Estimation of Scale and Scope Economics in Life Insurance: A Stochastic Frontier Analysis with Panel Data

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Most studies on the economics of scale and scope in the insurance industry assume no X-inefficiency. That is, insurances are assumed to be always on their efficient frontier, which can in empirical studies confound scale and scope efficiencies with X-efficiency. The current paper employs a stochastic frontier cost function incorporating technical and allocative inefficiencies, as well as a system of share equations, to estimate scale and scope efficiencies. Using data from Taiwan's insurance industry, evidence is found that both scale and scope economics exist, and that the assumption of no X-inefficiencies results in underestimating of such economies.

I. Introduction

A flexible translog functional form, the translog cost function, has been widely used to examine scale and scope economics in banking and insurance, as evidenced by Grance et al. (1999), Mayers et al. (1999), Weiss (1994), Lang and Welzel (1996), and Mester (1996). However, those studies don't apply -a stochastic frontier estimation approach, which can be used to investigate economic efficiencies - all technical and allocative efficiencies of individual firms – of the insurance as well as other insurances; -see Ferrier and Lovell (1990) and Bauer et al. (1991). In other word, the above studies presume that firms are always on the frontier of efficiency.

Berger and Humphrey (1991), Grace and Timme (1999), Mester (1996), and Cummis and Weiss (1997) find that evaluating data without being on the cost frontier could confound X-efficiencies. Although substantially scope economies with Mester(I996) and Lang and Weizel (1996) estimate the stochastic frontier translog cost function in insurance, they only allow for technical inefficiencies in the cost function and ignore allocative inefficiencies. Moreover, they estimate the cost function without estimating the corresponding share equations simultaneously.

This paper will start with a system of translog cost function and the corresponding share equations. The specification takes both technical and allocative inefficiencies into account. After estimating the cost system using a maximum likelihood procedure, scale and scope economics will not be confounded with X-inefficiencies. To exemplify this approach, a panel data set consisting of 25 Taiwan's life insurance companies, including 11 foreign companies, was collected to be used in the empirical study.

The remainder of the paper is organized as follows. Section II outlines the econometric model used for estimation. Section III briefly describes the data, analyses empirical results and compares them with previous findings, while Section IV summarizes the main conclusions.

II. Methodology

Based on the financial intermediation approach, insurance firms are assumed to employ two inputs-labor (X_1) and capital (X_2)—to produce two outputs—premium (Y_1) and investment (Y_2). Total costs include operating costs and financial costs. The system of translog cost function as well as share equations can be written as:

$$\ln C = \ln C^* + \varepsilon$$

$$= \alpha_0 + \sum_{j=1}^{2} \alpha_j \ln Y_j + \sum_{i=1}^{2} \beta_i \ln P_i + {}^1/_2 \sum_{j=1}^{2}\sum_{k=1}^{2} \delta_{jk} \ln Y_j \ln Y_k + {}^1/_2 \sum_{i=1}^{2}\sum_{k=1}^{2} \gamma_{ik} \ln P_i \ln P_k + \sum_{i=1}^{2}\sum_{j=1}^{2} \rho_{ij} \ln P_i \ln Y_j + \varepsilon \quad (1)$$

$$S_i = S_i^* + u_i$$

$$= \frac{\delta \ln C^*}{\delta \ln P_i} + U_i$$

$$= \beta_i + {}^1/_2 \sum_{k=1}^{2} \gamma_{ik} \ln P_k + {}^1/_2 \sum_{j=1}^{2} \rho_{ij} \ln Y_j + U_i \quad (2)$$

with C = observed total costs

C^* = optimal total costs

S_i = observed cost share of input i, i = 1, 2

S_i^* = optimal cost share of input i

Y_j = quantity of the i-th output, j = 1, 2. and

P_i = price of the i-th factor input

The cost function must be linearly homogeneous in factor prices and symmetrical in input prices as well as output quantities.

The global scale economics (GSE) over the production of the two outputs-are given by:

$$GSE = \frac{C^*(Y)}{\sum_{i=1}^{2} Y_i C_i^*(Y)} \quad (3)$$

where $C^*(Y) = \dfrac{\delta C^*(Y)}{\delta Y_i}$

Following Kim (1986) and Mester (1993), scope economics (SC) are computed via:

$$SC = \frac{C^*(Y_1 = 2\varepsilon_1, \varepsilon_2) + C^*(\varepsilon 1, Y_2 = 2\varepsilon_2) - C^*(Y_1, Y_2)}{C^*(Y_1, Y_2)} \quad (4)$$

where ε_1 = 10% of Y_i at same mean, i = 1,2,

with SC>0 donating global scope economies.

