given the error term ε . For the normal half-normal model, a point estimator of technical cost efficiency is given by equation (11), i.e., by the mean of u_{it} , given ε_{it} :

$$E(u_{it} | \varepsilon_{it}) = \frac{-\lambda \varepsilon_{it}}{\sigma} \quad (10)$$

Technical cost efficiency (TCE) per firm and year may then be calculated as

$$TCE_{it} = [\exp(-u_{it})]. \quad (11)$$

We now turn to the derivation of profit efficiency according to Kumbakhar (2006). Our study analyzes the reaction of German life insurers to the changes in the market environment that resulted from liberalization. In so doing, the study also accounts for possible changes in the firms' profit efficiency as a consequence of the firms' increasing price-setting power arising from offering superior services or innovations, as explained in section 3. Thus, the standard neoclassical profit function that assumes given input and output prices may not apply in this case. Humphrey and Pulley (1997) suggested a nonstandard (alternative) profit function (NSPF) that allowed for imperfect output markets.

$$P(w, y) = py - wx, \quad (12)$$

where w is a vector of input prices ($w = w_1, \dots, w_K$), p is the price for the output y , P is a firm's profits, and the remaining variables are as explained above.

In this approach, output prices are assumed to be endogenous and are determined from the pricing opportunity set. Thus, the NSPF in equation (12) is expressed as a function of output quantities and prices, not of output and input prices, as in the standard neoclassical case. However, Kumbakhar and Lovell (2000) pointed out that the NSPF does not satisfy theoretical foundations, as the optimal prices which are derived from the pricing opportunity set are not related to the production technology. Thus, the cost of production is not considered when determining optimal output prices. Kumbakhar (2006) suggested a new approach to determine a firm's profits and profit efficiency under the assumption of non-competitive output markets.

Kumbakhars analysis departs from the fact that, in both the NSPF and the cost function, w and y are the arguments in the function. The only difference between the functions is in the left-hand side of the equations: In the NSPF, profit (revenue minus cost) forms the left-hand side, whereas in the cost function, it is cost.

$$P(w, y) = py - wx \Leftrightarrow C(w, y) = wx \quad (13)$$

As can be seen from the equation (13), the NSPF can be transformed easily into a standard cost function by subtracting revenues and multiplying the function by -1. Thus, a standard cost function may be also used to calculate profit efficiency of a firm as follows:

$C|_{u=0}$ represents the product of firm's actual costs C and the technical efficiency score $TE = \exp(-u_{it})$, i.e., minimum costs. In Kumbhakhar (2006), u was obtained from the estimation

of a cost function. However, Kumbhakar assumed allocative efficiency, so u represented input-oriented technical inefficiency. Kumbhakar noted: “In our formulation u is input-oriented technical inefficiency (percentage over-use of all inputs). Therefore, it is also the percentage by which cost is increased....” (p. 254).

In our study, we modify Kumbhakar’s approach by deriving u_{it} from the estimation of an input distance function, as it has been presented in equation (10). We likewise assume that all firms act allocatively efficient.

As all inputs used in this study represent monetary costs, minimum costs may be calculated as:

$$C^D|_{u=0} = \sum_{k=1}^K x_{kit} \cdot TCE_{it} = \sum_{k=1}^K x_{kit} [\exp(-u_{it})], \quad (14)$$

and actual costs as:

$$C^D = \sum_{k=1}^K x_{kit}, \quad (15)$$

where all variables are as presented before, the superscript D indicates that the distance function approach is used to calculate minimum and actual costs.

Profit efficiency is defined as the ratio between a firm’s actual profits $(\hat{\pi}(w, y)|_u)$ and the maximum attainable profits $(\hat{\pi}(w, y)|_{u=0})$. Actual profits are determined as:

$$(\hat{\pi}(w, y)|_u) = py - C^D, \quad (16)$$

And maximum attainable profits are calculated by

$$(\hat{\pi}(w, y)|_{u=0}) = py - C^D|_{u=0}. \quad (17)$$

Finally, profit efficiency is calculated as:

$$PE = \frac{(\hat{\pi}(w, y)|_u)}{(\hat{\pi}(w, y)|_{u=0})}; -\infty \leq PE \leq 1. \quad (18)$$

A fully profit-efficient firm shows a profit efficiency of 1. As profits can turn negative, profit efficiency is not bounded below by 0, but can turn negative (zero) if actual profits are negative (zero).⁶ Further, the measure would be undefined if the maximum attainable profit in an industry were negative (e.g., Banker and Maindiratta, 1988).

⁶ We decided not to remove firms which exhibit negative profits from the sample, as it is possible that firms incur short-term losses but are able to establish themselves solidly in the market in the long run. This is especially true for young firms which enter the market and incur high initial investments. Our sample contains a

4.4 Measurement of TFP Growth and Efficiency Change

The traditional approach to TFP measurement equates technical change with the percentage growth in TFP. According to this traditional Divisia approach (Solow, 1957), TFP growth is calculated as:

$$\dot{\text{TFP}} = \dot{y} - \dot{F}, \text{ where } \dot{F} = \sum_{i=1}^K \frac{w_i X_i}{C} \dot{x}_i = \dot{\text{TC}}. \quad (19)$$

