© *Risk Management and Insurance Review*, 2008, Vol. 11, No. 2, 349-375

THE IMPACT OF DEREGULATION ON EFFICIENCY: AN ANALYSIS OF LIFE INSURANCE INDUSTRY IN TAIWAN FROM 1981 TO 2004

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ABSTRACT

We examine the impact of deregulation and liberalization (D&L) on the efficiency of the Taiwanese life insurance industry from 1981 to 2004. We utilize the data envelopment analysis (DEA) to measure the efficiency performances and the Malmquist index approach to measure changes in efficiency and productivity over time. Both the DEA and Malmquist results show that the old domestic firms have been slightly impacted by the new competitors around 1992–1994 (the end of foreign and new local entry period and the beginning of post-D&L period). More important, our results show that the D&L does not have major adverse impact on the technical, cost, and revenue efficiency performances of existing domestic firms in the long run. The dominance of existing domestic firms has declined but persists throughout the sample period. In addition, our results show that it is relatively easy for new firms to become technically efficient in just few years after entering the market, but it is more difficult for them to become efficient in cost and revenue efficiency. We, thus, suggest that a new market entrant should take advantage of the existing mechanisms by acquiring an old (existing) firm, rather than establish a new one, if a new entrant wants to become efficient in cost and revenue efficiency in a short time.

INTRODUCTION

With the rapid emergence and continuing evolution of a global economy, any country that intends to play an important role in world trade must ultimately remove the protection and restrictions on its insurance market. Specifically, under the rules of the World Trade Organization (WTO) agreements regarding liberalization in the financial service industries, these developing countries have to balance dual goals of survival and free trade. On the one hand, the local governments are persuaded that deregulation

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and liberalization (D&L) will improve the efficiency of existing domestic companies and that the degree of competitiveness of the entire industry could be raised by the new technologies brought by new entrants. On the other hand, local governments always fear that the D&L will undermine the development of domestic industries and ultimately result in the failure of domestic firms. Which argument prevails is an empirical question.

Liberalization in the financial service industries also increases the incentive of global insurers to enter new markets because liberalization has lessened the entry barrier for local markets. If global insurers decide to enter a new market, then their very next question is to decide what the best method is to enter the market. In other words, is it better to enter a new insurance market by establishing a new insurer or to go through mergers and acquisitions with an existing domestic insurer?

We find that the insurance market in Taiwan provides an interesting study to answer the above two questions. Taiwan, being one of the potentially lucrative markets in global insurance, has followed a policy of gradual D&L in its insurance sector in the late 1980s. The life insurance industry in Taiwan was first established with eight domestic life insurance companies in 1962. The market remained closed to foreign entrants until 1987. In 1993, the government further allowed new domestic firms to enter the market for the first time. Since 1993, the Taiwanese insurance market has been going through the establishment of new firms and some mergers and acquisitions. Global insurers have shown interests in the eight old domestic firms. For example, Chinfon Insurance Company, one of the eight old domestic firms, was acquired by Prudential Life in 1998. In 2004, 17 years after the first foreign insurer joined Taiwan's life insurance industry, there were 29 life insurers in Taiwan, with 16 of them domestic and 13 of them foreign. The insurance premium increased from NT$80 billion (US$2.67 billion) in 1987 to NT$1,308 billion (US$41 billion) in 2004.

The purpose of this article is to examine the impact of D&L on the efficiency of the life insurance industry. Specifically, we use the Taiwanese experience as an example. We first examine the efficiency performance of existing (old) domestic firms before and after the D&L. Taiwan's D&L process can be separated into three stages: the pre-D&L period (before 1987), the foreign-entry period (1988–1993), and the post-D&L period (1994–2004). We compare the efficiency performances of old domestic firms to that of the new firms in these three stages. On the one hand, we expect to observe an efficiency improvement in the existing domestic firms as the D&L proceeds because the competition in the insurance market intensifies throughout the years. In other words, competition may make old domestic insurers become more efficient. On the other hand, we may observe the efficient performance of domestic firms to remain constant before and after the D&L. The result of this investigation would provide evidence as to whether the D&L has a positive or negative influence on the domestic insurance industry.

We also examine the efficiency difference between existing domestic firms and their competitors: domestic firms versus foreign firms in stage 2 and domestic firms versus foreign/new domestic firms in stage 3. By comparing the efficiency performance among different groups, we can further explore whether existing domestic firms remain competitive after the D&L. If we find that foreign and/or new local firms are more efficient than old domestic firms, it means that old firms have an inferior position in the market

competition. Even under this scenario, domestic consumers may benefit from the competition if the overall efficiency of the industry has been improved. On the other hand, if we find old domestic firms to be more efficient than new firms, it suggests that existing firms are mature enough to face the D&L in the insurance market. One can conclude that introducing new competitors into the market does not jeopardize the efficiency of the domestic insurance industry.

This article studies three efficiency measures—technical, cost,[1] and revenue efficiency of the life insurance industry in Taiwan throughout the sample years. If the frontier of domestic firms is distinct from that of new firms, we further utilize the cross-frontier approach to test whether new firms could have produced their outputs using old firm technology more efficiently than they use their own technology. If new firms are more efficient using old firms' technology and cost frontiers, then it implies that it is better to enter a new insurance market, such as Taiwan, through mergers and acquisitions with old domestic firms. If the results show that new firms are more efficient using their own frontiers, establishing a new firm is a better choice for new entrants. Finally, we apply the Malmquist analysis to examine if the existing domestic firms have productivity improvement as the D&L proceeds.

Our sample consists of all life insurers in Taiwan and the sample period is from 1981 to 2004. The empirical results are summarized as follows. First, the results show that the old domestic firms were slightly influenced by the D&L in all technical, cost, and revenue efficiency performances around 1993, but the old domestic firms coped with challenges well and became highly efficient around 1997. We, thus, suggest that the D&L has little adverse impact on the competitiveness of existing domestic firms. Second, we find that old domestic firms and their new competitors do not share the same frontiers in terms of the way they operate their businesses. Third, the old domestic firms have dominated new firms for producing old firms' outputs in all technical, cost, and revenue frontiers. The dominance of old firms has decreased gradually, but it still persists up to the end of the sample period. Finally, our results show that it could be easy for new firms to acquire new technology, and thus become technically efficient in few years, but it is more difficult for new firms to become efficient in cost and revenue scheme. Our results, thus, suggest that any new entrants to the market should take advantage of the existing mechanisms by acquiring an old firm rather than building up a new one.

The remainder of this article is organized as follows. The next section provides the background and the research questions to be investigated in this article. "Methodology and Data" presents the methodology applied and data used. The results are presented in "Results" section, and the last section concludes.

BACKGROUND AND RESEARCH QUESTIONS

D&L in the Taiwanese Life Insurance Industry

D&L have both been characterized as important parts of regulatory changes in domestic insurance markets. A measure to raise the competitiveness of domestic insurance market

[1] It should be noted that cost efficiency reflects allocative efficiency. We do not report allocative efficiency scores to save space.

by reducing government supervision can be regarded as one kind of deregulation. For instance, the removal of price or policy form control, free capital investment of insurers, or open access to reinsurance are all examples of deregulation. Liberalization is related to the globalization and internationalization of local insurance market. For instance, if a foreign insurer has free access to enter domestic market, the market can be regarded as liberalized. The entry of a foreign insurer can affect the local market through both D&L. By providing the latest products or by introducing more capable managers, foreign insurers can attract more customers and perform efficiently given their limited business connection relative to the domestic insurers.