To understand the characteristics of the production function through duality, the following four structural tests of the cost function are carried out: (1) the production function is homothetic if and only if the cost function is separable in prides and outputs, which means that $\rho_{ij} = 0$, j = 1,2 ; (2) the production function is homogeneous in outputs if and only if the elasticity of cost with respect to each output is constant, which requires $\delta_{ij} = 0$, $i,k = 1,2$; (3) the Allen-Uzawa (A-U) elasticity of substitution between inputs i and k equals unity for i,k = 1,2, and $i \neq k$; (4) the production function has a Cobb-Douglas form, which requires all the restrictions listed in the above three hypotheses be satisfied simultaneously.

Following Kumbhakar (1991) the random disturbance (e) in the cost function can be expressed as:

$\varepsilon = TI + AI + v$

The term $TI \geq 0$ represents the incremental cost to efficient cost due to technical inefficiency, and the term $AI \geq 0$ captures the addition to efficient cost due to allocative inefficiency. The term v captures all random impacts on a firm's efficient cost.

The system given by Equation 1 and 2 can be estimated using maximum-likelihood once the following assumptions are made regarding distributions of the disturbance terms:

(i) $II \sim N(0, \sigma_v^2)$

(ii) II, v and U are mutually independent.

III. Data and Estimation Results

This paper identifies two output categories, i.e. premium (Y_1) and investments (Y_2). Investments include government and- corporate securities. Labor (X_1) and physical capital (X_2) are defined as inputs. This study uses panel data on 25 Taiwan's insurance companies, of which 11 are foreign companies, from 1992 through 2002. Except the stochastic frontier model, I estimate two more models. One is the fixed effect model, according to Atkinson and Cornwell (1994), is equivalent to a model allowing only technical inefficiency. The other ignores both technical and allocative inefficiencies and is called conventional model. The parameter estimates of the three cost functions are not presented so as to save space (these estimates are available upon request). Since the regularity conditions are generally accepted on the one hand, and the four structural tests proposed in section II are all rejected on the others, these estimates can properly reflect my representative insurance's technology.

Table 1 and table 2 list the estimation of economies of scale and scope, respectively. Table 1 shows that increasing-returns to scale are observed in all three models. There is evidence of an inverse relationship between total costs and GES. Estimated GES's from the stochastic frontier model are larger than those from both the fixed effect and conventional models, indicating that ignoring X-inefficiencies will cause a downward bias in the-estimation of GES. Significant product mix economies are detected when the stochastic frontier model is used as shown in Table 2. However, all the scope economies hypotheses are decisively rejected by the other two models. These results suggest that evaluation using data from insurance companies of the cost frontier could confound scope economies with X-efficiency, and thus are consistent with Berger and Humphrey (1991), Batier et al. (1997), and Cummis and Weiss (1997).

Table 1. Estimation of Economies of Scale

	Stochastic cost frontier model	Fixed effect model	Conventional model
Industry	1.214[a] (0.004)	1.117[a] (0.008)	1.068[a] (0.007)
Domestic insurance companies	1.088[a] (0.005)	1.093[a] (0.017)	1.037[a] (0.014)
Foreign insurance companies	1.287[a] (0.009)	1.141[a] (0.011)	1.108[a] (0.006)
Cost size class ($ millions)			
0~2000	1.393[a] (0.015)	1.136[a] (0.011)	1.218[a] (0.027)
2001~8000	1.353[a] (0.008)	1.142[a] (0.009)	1.144[a] (0.018)
8001~20000	1.293[a] (0.005)	1.149[a] (0.014)	1.098[a] (0.015)
above 20000	1.214[a] (0.007)	1.145[a] (0.021)	1.011[a] (0.022)

Note: a. significant at 1% level

Table 2. Estimation of Economies of Scope

	Stochastic cost frontier model	Fixed effect model	Conventional model
Industry	7.478[a] (1.141)	1.018 (0.978)	37.114 (28.578)
Domestic insurance companies	11.417[a] (1.147)	3.018 (2.714)	81.047 (77.414)
Foreign insurance companies	6.017[a] (0.907)	0.161 (0.647)	17.151 (14.058)
Cost size class ($ millions)			
0~2000	2.917[a] (0.367)	0.047 (0.141)	11.148[b] (5.685)
2001~8000	6.146[a] (0.968)	0.117 (0.513)	17.117 (14.080)
8001~20000	44.917[a] (4.081)	2.454 (2.087)	87.004 (80.581)
above 20000	20.080[a] (2.154)	5.157 (4.981)	93.083 (96.486)

Note: a. significant at 1% level b. significant at 10% level

IV. Conclusions

The main purpose of this study is to estimate scale and scope economies for Taiwan's insurance sector, using a stochastic frontier approach which allows for X-inefficiencies. Two alternative simplified models are also estimated for comparisons. Evidence is found that both scale and scope economies exist in the insurance industry and that exclusion of X-inefficiencies from the cost function could bias the estimates of the economies of scale downward and would confound scope economies with X-efficiency.

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