All variables are as presented before, F is an aggregated measure of input usage, TC represents technical change, and rates of change are denoted with a dot over the variable. Equation (19) only holds under restrictive assumptions, i.e., there are constant returns to scale, neutral technical change, and perfect competition in both output and input markets (e.g., Baltagi and Griffin, 1988). Further, it is assumed that all firms act efficiently overall, which is unrealistic in most cases. Thus, recent work decomposes TFP change into different sources, including technical change, technical and allocative efficiency change, and scale efficiency change (e.g., Kumbhakar and Lovell, 2000; Orea, 2002). Coelli et al. (2003) applied the decomposition of TFP change to the input distance frontier case such that the log of the TFP change between periods t and $t+1$ for the i^{th} firm is calculated as:

$$\begin{aligned} \ln(\text{TFP}_{i,t+1}/\text{TFP}_{i,t}) = & \ln(\text{TCE}_{i,t+1}/\text{TCE}_{i,t}) + 0,5[(\partial \ln D_{i,t}/\partial t) + (\partial \ln D_{i,t+1}/\partial t)] \\ & + 0,5[(\text{SF}_{i,t}\varepsilon_{i,t}) + (\text{SF}_{i,t+1}\varepsilon_{i,t+1})] \cdot (\ln y_{i,t+1} - \ln y_{i,t}) \end{aligned} \quad (20)$$

The three terms on the right-hand side of equation (20) represent technical cost efficiency change, technical change and scale efficiency change, respectively. Technical cost efficiency change is easily calculated by taking the log of the ratio between the technical cost efficiency scores for a given firm i in periods $t+1$ and t .

The technical change measure represents the mean of the technical change measures, which are calculated at the period t and period $t+1$ data points with the distance frontier:

$$\partial \ln D_{i,t+1}/\partial t = \eta_1 + \eta_{11}t + \sum_{k=1}^K \phi_k \ln x_{ki,t+1} + \kappa_1 \ln y_{i,t+1} \quad (21)$$

$$\partial \ln D_{i,t}/\partial t = \eta_1 + \eta_{11}t + \sum_{k=1}^K \phi_k \ln x_{ki,t} + \kappa_1 \ln y_{i,t} \quad (22)$$

number of young firms which entered the market after the liberalization of the German insurance market in 1994. As we found very few firms showing only small negative profit efficiency scores, and none of these with negative profit efficiency scores over the whole observation period, the impact on the market-wide profit efficiency scores is rather small.

The third summand in equation (20) measures the change in scale efficiency. For it, production elasticities are calculated at each data point for both periods:⁷

$$\varepsilon_{i,t+1} = \partial \ln D_{i,t+1} / \partial \ln y_{i,t+1} = \beta_1 + \beta_{11} \ln y_{i,t+1} + \sum_{k=1}^K \delta_k \ln x_{ki,t+1} + \kappa_1 t \quad (23)$$

$$\varepsilon_{it} = \partial \ln D_{it} / \partial \ln y_{it} = \beta_1 + \beta_{11} \ln y_{it} + \sum_{k=1}^K \delta_k \ln x_{kit} + \kappa_1 t \quad (24)$$

The scale factors SF_{it} are calculated as:

$$SF_{it} = (\varepsilon_{it} + 1), \quad (25)$$

where ε_{it} equals the negative of the standard returns to scale elasticity (RTS).

RTS is calculated as:

$$RTS = -\frac{1}{\varepsilon_{it}} = -\frac{1}{\frac{\partial \ln D_{it}}{\partial \ln y_{it}}} \quad (26)$$

Thus, if constant returns to scale prevail, ε_{it} equals -1 , RTS equals 1, and the scale efficiency change equals 0. Thus, increasing returns to scale are represented by values of $RTS > 1$, and decreasing returns to scale by $RTS < 1$.

Finally, profit efficiency change (PEC) is calculated by taking the log of the ratio between the profit efficiency scores for a given firm i in periods $t+1$ and t :

$$PEC = \ln (PE_{i,t+1} / PE_{it}). \quad (27)$$

5 Data Set and Variables

5.1 Data Set

The data used in this study are taken from periodically published insurance industry reports and insurers' income statements for the years 1995-2002 (Hoppenstedt, 1997-2004). Since Hoppenstedt registers every licensed insurance firm in Germany, the database contains also information about firms that do not actively participate in the insurance market. We eliminate firms which had not delivered any information at all; firms which showed negative observations for inputs or outputs; firms which operated only in very specialized product niches, offering products only to a very specialized customer base (e.g., civil servants, doctors); and firms which offered only single, specialized insurance products (e.g., exclusively term-life insurance) because they are not representative of the industry as a whole.

⁷ We assume that firms are allocatively efficient. Thus, the additional component of TFP change which accounts for changes in allocative efficiency is left out of this study.

In the end, our data set accounts for approximately 90 percent of the total premium income of the industry. We use an unbalanced panel in order to account for developments in efficiency/TFP growth caused by newcomers in the industry and by market exits, which would not be included in a balanced panel. Hence, a balanced panel containing only firms which were active over the whole observation period could bias our results.

Table 1 displays information about the number of firms in each year of the observation period (n), and presents two different measures of market concentration: C 5 represents the market share of the top five life insurance firms, and the Herfindahl-Hirschman concentration index (HHI) measures market concentration by the sum of squared market shares of all firms.