It is very difficult to categorize an insurance market as deregulated/liberalized or regulated/nonliberalized. In practice, each country has some types of insurance regulation. We categorize insurance markets in the world into two categories: highly deregulated/liberalized markets and less highly deregulated/liberalized markets. We believe the insurance market in Taiwan can be treated as a highly deregulated/liberalized market.[2] Unlike most countries in East Asia, Taiwanese government puts no formal impediments on market access for foreign insurers. In addition, Taiwanese government agreed, in July 1999, to a series of guarantees to completely open the insurance market as part of an agreement to secure membership in the WTO. It is fair to say that the openness of Taiwanese insurance market is close to that of the markets in developed countries.

Literature Review

Traditional research of efficiency in the financial services industry, such as the banking industry, first used the frontier approach that has been popular since the late 1980s. Sherman and Gold (1985), Rangan et al. (1988), Aly et al. (1990), and Ferrier and Lovell (1990) are among some of the studies that have used the frontier approach to examine the efficiency issues of banks. Cummins and Weiss (1993), Gardner and Grace (1993), and Yuengert (1993) investigate the X-efficiency of insurers in either the life or the property–casualty industry in the United States. Recently, Cummins, Weiss, and Zi (1999) used a frontier analysis (data envelopment analysis, DEA) to examine the efficiency difference between different organizational forms in the U.S. property–casualty insurance industry. Cummins, Tennyson, and Weiss (1999) also used the DEA method to examine the efficiency performances of target insurers before the mergers and acquisitions. Cummins, Rubio-Misas, and Zi (2004) further uses the DEA method and examine the effect of organizational structure on efficiency by analyzing stock and mutual Spanish insurers from 1989 to 1997.

Outside the United States, few studies use the frontier analysis to study efficiency in the insurance industry, such as Fecher et al. (1993), who examined technical efficiency in the French insurance industry, and Fukuyama (1997), who examined the Japanese

[2] Currently the Taiwanese government still has some regulatory restrictions on the local insurance market. However, we believe that these restrictions are commonly seen in developed countries. Examples include: (1) on insurance pricing, both prior-approval method and file-and-use method are used, and (2) local consumers (insurers) cannot purchase insurance (reinsurance) products abroad.

life insurance industry. Prior to our article, two studies (Liu, 1994; Chang, 1998) used the frontier analysis to investigate efficiency changes in the life insurance industry in Taiwan. Liu (1994) used DEA to examine technical efficiency of life insurers from 1986 to 1993. By further decomposing technical efficiency into scale efficiency and pure technical efficiency, he found that the efficiency performances of foreign insurers were usually poor in the first 2 years, but the inefficiency was mostly due to low-scale efficiency scores. After reaching constant return-to-scale in 2 years, foreign insurers tend to largely improve their technical efficiency performances. Chang (1998) used the X-efficiency analysis to examine the efficiency change of existing domestic firms from 1975 to 1996. His results show that the X-inefficiency of domestic firms on average is 42 percent before the D&L but drops to 23 percent after the D&L. Therefore, he claims that the market competition after the D&L has improved the efficiency performances of existing domestic firms.

Our article extends the prior literature by providing many distinct perspectives to life insurers studies in Taiwan. First, in addition to technical efficiency, we consider two more efficiency measures. One is cost efficiency, the product of technical efficiency and allocative efficiency which reflects the ability of firms' managers to allocate the resources based on input prices. Cost efficiency is critical to life insurers because it takes input prices and allocation of resources into consideration. The other is revenue efficiency, which reflects the ability of the firm to maximize its revenues. It is also crucial to life insurers since any strategy of market movement is ultimately related to revenues of the firms.

Second, we use the cross-frontier analysis developed by Cummins, Weiss, and Zi (1999) to estimate the efficiency between old firms and new firms from a different scheme. Previous studies such as Liu (1994) compared the technical efficiency of different groups of insurers based on the assumption that all groups being compared used the same technology to produce their outputs. In this article, we test this assumption and examine whether different groups of insurers have different frontiers. By applying the cross-frontier analysis, we further examine whether each type of insurers has developed a dominant technology frontier and cost frontier for producing their outputs.

Third, we use the Malmquist index approach to investigate the productivity change of existing domestic insurers throughout the years, while previous studies such as Chang (1998) examined the efficiency change of domestic firms using the DEA and the time-variant inefficiency method. We believe Malmquist analysis is better because it can further separate the productivity change into two components: technical change and technical efficiency change. It allows us to investigate whether a firm's productivity improvement is due to its adoption of new technology or due to its favorable efficiency improvement.

Finally, we use a longer data period than was used in previous studies. Specifically, Liu (1994) used the time period from 1986 to 1993 and Chang (1998) used the period from 1975 to 1996. The additional data are significantly important because the post-D&L period starts in 1994 and the life insurance market has a few entries and exits after 1996. In fact, our results indicate that the new entrants show substantial efficiency changes

from 1996 to 2004. In summary, with better methodology and longer data, we are able to provide new evidence, different results, and new policy implications.

Hypotheses

To examine the efficiency performance among the three groups of firms—old domestic firms (hereafter ODs), new domestic firms (hereafter NDs), and foreign firms (hereafter Fs), we follow Cummins, Weiss, and Zi (1999) and test a sequence of null hypotheses, at the firm level. We first test the null hypothesis that all three groups of firms are operating on the same frontier. If the null hypothesis is not rejected, we conduct the analysis based on pooled efficient frontiers. However, if the null hypothesis is rejected, it implies that comparisons of efficiencies based on the pooled frontier is invalid because these three groups of firms operate on different frontiers.

A second null hypothesis is then tested to see whether each group is equally efficient relative to other group's production frontier. This hypothesis is based on the "cross-frontier" efficiency method used by Cummins, Weiss, and Zi (1999), Cummins, Rubio-Misas, and Zi (2004), and Jeng and Lai (2005). The purpose of this approach is to examine whether each group's output vector could be produced with equal efficiency using the other group's technology. Rejection of this hypothesis for one or both groups would imply that one or both groups have developed a dominant technology for producing their outputs. We also follow the literature (Cummins, Rubio-Misas, and Zi, 2004) to calculate the cross-frontier efficiency score (F-scores) to measure the dominance of each group.

In addition to the null hypotheses mentioned above, we are also interested in the productivity change of domestic firms throughout the years. Malmquist index analysis is important because the increased competition in the post-D&L may influence the productivity change of the domestic insurers.

METHODOLOGY AND DATA

Methodology

There are two principal types of efficiency methodologies—the econometric (parametric) approach and the mathematical programming (nonparametric) approach. The econometric approach requires the specification of a production, cost, revenue, or profit function as well as assumptions about the error terms. The nonparametric programming approach imposes less specification on the optimization problem. We adopt the nonparametric programming approach in this article because it avoids the problem of vulnerability to specification errors that occurred frequently with the econometric approach.[3] To save space, we do not provide the detailed methodology in this article. For the efficiency and productivity methods, we follow Cummins and Zi (1998) very closely. We also follow the cross-frontier efficiency method, which was advanced by Cummins, Weiss, and Zi (1999) and Cummins, Rubio-Misas, and Zi (2004). Readers who are not familiar with the methodology can further refer to Cummins and Weiss (2000). They provide an excellent review of the frontier efficiency and productivity methods.

[3] See Cummins and Weiss (2000) for detailed discussion about the pros and cons of the nonparametric programming approach.

Data Selection

The data source is the *Annual Report of Life Insurance, Republic of China* from 1981 to 2004. The descriptive statistics of the input and output variables are presented in Table 1, where the means of the input/output variables and the number of firms in each group are both exhibited.