[Table 1 about here]

The number of life insurance firms increased in the beginning of the observation period as a result of market entries arising out of market liberalization. From 1998 on, the number of firms in the market decreased, mainly because of M&A activities in the market. Cummins and Weiss (2004) analyzed the M&A activities in the European insurance markets for the observation period 1990-2002 and found that German insurance firms were the targets in 126 deals involving a change in control and the acquirer in 167 cases. The high level of M&A activities and the corresponding market consolidation is also reflected in the development of the measures of market concentration: Both the C 5-measure and the HHI initially decrease as a consequence of market liberalization and entry of new firms, then increase again towards the end of the observation period. At the end of the observation period, the HHI measure reaches an even higher value than at the beginning of the observation period, indicating that the market consolidation effect outweighed the competition-enhancing effect of market liberalization.

5.2 Variables

Using SFA requires identifying the relevant inputs and outputs of an insurance firm. However, a review of the literature does not show clear consensus on a single input/output specification. This study uses the value-added approach, which is common in the literature (e.g., Cummins and Weiss, 2000). In using this approach, we define the services provided by insurers before choosing suitable output proxies. These services can be split into three major groups: risk-bearing/risk-pooling services, “real” financial services related to insured losses, and intermediation services. Following the value-added approach, then, the output of a life insurance company is defined in our study as follows:

We approximate the risk-bearing function by using *incurred benefits*, net of reinsurance. Incurred benefits are payments received by policyholders in the current year, which can be seen as proxies for the risk-bearing/risk-pooling function because they measure the amount of funds distributed to the policyholders as compensation for incurred losses. The funds received by insurers that are not needed for benefit payments and expenses are added to policyholder reserves; so *additions to reserves* are a suitable proxy for the intermediation function of the insurer. We include *bonuses and rebates* into our output measure because these funds benefit the policyholders. By choosing incurred benefits net of reinsurance and the additions to reserves as output proxies, we follow the majority of life insurance studies (e.g., Meador et al., 1997; Cummins and Zi, 1998; Fenn et al., 2008). All three output measures are correlated with real services provided by life insurers. Because of limited data availability, it is not possible to divide the output measures provided by the life insurance firms according to the different life insurance lines.

Besides information about insurers' outputs, data about the costs of an insurance firm are necessary in order to estimate the stochastic input distance frontier. Insurers' inputs can be classified into three principal groups: labor, business services and materials, and capital. In most cases, physical measures for these inputs (e.g., the number of employees) are not available, but information about the costs an insurance firm incurs for their use is available. To measure insurers' costs, we choose acquisition and administration expenses, which sum to equal *operating expenses*, as a proxy for the insurers' inputs for labor and business services (e.g., Cummins and Zi, 1998), since administration and acquisition expenses contain the insurers' expenses for labor and business services.

The consideration of financial capital is also important in the case of insurance firms.⁸ Insurance studies frequently use financial equity capital but seldom use financial debt. Equity capital is used as an input because insurance is viewed as risky debt (e.g., Cummins and Danzon, 1997). With this approach, insurance premiums are discounted in the market to account for the insurer's default risk. This study follows the majority of extant insurance studies by using *statutory policyholders' surplus* as a proxy for financial equity capital. To measure the cost of equity, financial equity capital should be valued according to the firm-specific price for equity capital. (For an overview of the different approaches to measuring the

⁸ Some studies also include physical capital as an input measure (e.g., Meador et al., 1997) but, in general, the amount of physical capital used by insurance firms is comparatively small. We checked for the influence of physical capital by including *capital expenses* into our analysis, but the estimated coefficient has a very small value. Thus, the influence on the obtained results is very small, with all the outcomes remaining largely unchanged. To avoid an unnecessary loss of degrees of freedom in the estimation, we decided to leave the variable out of the estimation.

cost of equity, see Cummins and Weiss, 2000.) Because of limited data availability and the small influence of the different approaches on the efficiency results found in other studies, we assume identical prices for equity capital over all firms in a given year. *Equity costs* are then obtained by valuing statutory policyholders' surplus with the price for equity capital in a given year. The average price for equity capital in the industry is obtained by calculating the average return on the book value of equity for the industry in a given year. Similar approaches can be found in the literature, as when Fenn et al. (2008) used a rate of interest variable from long-term government bond rates as a proxy for the price of capital, and Cummins and Rubio-Misas (2006) used the rate of total return of the most important Spanish Stock Exchange as a proxy for the price of equity capital for every year in their observation period. As the rate of total return of the most important German Stock Exchange (DAX) showed negative values in some of the observation years because of the stock market crash in the year 2000, we prefer to use the average return on the book value of equity as a proxy for the price of equity. The return on the book value of equity has been used before by Cummins and Weiss (1993) and Cummins and Sommer (1996). The latter noted that the use of market values instead of book values in calculating the rate of return is preferable but is limited because of the small number of insurers with publicly traded equity. This holds especially true for the German market, where only about 20 percent of the stock insurance firms are listed on the stock exchange (Elgeti and Maurer, 2000), and there is a significant number of mutual and public-owned insurance firms. Finally, the calculation of profit efficiency requires information about the *revenues* of an insurance firm. Revenues are defined as the sum of *net premium income* and *investment income*. Net premium income is measured by the sum of gross written premiums, less ceded reinsurance premiums, less the change in the provision for unearned premiums.

Table 2 presents the summary statistics for the variables used in the analysis for the whole observation period. An analysis of the development of the single variables over time reveals that the output of the industry increased by approximately 68 percent over time, while *operating expenses* increased by approximately 97 percent, and *equity costs* slightly decreased from 1995 to 2002. On average, industry revenues more than doubled.

[Table 2 about here]

6 Results

In this section we present the results of estimating the stochastic input distance frontier and the results of calculating TFP growth and changes in efficiency. We start with a discussion of the parameter estimates in section 6.1, while section 6.2 analyzes the development of TFP growth and efficiency change over time.

6.1 Estimation Results

The data described in section 5 was used in the panel estimation of the stochastic distance function described in section 4. The ML parameter estimates for the function are listed in table 3. All the estimated coefficients are statistically significant and show the expected signs. Concerning the overall evaluation of the model, the λ coefficient is significantly different from zero, indicating that inefficiency effects are significant in the stochastic frontier model. Therefore, it would be an inappropriate representation of the data if we estimated a model without the assumption of inefficiency. The Wald-Chi-Squared test of the overall significance of the model also proves highly significant. We finally analyzed whether the chosen translog specification is appropriate by testing it against a Cobb-Douglas functional form. Unlike a Cobb-Douglas specification, the translog specification contains the second-order and cross-term coefficients. Our likelihood ratio (LR) test strongly rejects the hypothesis that the Cobb-Douglas function fits the data better, so we conclude that the translog specification is appropriate. We further test whether the assumption of technical change is appropriate; the hypothesis of no technical change is rejected based on the results of the LR test, so we conclude that the incorporation of a time trend is adequate.

[Table 3 about here]

We now turn to the estimates of the input elasticities in table 4.3. The estimate of 0.484 for the operating expenses shows the expected sign and is highly significant. The coefficient for the second input, equity costs, is calculated via the homogeneity restriction presented in section 4.4, and amounts to 0.516.

The estimated parameters also provide information on scale economies and technical change. The first order coefficient of the output variable (β_1) is less than one in absolute value, indicating increasing returns to scale for the industry at the sample mean. We tested the assumption of constant returns to scale in the industry by applying a Wald test, and the hypothesis of constant returns to scale is strongly rejected, confirming our theory that, on

average, German life insurers operate under increasing returns to scale, i.e., firms are able to reduce costs by increasing firm size.

The first-order coefficient of the time trend variable (η_1) estimates the technical change over time; the positive sign of the coefficient indicates that there has been positive technical change in the industry during the observation period. The quadratic time trend (η_{11}) shows a weakly significant positive sign, indicating technical change growing at an increasing rate during the observation period. These results already indicate that hypothesis 3 cannot be rejected because the industry experienced positive technical change, resulting in potential savings for the firms. Further, the coefficient of the cross term of operating expenses and the time trend (ϕ_1) is negative and highly significant, indicating non-neutral technical change (e.g., Färe et al., 1997, and Sipiläinen, 2007, for an application in a distance function estimation framework). The elasticity with respect to operating expenses decreases over time, indicating labor-saving technical change. This is according to our expectations, as the improvements in information technologies were mainly labor-saving. Correspondingly, the coefficient of equity costs with respect to time is calculated via the homogeneity restrictions and amounts to 0.02. Thus, the elasticity with respect to equity costs increases slightly over time.

6.2 Efficiency Levels, TFP Change and Profit Efficiency Change

Table 4 is a summary of the technical cost efficiency measures obtained from estimating the stochastic distance function, and the profit efficiency estimates calculated in a second step, following Kumbakhar (2006). Results are presented as yearly average values and as mean values over the whole sample.

[Table 4 about here]

The yearly results give an initial insight into the development of technical cost and profit efficiency. As far as the mean values of technical cost efficiency are concerned, no clear trend emerges for the observation period; the average value over the whole observation period is 67.78 percent, with the efficiency scores for the single years ranging from 65.05 percent in 1999 to 70.54 percent in 2001. Mean profit efficiency over the whole observation period adds up to 91.37 percent. There seems to be an upward trend in the development of profit efficiency over time, although the standard deviation of the mean efficiency scores for the single years is quite large, indicating significant variations in the profit efficiency of single firms. Thus, the decomposition of TFP growth into its components and the analysis of profit efficiency change provide a more detailed analysis of productivity change in the industry.

Table 5 reports the results for the single periods and as mean values over the whole sample. The calculation of TFP components and changes in profit efficiency in the last line of the table compare the beginning and ending years of the sample period, 1995 and 2002, so the results in this line contain only those firms which were active during the whole observation period. The comparison of these results with the mean values delivers some interesting differences. We start with a discussion of the reported mean values delivered by year-to-year comparisons.

The mean value reported for the TFP change measure is 12.503, so the average annual change of TFP in this period is 12.50 percent. The single components of this TFP change measure are the center of interest of this study, as the decomposition of TFP into technical change and efficiency change allows us to differentiate between a shift of the frontier (technical change), a movement towards the frontier (efficiency change), and a movement along the frontier (scale efficiency change). We start with the development of technical change (TC), and focus afterwards on the development of technical cost efficiency (TCEC) and scale efficiency change (SEC). Finally, we analyze profit efficiency change (PEC).