Outputs and Output Prices

Following the recent insurance and banking literature (see Yuengert, 1993; Cummins et al., 1998), we adopt the value-added approach to measure outputs. Our article defines output as benefit payments and increase in policy reserve. It is suggested that insurers provide three principal services: real services relating to insured losses, risk-pooling and risk-bearing, and intermediation. Benefit payments are useful proxies for the risk-pooling and risk-bearing functions because they measure the amount of funds pooled by insurers and redistributed to policyholders as compensation (Cummins et al., 1999, p. 336).

We further disaggregate benefit payments into four categories: ordinary life insurance (Y_1), personal accident insurance (Y_2), individual health insurance (Y_3), and group insurance (Y_4).[4] We focus on the benefit payments reported in dollar amount.[5] In addition, we select the increase in policy reserve (Y_5)[6] as the output of intermediation function. Increase in policy reserve (additions to reserve) "represent the insurer's best estimate of claims and other benefits to be paid in the future as a result of the current year's insurance coverage, and the net additions to reserves also provide a satisfactory proxy for the current year's intermediation output" (see Cummins, Rubio-Misas, and Zi, 2004, p. 3130).

The insurers in Taiwan are not required to allocate increase in policy reserve by line in their annual reports, thus, we are not able to segregate increase in policy reserve into different lines. We, thus, treat our first four outputs representing risk-pooling and risk bearing function and focus our fifth output, increase in policy reserve only on the intermediation function it represents. Both variables benefit payments and increase in policy reserve, are correlated with real services provided by insurers such as benefit administration in group insurance (see Cummins et al., 1999). All five outputs are deflated to the base year 1996 using the Consumer Price Index (CPI) in Taiwan.

[4] Annuity insurance (both in individual and group annuities) has always been trivial in the Taiwanese life insurance market,. For example, in year 2004, the benefit payment of annuities insurance (including both individual and group annuities) is NT$13 billion, accounting for 2.71 percent of the total benefit payments in the industry. Therefore, we are unable to follow Cummins, Weiss, and Zi (1999) and Cummins, Rubio-Misas, and Zi (2004) and decide not to include annuities insurance as one of our outputs.

[5] We follow Cummins, Weiss, and Zi (1999) and Cummins, Rubio-Misas, and Zi (2004) in this application of output variable.

[6] The increase in policy reserve is used as an additional output variable in our analysis. Unlike the data from U.S. insurance industry, data of increase in policy reserve (additions to reserve) are not segregated into different lines in the Taiwanese insurance industry. Thus, we are unable to analyze the intermediation function of the insurers based on different lines of insurance.

TABLE 1
Descriptive Statistics for Life Insurers in Taiwan

	All Firms (1)	Old Domestic Firm (2)		New Firms (4)	New Domestic Firms (5)		Foreign Firms (7)
			(3)			(6)	
Number of firms							
In 1981	8	8		0	0		0
In 2004	29	7		22	9		13
Output (unit: NT$1,000,000) (on average)							
Y_1 = benefit payments in ordinary life insurance	5,606	12,732	***	816	1,029		693
Y_2 = benefit payments in personal accident insurance	458	988	***	102	95		106
Y_3 = benefit payments in individual health insurance	462	815	***	225	235		219
Y_4 = benefit payments in group insurance	296	607	***	87	107	*	75
Y_5 = increase in life policy reserve	15,713	32,641	***	4,334	5,498	*	3,665
Output price							
P_1 = price of ordinary life output	27.17	2.97	*	48.44	81.07		22.27
P_2 = price of personal accident output	2.95	2.15	***	3.66	2.50	**	4.59
P_3 = price of individual health output	4.13	3.18	***	4.96	5.16		4.80
P_4 = price of group output	2.72	1.28	***	3.98	1.59	**	5.90
P_5 = price of additions to reserve	0.30	0.33	***	0.27	0.29		0.25
Input							
X_1 = number of home office labor	1,001	2,010	***	323	362		300
X_2 = number of agent labor	7,508	14,754	***	2,637	3,782	***	1,978
X_3 = unit of business service	1,147	2,202	***	439	479		416
X_4 = equity capital (unit: NT$1,000,000)	5,210	11,328	***	1,097	1,776	***	707

(continued)

TABLE 1
(Continued)

	All Firms (1)	Old Domestic Firm (2)	(3)	New Firms (4)	New Domestic Firms (5)	(6)	Foreign Firms (7)
Input price							
P_1 = price of home office labor	1,883,341	1,676,208	***	2,022,576	1,780,751	***	2,161,666
P_2 = price of agent labor	518,097	284,341	***	723,597	627,472	***	800,687
P_3 = average monthly wages for insurance industry	51,806	43,513	***	57,381	59,495	***	56,165
P_4 = price of equity capital	0.17	0.17		0.17	0.17		0.17

Note: The table reports the output, output price and input, input price and number of firms in Taiwan's life insurance industry. Data source is *Annual Report of Life Insurance, Republic of China*, from 1981 to 2004. Output and input quantities are based on 1996 price level. The tests in column (3) are between old domestic firms (column 2) and new firms (column 4), and the tests in column (6) are between new domestic firms (column 5) and foreign firms (column 7).
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

Table 1 shows that all the outputs of old domestic firms are significantly larger than those of new firms, while the outputs Y_4 and Y_5 between new domestic firms and foreign firms are significantly different at 10 percent level.

For the output prices, we define the price of first four outputs (benefit payments for different lines) as premiums minus output for the line divided by output. The price of the fifth output is defined as rate of return on invested assets times total policy reserves divided by increase in policy reserve. As a result, the product of price and quantity of the first four outputs is equal to net revenues of each line of business for risk-pooling function. The product of price and quantity of the fifth output is equal to net revenues for intermediation function. The descriptive statistics of Table 1 show that the prices of first four outputs for new firms are significantly larger than that for old domestic firms. A possible reason is that the benefit payments of new firms are generally small or close to zero in the first few years when the firms are newly established.

Inputs

The inputs used in the calculation of the efficiency measures include: home office labor (X_1), agent labor (X_2), business service (X_3), and equity capital (X_4). Home office labor is measured by the number of full-time home office employees and their input price equal to home office expenses per person. Agent labor equals to the number of agents and its price equals the commission per person. The quantity of business service input

is defined as general insurance expenses divided by an expense deflator, which indexes average monthly wages for business service industry in Taiwan. The expense deflator is interpreted as the price of business service input.

Finally, capital is measured by the book value of equity capital. It should be noted that we have many new firms in our sample. New firms tend to have negative net income (net loss) in the first few years after they are established. If we follow previous literature such as Cummins, Weiss, and Zi (1999) and estimate cost of equity capital as the ratio of net income to the capital input, it would create a negative input price for those new firms. We decide to follow Cummins, Rubio-Misas, and Zi (2004) and measure the average rate of return on the Taiwanese stock exchange index as a proxy for the cost of equity capital.[7] The average rate of return of stock exchange index is used because few insurers are traded in the exchange. We calculate the average return for the 5-year period preceding each year of the sample period.

Table 1 shows that all the inputs of old domestic firms are significantly larger than those of new firms, and the inputs of new domestic firms are larger than those of foreign firms. On the other hand, the input prices ($P1$ to $P3$) of old firms are lower than those of new firms.

Our findings in Table 1 are consistent with the conventional belief that old firms have more resources and enjoy lower input prices because of their long-established business connection and sophisticated distribution system experiences. New firms (including both foreign and new domestic firms) have less inputs and higher prices than old firms since new firms do not have established channels and are also small in size. It should be noted that the results in Table 1 are the average values in the 24-year sample period starting from 1981. After new firms have been established in later years, it is questionable whether the comparative advantage of old firms could persist throughout time. Therefore, we examine how efficiency changes throughout the sample period.