As can be seen from table 5, German life insurance firms experienced significant positive technical change during the observation period. On average, over the observation period, the industry benefited from cost reductions of 7.019 percent resulting from pure technical change, which slightly increased over time. Thus, our hypothesis 4 is confirmed: Improvements in information technologies and connected innovations in communication and distribution services of insurance firms have led to significant technological progress in the industry. The liberalization of the market may have induced firms to adopt technological innovations and thereby caused positive technical change. The large effect of positive technical change may also explain why the majority of German life insurance firms continue to operate under increasing returns to scale; large fixed costs in conjunction with investments in information technologies may result in an increase in the optimal size of the firm (e.g., Cummins et al., 1999).

No clear trend in the development of technical cost efficiency can be deduced from the results. Technical cost efficiency increased for three years of the observation period, but the industry also experienced significant decreases in technical cost efficiency in three years of the observation period, leading to a small negative mean value (-0.353 percent) over the whole period. Table 5 shows that profit efficiency remained more stable than technical cost efficiency; only modest changes were observed during the observation period, resulting in an average change close to zero (0.361 percent). From these results, we conclude that hypothesis

1 must be rejected; there was no clear upward trend in the development of technical cost and profit efficiency in the German life insurance industry.

We conclude that potential competition as a consequence of market liberalization has not resulted in technical cost and profit efficiency increases. We find no clear evidence for hypothesis 2, as profit efficiency levels remained much more stable compared to technical cost efficiency, and we find only a small increase in the average value over the whole observation period, while technical cost efficiency slightly decreased. However, the effects are far too small to indicate that firms realized significant gains in profit efficiency resulting from cost-increasing innovations. Further, there is no evidence of negative correlation between changes in technical cost efficiency and profit efficiency; on the contrary, in two of the three years in which technical cost efficiency decreased, profit efficiency also decreased.

Firms have realized important increases in scale efficiency, as the industry experienced a significant positive scale efficiency of 5.837 percent on average. The first years, from 1997-2000, showed significant positive scale efficiency changes, while the last two years showed a negative contribution of scale efficiency change to TFP growth. Increasing returns to scale are found for the sample mean and for all single years. The negative scale efficiency change in the last two years may be explained by decreases in output, which may have been a consequence of the bursting of the dotcom bubble and the stock market crash in 2000. Overall, hypothesis 3 cannot be rejected because market liberalization and subsequent market consolidation have led to positive changes in scale efficiency. By increasing firm size, partly as a consequence of M&A activities, firms have moved closer to their optimal size.

The positive contribution of changes in scale efficiency to TFP growth may partially explain why technical cost and profit efficiency have not increased significantly. The descriptive results indicate that market concentration increased again after an initial decrease as a reaction to market liberalization. Thus, firms may have reacted to increasing competition primarily by realizing scale economies. This, in turn, may have decreased competition again and consequently lowered efficiency-enhancing incentives of the firms. This explanation may be supported by the fact that foreign insurers have entered the German market through M&A with German firms, while the establishment of foreign branches and agencies, as well as direct cross-border trade, remains limited (Beckmann et al., 2002). This indicates that market liberalization, which was meant to increase competition, may have resulted in higher market concentration, as remaining barriers to entry make it difficult for foreign insurers to enter the market via cross-border trade or the establishment of agencies or branches. Weill (2004) and Casu and Girardone (2006) found a similar effect in the U.S. and the European banking

markets, i.e., that the deregulation and liberalization of the banking markets forced banks to be more efficient. (In our study, firms mainly increase their scale efficiency.) However, as a second step, the most efficient banks increased their market share and, thus, the market became more concentrated. The authors concluded that the liberalization of the markets has thus not resulted in more competitive markets.

A second reason for the co-occurrence of unchanged technical cost and profit efficiency with increased scale efficiency may be found in large post-merger integration costs, especially as a consequence of cross-border mergers (e.g., Rhoades, 1998). In that case, the detrimental effect on efficiency would be transitory, leading to an increase in technical cost and profit efficiency once the integration process has finished.

In comparing the first and last year of the observation period, i.e., those which include only those firms which remained in the market throughout the whole observation period, we find very similar results concerning technical cost efficiency change, which decreased by only 0.214 percent. This suggests that firms which were active during the whole observation period did not increase their cost efficiency, either. However, profit efficiency change is positive for those firms, although the effect is relatively small: Profit efficiency increased by 1.518 percent between 1995 and 2002. This finding provides at least some evidence for hypothesis 2 holding true, since those firms which remained in the market during the whole observation period increased profit efficiency, though not in cost efficiency. This may indicate that those firms have realized service and product innovations which increased revenues by more than they raised costs. Finally, the scale efficiency effect is much stronger for those firms (24.265 percent), possibly because it was mainly these firms which acquired other life insurers over the observation period, thus increasing their size and realizing important gains in scale efficiency.

7 Conclusions

This study analyzed the effects of liberalization of the European insurance industry on the German life insurance market. The Third European Life Insurance Directives exposed European life insurance markets to cross-border competition. In the case of the heavily regulated German life insurance market, former price and product regulation was abolished. These major changes were implemented to increase the efficiency of the industry by enhancing competition.

This study tested several hypotheses by analyzing TFP growth in the German life insurance industry for the years 1995-2002 and decomposing it into its sources – technical cost efficiency change, technical change, and scale efficiency change. We applied a stochastic distance frontier panel approach to derive estimates of technical cost efficiency and, following a recent approach by Greene (2005), we accounted for firm-specific heterogeneity by estimating a true fixed effects model. Further, we estimated changes in profit efficiency following Kumbakhar (2006), as the underlying non-standard profit function allows for price-setting power of firms which may have occurred as a consequence of market liberalization.

We found evidence for positive TFP growth in the German life insurance industry over the observation period, but the decomposition of TFP growth reveals that positive technical change is the main driver of positive TFP growth. Thus, we concluded that hypothesis 4 may not be rejected. These results were confirmed by Hussels and Ward (2004), who found positive technical change in the German life insurance industry for the period 1991-2002, although to a smaller extent. Their results must be treated cautiously, as the authors included yearly data of only 31 life insurance firms in their calculations.

Technical cost efficiency did not increase during the observation period, indicating that firms have experienced small efficiency losses over the observation period. These results are broadly in line with existing studies on the German market; Hussels and Ward (2004) found comparable changes in cost efficiency for the same observation period, while Mahlberg and Url (2007) reported a modest positive change in technical efficiency for the whole German industry, and Fenn et al. (2008) found that mean cost efficiency of German life insurers remained largely unchanged after liberalization. We also found that profit efficiency remains largely unchanged, so hypothesis 1 must be rejected. The aims of the liberalization process to increase market efficiency significantly were not reached until 2002, which may be partly explained by post-merger integration and transaction costs. We find no clear evidence for hypothesis 2 holding true, because only those firms which were active during the whole observation period realized small improvements in profit efficiency.

Scale efficiency has increased on average, as was hypothesized. Market consolidation in the presence of scale economies leads to efficiency gains as the firms move closer to their optimal size. By estimating firm-specific scale elasticity, we found that increasing returns to scale prevailed for the majority of the firms over the whole sample. These results are confirmed by previous literature; Mahlberg and Url (2007) reported large improvements in scale efficiency for the whole German insurance industry, and Fenn et al. (2008) also found increasing returns to scale prevailing in the German life insurance industry.

This significant increase in scale efficiency, taken together with the descriptive measures of market concentration, which indicate that market concentration increased again towards the end of the observation period, leads to an interesting conclusion: The liberalization of the European financial markets aimed at increasing competition and the efficiency of the markets. However, the increase in (potential) competition primarily provided incentives for the firms to realize economies of scale, mainly through M&A activities. This market consolidation may, in turn, reduce competition and efficiency-enhancing incentives. Fenn et al. (2008) drew a similar conclusion in finding that gains in scale efficiency of European insurance firms are linked with increasing X-inefficiencies.

Our work represents a twofold contribution to the existing literature. First, it contributes to the existing research on the development of European insurance markets after the liberalization of the market and, in doing so, is the first study to disentangle TFP growth into its three components for the German life insurance industry. The study used a recent approach for estimating stochastic frontiers by Greene (2005). The present study is also the first study to incorporate changes in profit efficiency into the analysis by applying an approach by Kumbakhar (2006) which allows for the price-setting power of firms.

The results indicate that the intended effects of the European financial market liberalization have only partially been achieved in the German life insurance market. It seems that increasing market consolidation as a reaction to market liberalization, in combination with still-existent barriers to entry, may reduce competition again as a feedback effect. However, this paper aims to analyze the effects of market liberalization on the performance of the industry, so a detailed analysis of the relationship between efficiency, and the structure and performance of the market is beyond the scope of this paper. As a task for future research, these central hypotheses which link market structure and performance should be tested for the German insurance market.