RESULTS

Average Efficiencies

Our first null hypothesis states that all three groups of firms (ODs, NDs, and Fs) are operating on the same frontier against the alternative hypothesis that they operate on different frontiers. We test this hypothesis using pair-by-pair comparison and we also test it based on three different frontiers—technical, cost, and revenue frontiers. Specifically, we test whether the pooled and separate frontiers of ODs versus NDs, ODs versus Fs, and NDs versus Fs are identical, respectively, and report the results in Panels A, B, and C of Table 2. If we reject the null hypothesis, then it suggests that the efficiency comparisons of different groups (e.g., ODs and NDs) should be based on separate frontiers.

The comparisons between the frontiers of OD and ND firms can be examined in two ways. First, we compare efficiency scores of old domestic firms (OD) relative to their own frontiers with efficiency scores of ODs and NDs relative to their pooled frontier. The results are shown in the first row of each type of efficiency in Panel A. Second, we compare efficiency scores of new domestic firms (ND) relative to their own frontiers

[7] We thank one of the referees' suggestions on this issue.

TABLE 2
Tests of the Null Hypothesis That the Pooled and Separate Frontiers Are Identical

Panel A: Old Domestic (OD) Firms Versus New Domestic (ND) Firms

Population Comparison	ANOVA *F* (Prob > *F*)	Wilcoxon Z (Prob > Z)	Median Z (Prob > Z)	Van der Waerden Z (Prob > Z)	Savage Z (Prob > Z)
Technical efficiency					
OD frontier efficiencies	8.064	2.2891	1.707	2.547	1.7662
vs. pooled frontier efficiencies	0.0048	0.0221	0.0878	0.0109	0.0774
ND frontier efficiencies	0.7081	0.5234	0.3098	0.5503	0.0179
vs. pooled frontier efficiencies	0.401	0.6007	0.7567	0.5821	0.9857
Cost efficiency					
OD frontier efficiencies	10.1047	3.091	2.2908	3.2781	2.1414
vs. pooled frontier efficiencies	0.0016	0.002	0.022	0.001	0.0322
ND frontier efficiencies	0.3059	0.7597	0.6538	0.5774	0.5032
vs. pooled frontier efficiencies	0.5808	0.4474	0.5132	0.5637	0.6148
Revenue efficiency					
OD frontier efficiencies	11.1541	3.3052	2.5266	3.5514	2.3871
vs. pooled frontier efficiencies	0.0009	0.0009	0.0115	0.0004	0.017
ND frontier efficiencies	11.9038	3.419	3.4059	3.1962	2.4697
vs. pooled frontier efficiencies	0.0007	0.0006	0.0007	0.0014	0.0135

(*continued*)

with efficiency scores of ODs and NDs relative to their pooled frontier and the results are shown in the second row of each type of efficiency in Panel A. The Wilcoxon, median, Van der Waeden, and Savage nonparametric tests as well as ANOVA are conducted in our analysis.

Our results in Panel A overwhelmingly reject the null hypothesis that the OD technical frontier is the same as the pooled technical frontier for all three types of efficiency measures. However, the evidence does not reject the hypothesis that the ND efficiency scores relative to its own frontier are the same as ND scores relative to the pooled frontier in terms of technical and cost efficiency. For revenue efficiency, our results reject

TABLE 2
(Continued)

Panel B: Old Domestic (OD) Firms Versus Foreign (F) firms

Population Comparison	ANOVA *F* (Prob > *F*)	Wilcoxon Z (Prob > Z)	Median Z (Prob > Z)	Van der Waerden Z (Prob > Z)	Savage Z (Prob > Z)
Technical efficiency					
OD frontier efficiencies	20.6309	3.7928	3.284	3.9696	2.815
vs. pooled frontier efficiencies	0.0001	0.0001	0.001	0.0001	0.0049
F frontier efficiencies	2.21	1.0395	0.4551	1.086	0.2343
vs. pooled frontier efficiencies	0.1381	0.2986	0.649	0.2799	0.8148
Cost efficiency					
OD frontier efficiencies	15.7116	3.8578	2.8366	3.9501	2.6089
vs. pooled frontier efficiencies	0.0001	0.0001	0.0046	0.0001	0.0091
F frontier efficiencies	0.2609	0.7397	1.1928	0.6525	0.6273
vs. pooled frontier efficiencies	0.6099	0.4595	0.233	0.514	0.5305
Revenue efficiency					
OD frontier efficiencies	21.8374	4.6143	3.9829	4.6827	3.6714
vs. pooled frontier efficiencies	0.0001	0.0001	0.0001	0.0001	0.0002
F frontier efficiencies	0.494	0.9223	0.3842	0.9015	0.1441
vs. pooled frontier efficiencies	0.4827	0.3564	0.7008	0.3673	0.8855

(*continued*)

the hypothesis that the ND group-specific frontier is the same as the pooled frontier. In summary, the results of Panel A of Table 2 indicate that all three efficiency comparisons should be based on separate frontiers when we perform the analysis between ODs and NDs.

Panel B of Table 2 shows the results of the comparisons between the ODs and Fs. The results are very similar to those of Panel A except that for revenue efficiency, our results do not reject the hypothesis that the foreign group-specific frontier is the same as the pooled frontier. However, we still conclude that the OD frontier is different from the F frontier. In other words, all technical, cost, and revenue efficiency comparisons between ODs and Fs should be based on separate frontiers.

TABLE 2
(Continued)

Panel C: New Domestic (ND) Firms Versus Foreign (F) Firms

Population Comparison	ANOVA *F* (Prob > *F*)	Wilcoxon Z (Prob > Z)	Median Z (Prob > Z)	Van der Waerden Z (Prob > Z)	Savage Z (Prob > Z)
Technical efficiency					
ND frontier efficiencies	4.2202	2.0491	1.8001	1.9997	1.7331
vs. pooled frontier efficiencies	0.0414	0.0605	0.0718	0.0455	0.0831
F frontier efficiencies	1.0259	0.9875	0.9942	0.8931	1.0694
vs. pooled frontier efficiencies	0.3122	0.3234	0.3201	0.3718	0.2849
Cost efficiency					
ND frontier efficiencies	1.1765	1.1389	0.7448	1.1595	1.0845
vs. pooled frontier efficiencies	0.2795	0.2547	0.4564	0.2463	0.2782
F frontier efficiencies	1.2325	1.0024	1.2626	0.9342	1.0753
vs. pooled frontier efficiencies	0.2681	0.3162	0.2067	0.3502	0.2822
Revenue efficiency					
ND frontier efficiencies	2.4729	1.4774	1.2054	1.5317	1.3305
vs. pooled frontier efficiencies	0.1177	0.1396	0.2281	0.1256	0.1833
F frontier efficiencies	0.9021	0.8931	0.8922	0.8509	0.8061
vs. pooled frontier efficiencies	0.3433	0.3718	0.3723	0.3948	0.4202

Note: This table reports the test results of null hypothesis that the pooled and separate frontiers are identical. Panel A reports the results of old domestic firms versus new domestic firms, Panel B reports the results of old domestic firms versus foreign firms, and Panel C reports the results of new domestic firms versus foreign firms.

Finally, the results in Panel C, which compare efficiency scores between new domestic firms and foreign firms, do not draw a similar conclusion. For technical efficiency, the results marginally reject the null hypothesis that the new domestic technical frontier is the same as the pooled technical frontier (close to 10 percent). All other results in Panel C of Table 2 also lead to the conclusion that the pooled and separate frontiers of NDs and Fs are not different.