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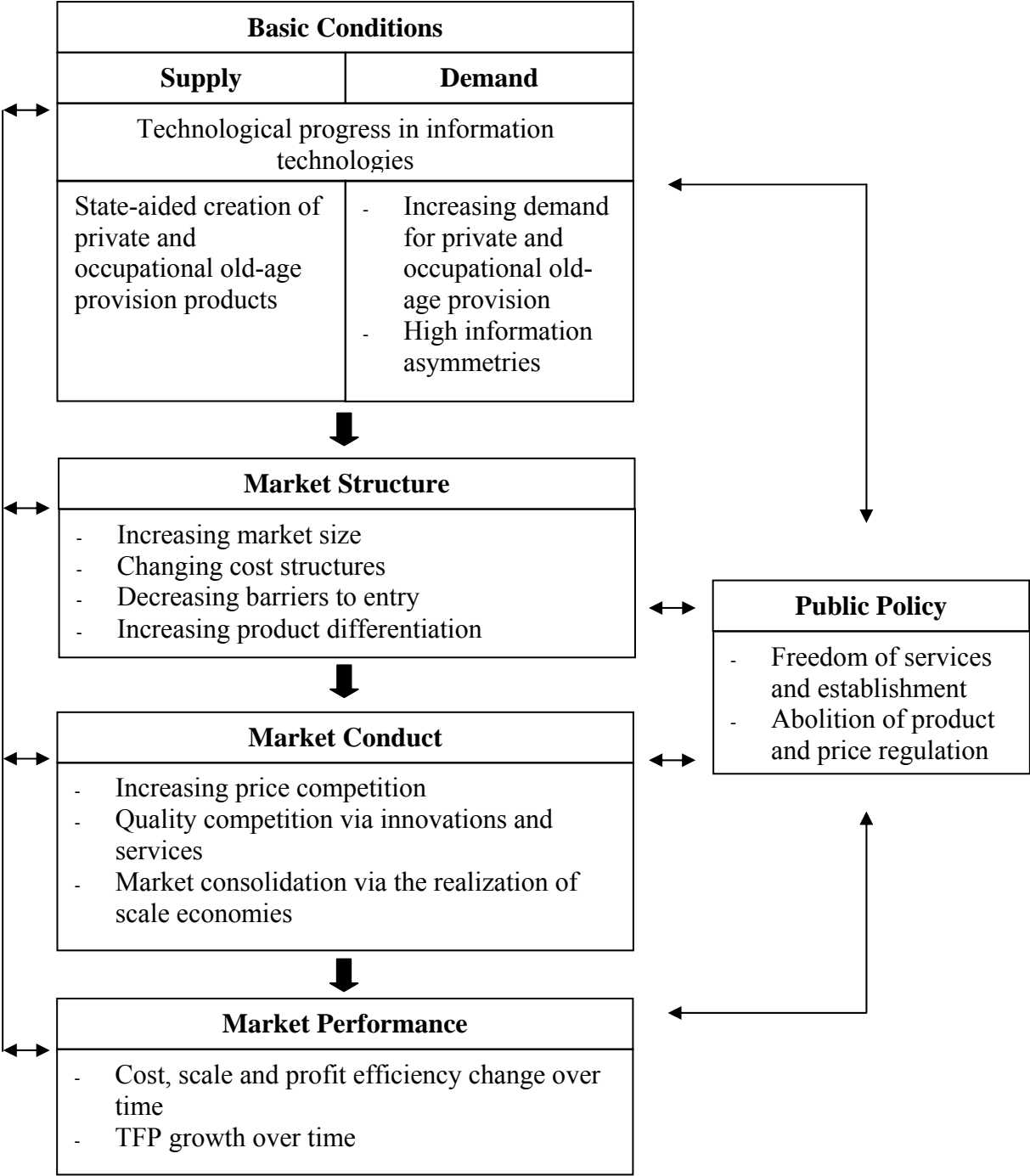
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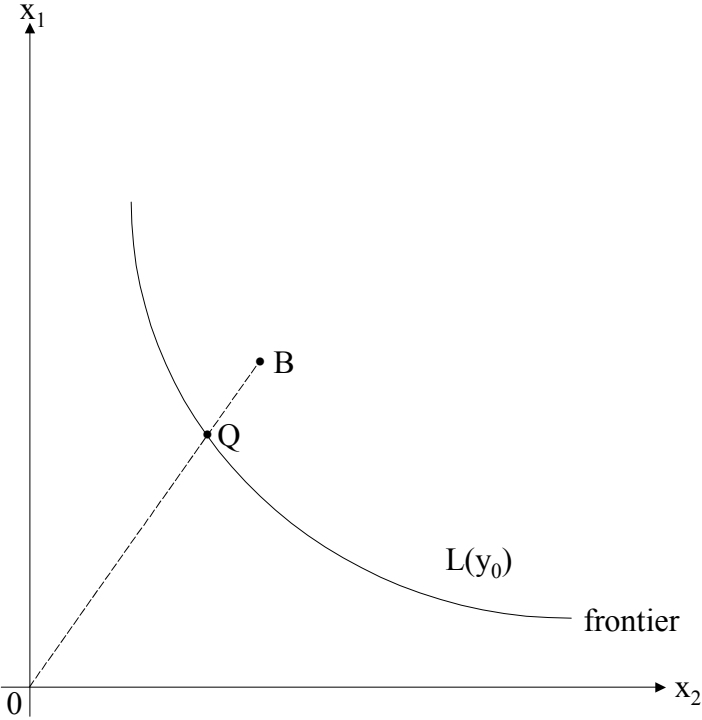
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Figure 1: Revised SCP Paradigm – Possible Effects of Market Liberalization



Source: Own composition following Neuberger (1998), p. 99.

Figure 2: Input Distance Function in the Two Input – One Output Case



Source: Own composition following Coelli et al. (2005), p. 50.

Table 1: Number of Firms and Measures of Market Concentration, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
n	94	97	89	96	95	92	83	84
C 5	34.29	33.71	32.94	33.34	31.44	31.80	32.70	32.74
HHI	440.46	426.60	408.44	418.11	414.13	403.12	448.56	458.20

Note: C 5 and HHI are presented in percent. Market share is measured by premium income.

Source: Own calculations.