In summary, the results of Table 2 indicate that old firms in the Taiwanese insurance industry have different technical, cost, and revenue frontiers from new firms in the

TABLE 3
Efficiency Scores of Old Domestic Firms Based on Separate Frontiers

Year	Technical Efficiency $T_{od}(X_{od}, Y_{od})$	Cost Efficiency $C_{od}(X_{od}, Y_{od})$	Revenue Efficiency $R_{od}(X_{od}, Y_{od})$	Year	Technical Efficiency $T_{od}(X_{od}, Y_{od})$	Cost Efficiency $C_{od}(X_{od}, Y_{od})$	Revenue Efficiency $R_{od}(X_{od}, Y_{od})$
1981	0.986	0.821	0.684	1993	0.985	0.866	0.845
1982	0.960	0.816	0.625	1994	0.937	0.852	0.868
1983	0.996	0.852	0.560	1995	0.972	0.915	0.890
1984	1.000	0.881	0.575	1996	0.983	0.896	0.888
1985	0.980	0.750	0.517	1997	0.951	0.890	0.905
1986	0.942	0.847	0.650	1998	1.000	0.878	0.913
1987	1.000	0.837	0.695	1999	1.000	0.977	1.000
1988	1.000	0.883	0.786	2000	1.000	0.985	1.000
1989	1.000	0.923	0.840	2001	1.000	0.945	0.978
1990	0.984	0.965	0.861	2002	1.000	0.958	0.988
1991	1.000	0.939	0.921	2003	1.000	1.000	0.972
1992	1.000	0.907	0.888	2004	1.000	1.000	0.920

Note: X_{od} and Y_{od} refer to the input–output bundle for old domestic firms, respectively. Subscript on T (technical efficiency), on C (cost efficiency), and on R (revenue efficiency) indicate the frontier on which the firms are based. Subscript od = old domestic frontier.

industry. However, new domestic firms share the same frontiers with foreign firms in all three efficiency measures. Therefore, in the following analyses, we merge new domestic firms with foreign firms and treat these "new firms" (NFs) as a group. Both old firms and new firms produce their products facing their own technical, cost, and revenue frontiers.

Table 3 presents the technical, cost, and revenue efficiency scores of old firms in 1981–2004 on separate frontiers. Note that X_{od} and Y_{od} refer to the input–output bundle for old domestic firms, respectively. T (implying technical efficiency), C (implying cost efficiency), and R (implying revenue efficiency) indicate the frontier on which the firms are based. For example, $T_{od}(X_{od}, Y_{od})$ refers to the technical efficiency of ODs relative to its own group-specific frontier. We find that the technical efficiency scores of old firms relative to their own frontier are quite high and do not fluctuate a lot. The efficiency scores drop in years 1993 and 1994, but the scores in other period are quite close to 1. Apparently, the old firms were challenged by the entrants of new domestic firms around years 1993 and 1994. The cost efficiency results are similar to the technical efficiency results. The cost efficiency scores gradually increase to 0.923 in 1989, but drop somehow in year 1993–1994 and increase to a higher level afterwards. Finally, the revenue efficiency scores are low in the beginning of our sample period. The scores grow gradually since 1986, drop in year 1993–1994 but also increase thereafter.

We summarize our results in Table 3 as follows. For technical and cost efficiency results, we find that the efficiency scores are quite stable and show slight improvement during our sample period. For revenue efficiency results, the efficiency scores are originally low (close to 0.6) and gradually improve thereafter. All three efficiency performances of old domestic firms have been somehow challenged by the introduction of new domestic firms around year 1993 and 1994, but they coped with new challenges well and become as efficient as before 1993 quickly. In contrast to previous findings (see Chang, 1998, for

TABLE 4
Efficiency Scores Based on Separate Frontiers

Technical Efficiency			Cost Efficiency				Revenue Efficiency			
Year	$T_n (X_{nd}, Y_{nd})$	$T_n (X_f, Y_f)$	Year	$C_n (X_{nd}, Y_{nd})$		$C_n (X_f, Y_f)$	Year	$R_n (X_{nd}, Y_{nd})$		$R_n (X_f, Y_f)$
1990		0.407	1990			0.245	1990			0.287
1991		0.737	1991			0.419	1991			0.406
1992		0.776	1992			0.402	1992			0.432
1993	0.498	0.701	1993	0.046	**	0.470	1993	0.132	**	0.497
1994	0.764	0.843	1994	0.313	*	0.627	1994	0.338		0.628
1995	0.632	0.716	1995	0.323		0.577	1995	0.308	**	0.627
1996	0.897	0.871	1996	0.456	*	0.679	1996	0.420	**	0.682
1997	0.884	0.934	1997	0.425	***	0.765	1997	0.549	*	0.722
1998	0.898	0.969	1998	0.706	*	0.843	1998	0.785		0.718
1999	0.866	0.945	1999	0.828		0.847	1999	0.769		0.797
2000	1.000	0.931	2000	0.935		0.993	2000	0.922		0.806
2001	0.952	0.926	2001	0.887		0.831	2001	0.918	*	0.752
2002	0.964	0.912	2002	0.804		0.771	2002	0.849	***	0.637
2003	0.959	0.896	2003	0.809		0.725	2003	0.872	**	0.684
2004	0.983	0.912	2004	0.720		0.707	2004	0.821	**	0.605

Note: X_{nd}, Y_{nd} = input and output for new domestic firms, respectively, and X_f, Y_f = input and output for foreign firms, respectively. Subscript on T (technical efficiency), on C (cost efficiency), and on R (revenue efficiency) indicate the frontier on which the firms are based. Subscript n = new firms (including both new domestic and foreign firms) frontier. Because of the small sample size, nonparametric Wilcoxon signed rank test is used to test differences between the efficiency scores of new domestic firms and foreign firms.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

technical efficiency results), our results suggest that the D&L seem to have little adverse impact on the efficiency of existing domestic insurance firms. In the following section, we further use the Malmquist analysis to verify our results. We believe our results are more reliable than previous literature because we use more appropriate methodology, longer time period, and better output measures.[8]

Table 4 reports the technical and cost efficiency scores of new firms relative to their own frontier. The technical efficiency scores of new domestic firms and foreign firms are reported in the column heading $T_n (X_{nd}, Y_{nd})$ and $T_n (X_f, Y_f)$, respectively, where the subscript n stands for the abbreviation of new firms (combining both domestic and foreign new firms). The results in Table 4 show that foreign firms tend to perform better than new domestic firms in the beginning of the sample period (the comparison starts from 1993 as new domestic firms are allowed to enter market then). The reason is that foreign firms on average have entered the market longer than the new domestic firms.

[8] Following Cummins, Weiss, and Zi (1999) and Cummins, Rubio-Misas, and Zi (2004), we use amount of benefit payments as output measures instead of premiums in Chang (1998). Using premiums as a proxy for output has one major drawback. If a firm charge higher price, the DEA approach will classify that firm as more efficient, other things being equal.

However, new domestic firms tend to be more efficient than foreign firms specifically after 2001 for all three efficiency measures. The reason is that no new domestic firms enter the market after 1995, while a few foreign firms (e.g., Zurich Life in 1999) enter and exit the market during the later sample period.

Cross-Frontier Results

We examine whether the efficiency performances are different after the D&L between existing domestic firms and their new competitors (new domestic and foreign firms) and present the cross-frontier efficiencies in Table 5. We treat old domestic firms and all the new firms as two different groups, and calculate the efficiency scores of one group relative to the frontier of the other in terms of technical, cost, and revenue efficiency. The cross-frontier analysis can provide evidence on our second null hypothesis whether each group of firms is dominant in producing its own output vectors. Panel A of Table 5 reports the technical efficiency results, Panel B reports the cost efficiency results, and Panel C reports the revenue efficiency results. In each panel we exhibit the cross-frontier results (e.g., $T_n(X_{od}, Y_{od})$) in columns (2) and (4) and compare them with each group's efficiency scores relative to their own frontier (e.g., $T_{od}(X_{od}, Y_{od})$) in columns (1) and (3).[9]

The results in Panel A show that OD relative-to-new firm-frontier scores ($T_n(X_{od}, Y_{od})$, column 2) are greater than one in each of the sample periods from 1990 to 2004. The results imply that it is not feasible to replicate old firms' input–output combinations using the new firms' technology. In addition, when we compare the OD efficiency scores relative to new firms frontier, $T_n(X_{od}, Y_{od})$, with the OD scores relative to their own frontier, $T_{od}(X_{od}, Y_{od})$, we find that $T_n(X_{od}, Y_{od})$ is larger than $T_{od}(X_{od}, Y_{od})$ in every year with an overwhelming rejection at the 1 percent level.[10] This implies that the OD frontier tends to lie to the left of the new firm frontier for ODs' input–output vectors. The OD technology, thus, tends to dominate the new firms' technology for producing ODs' output combinations.

However, we also find an interesting trend that the dominance of old domestic firms is decreasing in our sample period. The score of $T_n(X_{od}, Y_{od})$ starts from 26.6 in year 1990 and keeps decreasing throughout the years and stays around 2 or 3 at the end of our sample period, 2004. The result is that $T_n(X_{od}, Y_{od})$ consistently exceeds one, implying that OD frontier dominates new firm frontier in producing OD output combinations, even though the dominance of old domestic firms decreases throughout time as new competition intensifies.

The cross-frontier results of new firms relative to old firms' frontier are slightly different from the above. The new firms' scores relative to the OD frontier, $T_{od}(X_n, Y_n)$ (column 4), are found to be smaller than $T_n(X_n, Y_n)$ (column 3), the new firms' scores relative to their own frontier in 1990, 1991, and 1992. This implies that the OD frontier dominates new firm frontier in producing new firm's outputs in terms technical efficiency. However, the scores of $T_{od}(X_n, Y_n)$ increase rapidly and become significantly greater than one

[9] We already reported the efficiency scores relative to the group's own frontier for old domestic firms in Table 3. To make it easy for comparison, we repeat them in Table 5.

[10] Because of the small sample size, we apply the nonparametric Wilcoxon signed-rank test to examine the difference between columns (1) and (2).

TABLE 5
Cross-Frontier Results Between Old Domestic (OD) Firms Versus New Domestic (ND) and Foreign (F) Firms

Panel A: Technical Efficiency

Year	$T_{od}(X_{od}, Y_{od})$ (1)		$T_n(X_{od}, Y_{od})$ (2)	$T_n(X_n, Y_n)$ (3)		$T_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.984	***	26.603	0.407		0.045	25.831	***	−0.817	
1991	1.000	***	21.884	0.737	*	0.212	20.884	***	−0.698	
1992	1.000	***	12.982	0.776		0.452	11.982	***	−0.463	**
1993	0.985	***	9.528	0.625		0.722	8.633	***	−0.050	
1994	0.937	***	7.254	0.817		0.912	6.774	***	−0.006	
1995	0.972	***	7.392	0.684		2.100	6.619	***	3.492	*
1996	0.983	***	7.455	0.881		1.765	6.562	***	0.863	*
1997	0.951	***	6.196	0.915		2.011	5.312	***	1.141	**
1998	1.000	***	4.476	0.943	**	2.413	3.476	***	1.479	***
1999	1.000	***	3.102	0.913	**	5.493	2.102	**	4.647	***
2000	1.000	***	2.333	0.963	***	7.566	1.333	**	6.636	***
2001	1.000	***	2.742	0.940	***	4.497	1.742	*	3.617	***
2002	1.000	***	2.835	0.940	***	2.939	1.835	*	2.123	***
2003	1.000	***	2.308	0.927	***	3.689	1.308	*	2.869	***
2004	1.000	***	3.250	0.950	***	2.985	2.250	*	2.171	***

Panel B: Cost Efficiency

Year	$C_{od}(X_{od}, Y_{od})$ (1)		$C_n(X_{od}, Y_{od})$ (2)	$C_n(X_n, Y_n)$ (3)		$C_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.965	***	14.524	0.245		0.270	14.122	***	−0.376	
1991	0.939	***	8.206	0.419		0.305	7.790	***	−0.413	
1992	0.907	***	28.921	0.402		0.269	30.633	***	−0.496	***
1993	0.866	***	7.755	0.311		0.208	7.785	***	−0.442	***
1994	0.852	***	7.993	0.522		0.377	8.168	***	−0.329	***
1995	0.915	***	5.280	0.480		0.543	4.829	***	0.003	
1996	0.896	***	15.809	0.594		0.879	15.941	***	0.243	***
1997	0.890	***	13.570	0.636		0.918	13.432	***	0.256	
1998	0.878	***	11.317	0.793		0.886	11.191	***	0.094	
1999	0.977	***	2.316	0.839		1.601	1.362	**	0.806	
2000	0.985	***	1.668	0.966		1.295	0.694	**	0.325	
2001	0.945	***	2.000	0.861		1.121	1.112	*	0.271	
2002	0.958	**	1.974	0.789		1.140	1.033	*	0.363	**
2003	1.000	***	1.778	0.767	*	1.361	0.778	*	0.654	***
2004	1.000	***	1.885	0.714	***	1.616	0.885	*	1.093	***

(*continued*)

TABLE 5
(Continued)

Panel C: Revenue Efficiency

Year	$R_{od}(X_{od}, Y_{od})$ (1)		$R_n(X_{od}, Y_{od})$ (2)	$R_n(X_n, Y_n)$ (3)		$R_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.861	***	9.288	0.287		0.039	9.214	***	−0.158	
1991	0.921	***	7.217	1.406		0.034	6.735	***	−0.223	
1992	0.888	***	5.027	0.432	**	0.108	4.676	***	−0.823	**
1993	0.845	***	4.277	0.360	**	0.202	4.104	***	−0.557	***
1994	0.868	***	3.468	0.531	***	0.195	3.019	***	−0.712	***
1995	0.890	***	3.281	0.505		0.394	2.681	***	−0.483	***
1996	0.888	***	3.064	0.582	**	0.334	2.403	***	−0.492	***
1997	0.905	***	2.593	0.656	*	0.562	1.807	***	−0.289	**
1998	0.913	***	2.459	0.743	*	0.633	1.667	***	−0.229	
1999	1.000	***	1.938	0.786		1.013	0.938	**	0.245	
2000	1.000	***	1.825	0.860		1.885	0.825	**	1.014	
2001	0.978	***	1.868	0.842	*	1.401	0.909	*	0.677	*
2002	0.988	***	1.519	0.750	**	1.010	0.536	*	0.438	***
2003	0.972		1.217	0.778	***	1.362	0.240		0.806	***
2004	0.896		1.047	0.720	***	1.438	0.142		1.175	***

Note: X_{od}, Y_{od} = input and output for old domestic firms, respectively, and X_n, Y_n = input and output for new firms (including both new domestic and foreign firms), respectively. Subscript on T (technical efficiency), on C (cost efficiency), and on R (revenue efficiency) indicate the frontier on which the firms are based. Subscript od = old domestic firms frontier and n = new firms frontier. Because of the small sample size, nonparametric Wilcoxon signed-rank test is used to test the differences between columns (1) and (2) and between columns (3) and (4).
$F_n(X_{od}, Y_{od}) = T_n(X_{od}, Y_{od})/T_{od}(X_{od}, Y_{od}) - 1$, and $F_{od}(X_n, Y_n) = T_{od}(X_n, Y_n)/T_n(X_n, Y_n) - 1$. Column (6) tests whether column (5) is significantly different from zero, and column (8) tests whether column (7) is significantly different from zero. Nonparametric Wilcoxon signed-rank test is used in both columns (6) and (8) because of the small sample size.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

since 1995. It thus implies that the new firms' technology tends to dominate old firms technology after 1994 for producing new firms' outputs.