Table 2: Variables and Summary Statistics, 1995-2002

		1995	1996	1997	1998	1999	2000	2001	2002	Total
Operating Expenses	Mean	61043.35	62482.22	75075.08	75499.62	105259.17	90646.41	108812.60	120273.11	86578.05
	(SD)	(98330.63)	101325.97	(117315.48)	(123382.59)	(171856.59)	(141489.76)	(175015.88)	(192603.93)	(143649.99)
	Min	97.94	62.37	224.40	106.72	168.73	123.00	1224.00	119.82	62.37
	Max	630640.35	678437.11	745224.87	820366.37	1164376.76	843474.00	999369.48	1229533.54	1229533.54
Equity costs	Mean	6843.61	5925.53	7826.77	6879.60	7420.82	7725.02	5043.59	5718.95	6698.34
	(SD)	(12688.07)	(11035.00)	(14135.48)	(12929.12)	(14000.97)	(14354.64)	(9290.31)	(14681.98)	(12984.27)
	Min	257.37	200.77	210.68	225.08	220.31	208.45	199.24	211.14	199.25
	Max	106358.96	94549.10	109295.69	105054.74	112858.60	116531.67	72974.50	120425.07	120425.07
Output	Mean	512481.19	541446.73	703043.00	716161.69	838529.96	901315.46	908291.01	858787.68	742635.07
	(SD)	(1028925.04)	(1085527.96)	(1270764.59)	(1386754.91)	(1576125.05)	(1678347.40)	(1757272.90)	(1619070.86)	(1440513.11)
	Min	11.52	20.95	375.32	1295.26	64.09	2154.00	5284.62	2878.66	11.52
	Max	8418832.61	8992354.08	9822743.11	11414185.26.92	12759379.92	13501076.00	13664132.16	12786620.81	13664132.16
Premiums net of reinsurance	Mean	343584.97	360270.74	448945.54	456772.95	524384.61	584622.40	623357.42	687359.51	498805.85
	(SD)	(612134.45)	(641511.60)	(732904.76)	(797152.07)	(903013.74)	(970137.23)	(1034890.13)	(1167132.82)	(872302.57)
	Min	30.73	32.16	1041.58	986.10	1320.25	1703.00	8376.24	9691.68	30.73
	Max	4669592.95	4945336.82	5325206.91	6213595.24	6976208.57	7359222.00	7430964.18	8732933.42	8732933.42
Investment income	Mean	220627.50	234939.02	316161.56	340717.54	396008.68	454982.89	470784.33	508431.45	363887.57
	(SD)	(468622.32)	(501885.25)	(610428.63)	(689993.31)	(796304.93)	(911084.40)	(989838.51)	(1126772.70)	(786414.13)
	Min	181.96	195.88	258.16	22.55	448.63	600.00	796.62	598.69	22.55
	Max	3981811.68	4335788.21	4907201.25	5745969.84	6598508.56	7433390.00	7858182.00	9366708.21	9366708.21

Note: All variables are expressed in 2000 Thousand Euro units deflated with the German Consumer Price Index.

Source: Own calculations.

Table 3: Translog Input Distance Function – Estimation Results

True Fixed Effects Model			
Dependent variable: $-(\ln(\text{Equity costs}))$			
Variable	Parameter	Coefficients	Standard Error
Ln(Opex)	γ_1	0.484***	0.011
Ln(Output)	β_1	-0.768***	0.010
Time	η_1	0.060***	0.003
$\frac{1}{2} (\ln(\text{Opex}))^2$	γ_{11}	0.079***	0.015
Ln(Opex)*ln(Output)	δ_1	0.011**	0.005
Ln(Opex)*time	ϕ_1	-0.024***	0.004
$\frac{1}{2} (\ln(\text{Output}))^2$	β_{11}	-0.132***	0.002
Ln(Output)*time	κ_1	0.008***	0.002
$\frac{1}{2} (\text{time}*\text{time})$	η_{11}	0.007**	0.002
Variance parameters			
σ		0.797***	0.010
σ_u (one-sided)		0.774	
σ_v (symmetric)		0.190	
$\lambda = \sigma_u / \sigma_v$		4.065***	0.193
Log Likelihood function		-184.81	
Wald test statistic (χ^2) (H_0 : No influence of exogenous variables)		8885.85***	
LR test (H_0 : Cobb-Douglas)		222.01***	
LR test (H_0 : No technical change)		13.535**	
Wald test statistic (χ^2) (H_0 : CRS)		519.98***	

Note: **: significant at a 5 percent level; ***: significant at at 1 percent level; Estimated with “LIMDEP 9.0”.

Source: Own estimations.

Table 4: Average Technical Cost and Profit Efficiency, 1995-2002

	Technical cost efficiency	Profit efficiency
	Mean (SD)	Mean (SD)
1995	0.6620 (0.1262)	0.8777 (0.2490)
1996	0.6949 (0.1169)	0.8817 (0.2156)
1997	0.6804 (0.0993)	0.9328 (0.1199)
1998	0.6989 (0.0815)	0.9196 (0.1906)
1999	0.6505 (0.0877)	0.8912 (0.2059)
2000	0.6671 (0.1074)	0.9311 (0.089)
2001	0.7054 (0.1057)	0.9305 (0.1032)
2002	0.6637 (0.1547)	0.9539 (0.038)
Total	0.6778 (0.1125)	0.9137 (0.1703)

Source: Own estimations.

Table 5: Average TFP Change and Profit Efficiency Change, 1995-2002

	Technical change	Technical cost efficiency change	Scale efficiency change	Total factor productivity change	Profit efficiency change
1995/96	4.031	5.429	12.715	22.175	0.017
1996/97	5.022	-2.304	12.066	14.784	1.088
1997/98	6.017	3.581	6.219	15.817	1.703
1998/99	7.081	-7.616	5.108	4.574	-2.402
1999/2000	7.762	2.364	6.030	16.159	1.445
2000/01	9.186	5.267	-1.604	12.849	2.063
2001/02	10.605	-9.408	-1.122	0.075	-1.535
Total	7.019	-0.353	5.837	12.503	0.361
1995-2002 ¹	7.289	-0.214	24.265	31.339	1.518

Note: All measures are in percentage terms. ¹ Calculation of TFP components and profit efficiency change for 1995 versus 2002.

Source: Own calculations.