Following previous literature (Cummins, Rubio-Misas, and Zi, 2004), we also report the results of the cross-frontier efficiency F-scores to further measure the dominance of one group relative to another group's frontier. For example, when we measure the dominance of old domestic firms relative to the new firms, we define the cross-frontier efficiency score F as $F_n(X_{od}, Y_{od}) = (T_n(X_{od}, Y_{od})/T_{od}(X_{od}, Y_{od})) - 1$ for each sample firm. A value of $F_n(X_{od}, Y_{od}) > 0$ implies that the OD's technology is dominant for the OD's input–output vectors (X_{od}, Y_{od}), and $F_{od}(X_n, Y_n)$ is defined *vice versa*.

The F-score is intended to evaluate the frontier difference between ODs' efficiency relative to their own frontier and ODs' efficiency relative to other groups' frontier. The

cross-frontier efficiency score for new firms can also be applied using the same rationale. We report the results of F_n (X_{od}, Y_{od}) and F_{od} (X_n, Y_n) in columns (5) and (7) and also test whether these *F*-scores for each year are significantly different from zero in columns (6) and (8). Consistent with our results in column (2) of Panel A, the scores of F_n (X_{od}, Y_{od}) are overwhelmingly greater than zero and the results are significantly at least at 10 percent level. Besides, we also find that the scores of F_{od} (X_n, Y_n) are lower than zero in the sample year of 1990–1994, but the results are significantly greater than zero since 1995.

Panel B and Panel C of Table 5 reports the cost and revenue efficiency results, respectively. We discuss the results of these two panels together as following. For the comparison between columns (1) and (2) in Panels B and C, we draw a similar conclusion as the results in Panel A. We find that OD efficiency scores relative to new firms frontier (column 2) in Panels B and C are all greater than one and are also significantly larger than OD scores relative to their own frontier (column 1). The OD cross-frontier scores also decrease gradually throughout the years, but they are still greater than one in the whole sample period. The results in column 5, F_n (X_{od}, Y_{od}), in Panels B and C are also consistent with the results in columns (1) and (2).

For the comparison between columns (3) and (4) in Panels B and C, the results are similar to those of Panel A. The new firms' efficiency scores relative to old firms' frontier (column 4) in Panel B are low in the beginning of our sample year (0.27) and increase gradually. The scores become greater than one in 1999 and stay greater than one since then. The results of column 7, F_{od} (X_n, Y_n) in Panel B generally support our comparisons between columns (3) and (4).

Finally, the scores of column (4) in Panel C are also low in the beginning of our sample (0.039) and increase subsequently to 0.633 in 1998. The scores become greater than one in 1999 and are greater than one since then. However, if we further examine the firm-to-firm efficiency scores for revenue efficiency, we find that the higher-than-one average scores, since 1999, are primarily due to the score of the firm Prudential Life, which merges Chinfon Life Insurance Company (one of the old domestic firms) in 1998. If we ignore this firm when calculating the average revenue efficiency scores, the scores after 1998 are still less than one.

We summarize our results as following. First, our results show that old firms have developed a dominant frontier for producing their outputs in terms of technical, cost, and revenue efficiency. The dominance of old firms has decreased gradually throughout our sample period, but the dominance still persists up to the end of our sample period, 2004. In addition, we find that it is more efficient for new firms to produce their outputs by using the ODs' frontier than new firms' own frontier in the beginning of the sample period. New firms start to become more efficient for producing their own outputs in terms of technical efficiency since 1995. For cost efficiency performances, new firms' frontier does not consistently dominate old domestic firms' frontier for producing their own outputs until 2002. Finally, for revenue efficiency performances, new firms' frontier does not significantly dominate old domestic firms' frontier for producing their own outputs until 2001. If we exclude one of the foreign firms (Prudential Life, United Kingdom) which merges with an old domestic firm in 1998, new firms never dominate old firms for producing their own outputs.

Our cross-frontier results provide some interesting implications. Generally, firms which are interested in a lucrative insurance market such as Taiwan have two alternatives to enter the market: merging an existing firm or establishing a new one. Our results indicate merging with an existing firm is a better alternative. Apparently, the comparative advantages possessed by old firms such as sophisticated distribution systems or established business are huge. The second alternative is to establish a new firm. The evidence shows that it is not very hard for new firms to acquire new technology and thus become efficient to produce their own outputs. But for cost and revenue efficiency, which relates to profits of the firm—the key element stockholders and policyholders pay attention to—it is much more difficult for new firms to compete. Specifically, our results show that it takes 12 years (1990–2002) for new firms to become more efficient than old domestic firms to produce new firms' outputs in cost frontiers. It is no wonder that the insurance industry has been long called a "localized" industry with high entry barriers. Our results thus suggest that new entrants should take advantage of the existing technologies and distribution system by merging with an old firm rather than establishing a new one by themselves.

Productivity Changes

The results of the Malmquist productivity analysis are shown in Table 6. Because the Malmquist analysis requires that firms be present in each year of the sample period, we focus on the productivity changes of old domestic firms as nearly all of them are existent throughout our sample period. The top section of each panel presents a year-to-year Malmquist index and its components, and the cumulative changes from year-to-year are in the lower section. The cumulative change for a given year is the product of the year-to-year indexes from the beginning of the period to the end of that year. For example, the cumulative index for 1983 (1.132) is the product of the 1981–1982 (0.867) and 1982–1983 (1.305) indexes.

The two components decomposed from the Malmquist index are technical efficiency change and technical change. Favorable efficiency change is interpreted as evidence of "catching-up" to the frontier, while favorable technical change is interpreted as innovation (Färe et al., 1994). On the other hand, it is possible to observe firms "falling behind," i.e., becoming less efficient, as well as technical regress, interpreted as unfavorable shifts in the production frontier.

As mentioned before, we characterized Taiwanese insurance market into three periods: the pre-D&L period (before 1987), the foreign-entry period (1988–1993), and the post-D&L period (1994–2004). Our focus is to examine the cumulative Malmquist index (the lower section of Table 6) in these three stages. Our results are summarized as follows. First, we find that for technical efficiency change, the efficiency of old domestic firms improves throughout time, and the cumulative results increase from 1.132 to 5.493, an increase of nearly four times in 24 years. Consistent with the results we observe in Table 3, the results of technical efficiency show a dip in year 1990 and 1994. We believe it is mostly due to the challenges of new entrants, as number of foreign firms increases rapidly since 1989 and new domestic firms are allowed to enter the market since 1993. However, old domestic firms catch up quickly and their efficiency keeps increasing till our last sample year 2004.

TABLE 6
Malmquist Index Summary of Annual Means

Year	Technical Efficiency Change	Technology Change	Total Productivity Change
1982	0.867	1.228	1.058
1983	1.305	1.045	1.362
1984	1.051	1.152	1.206
1985	0.957	1.239	1.158
1986	0.978	1.004	0.980
1987	2.009	1.094	2.163
1988	0.980	0.930	0.903
1989	1.116	1.114	1.252
1990	0.810	1.283	1.018
1991	1.039	1.141	1.197
1992	1.011	0.945	0.956
1993	1.013	0.978	0.967
1994	0.858	1.161	0.978
1995	1.188	0.968	1.140
1996	1.372	1.009	1.461
1997	1.001	1.020	1.021
1998	1.252	1.040	1.252
1999	0.922	1.029	0.966
2000	0.971	1.093	1.060
2001	0.996	1.074	1.070
2002	1.038	1.392	1.383
2003	1.224	0.895	1.077
2004	1.314	1.339	1.792
		Cumulative Results	
1983	1.132	1.283	1.441
1984	1.189	1.478	1.738
1985	1.137	1.832	2.012
1986	1.112	1.838	1.972
1987	2.234	2.011	4.265
1988	2.189	1.871	3.850
1989	2.442	2.084	4.821
1990	1.977	2.673	4.909
1991	2.055	3.050	5.878

(*continued*)

TABLE 6
(Continued)

Year	Technical Efficiency Change	Technology Change	Total Productivity Change
1992	2.078	2.882	5.617
1993	2.106	2.819	5.433
1994	1.807	3.272	5.313
1995	2.148	3.167	6.059
1996	2.946	3.195	8.853
1997	2.950	3.258	9.037
1998	3.693	3.386	11.315
1999	3.403	3.486	10.934
2000	3.305	3.811	11.595
2001	3.292	4.091	12.404
2002	3.418	5.694	17.155
2003	4.182	5.097	18.474
2004	5.493	6.822	33.109

Note: The table presents the results of Malmquist productivity analysis. The top section presents year to year Malmquist index and its components, and the cumulative changes from year to year are in the lower section. The cumulative change for a given year is the product of the year-to-year indexes from the beginning of the period to the end of that year; e.g., for 1983, the cumulative index is the product of the 1982–1983 and 1983–1984 indexes.

In addition, we also find that technology frontier enjoys innovations over the sample period, and the cumulative technical change scores increase from 1.283 to 6.822. The total productivity change combines the effect of technical change and technical efficiency change and causes the productivity to improve in the long run.

In summary, the results in Table 6 are consistent with our findings in previous sections. Although the existing domestic firms have been challenged by new competitors—especially, in the foreign-entry and post-D&L period, the deregulation seems to have little adverse impact on their performances. In addition, our results in Table 6 are also consistent with the cross-frontier results in Table 5. Although the dominance of old firms has decreased gradually, the existing firms still enjoy their comparative advantages in the industry throughout the whole sample period.

CONCLUSIONS

This article uses the DEA and the cross-frontier analysis to examine the impact of D&L on Taiwanese life insurers by comparing their efficiency before and after the D&L. Our results are summarized as follows. First, both the DEA and Malmquist results show that the old domestic firms have been slightly impacted by the new competitors around 1992–1994 (the end of foreign and new local entry period and the beginning of post-D&L period). However, the existing firms cope with new challenges well. Specifically, the Malmquist cumulative results show the increasing trend from 1983 to 2004 with a

couple dips in 1993 and 1994. It seems that the D&L is good for the consumer in general. These results are different from Chang (1998) which documented that the X-efficiency of domestic firms dropped after the D&L.

Second, we find that old domestic firms and their new competitors have two distinct frontiers in terms of technical, cost, and revenue efficiency. It is, thus, important to treat new firms (new domestic and foreign firms) as one group and the old domestic firms as another group when examining their efficiency differences. Third, old domestic firms' frontier dominants new firms' frontier for producing their outputs in terms of technology, cost, and revenue efficiency. Such dominance further confirms that the old domestic firms are mature enough to face the D&L in the local market.

Finally, new firms' frontier does not dominate old firms' frontier for producing their outputs in terms of technology, cost, and revenue efficiency after significant time elapse. Our results further show that it is relatively easy for new firms to acquire new technology and thus new firms' frontier dominants old firms' frontier for producing new firms' outputs in terms of technical efficiency. But this is not true for cost and revenue efficiency. Our results suggest that any new entrants into the market should acquire an old firm rather than establish a new one because it takes longer for new firms to establish the distribution system and business connections in the new market.

We believe our results shed lights on the strategic move of international insurers to enter the local market. The merger of Prudential Life with the domestic firm Chinfon in 1998 is a good example. Recently, Temasek Holdings from Singapore and ING Group are both interested in acquiring a stake in Kuo-Hwa Life Insurance Company, one of the eight old existing firms, which was established in 1974. Their action is consistent with our recommendation.

APPENDIX

In the previous sections, we adopt the value-added approach to measure the inputs/outputs used and apply four inputs and five outputs in the analysis. However, the numbers of inputs and outputs are very important in DEA analysis in order to obtain reasonable estimates.[11] In DEA literature, a rough rule of thumb is often used, i.e., no. of observations $\geq \max\{M \times N, 3(M + N)\}$, where M = number of inputs and N = number of outputs (see Cooper, Seiford, and Tone, 2000). Although the rule is rough, it is desirable to reduce numbers of inputs and outputs when the sample size is small.

We aggregate the inputs and outputs to two inputs and two outputs because the sample size is small for Taiwanese life insurance industry in earlier years. We believe adopting the two-input/two-output (2–2) model is appropriate for the following reasons. On the one hand, it considers the most important inputs/outputs (see Cummins and Weiss, 2000). On the other hand, it complies with the rule of thumb in the DEA literature in most of our analysis. For example, the number of observations in 1990 is 13, which is higher than the right-hand side of the inequality above (12) in the 2–2 model.

We aggregate the first four outputs used in previous sections—benefit payments in different lines into one output, benefit payments and keep increase in life policy reserve

[11] We thank one of the anonymous referees' suggestions on this issue.

TABLE A1
Cross-Frontier Results Between Old Domestic (OD) Firms Versus New Domestic (ND) and Foreign (F) Firms

Panel A: Technical Efficiency

Year	$T_{od}(X_{od}, Y_{od})$ (1)		$T_n(X_{od}, Y_{od})$ (2)	$T_n(X_n, Y_n)$ (3)		$T_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.778	***	14.374	0.563		0.099	16.315	***	–0.861	*
1991	0.805	***	10.715	0.547	**	0.104	12.125	***	–0.813	**
1992	0.782	***	5.717	0.774	***	0.148	6.122	***	–0.814	***
1993	0.751	***	4.398	0.551	***	0.157	4.650	***	–0.639	***
1994	0.840	***	3.451	0.699	***	0.221	3.086	***	–0.664	***
1995	0.790	***	2.639	0.488	**	0.252	2.354	***	–0.483	***
1996	0.696	***	2.441	0.511	***	0.262	2.401	***	–0.418	***
1997	0.636	***	1.616	0.553	***	0.320	1.491	***	–0.292	***
1998	0.704	***	2.150	0.697	***	0.359	1.983	***	–0.466	***
1999	0.711	*	1.071	0.619		0.550	0.475	**	–0.128	
2000	0.882	**	1.362	0.700		0.668	0.531	**	0.016	**
2001	0.750	**	1.346	0.680		0.514	0.740	*	–0.118	
2002	0.637		0.942	0.453	*	0.429	0.473	*	0.945	
2003	0.684		1.120	0.506		0.610	0.647	***	0.026	**
2004	0.828		0.920	0.502		0.660	0.204		0.293	

Panel B: Cost Efficiency

Year	$C_{od}(X_{od}, Y_{od})$ (1)		$C_n(X_{od}, Y_{od})$ (2)	$C_n(X_n, Y_n)$ (3)		$C_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.628	***	3.226	0.450		0.095	4.102	***	–0.746	*
1991	0.629	***	2.861	0.408	**	0.100	3.554	***	–0.747	***
1992	0.535	***	2.474	0.475	***	0.111	3.588	***	–0.776	***
1993	0.599	***	2.278	0.354	***	0.107	2.755	***	–0.677	***
1994	0.716	***	2.566	0.470	***	0.161	2.544	***	–0.653	***
1995	0.755	**	1.340	0.336	**	0.211	0.774	***	–0.390	***
1996	0.661	**	1.607	0.330	***	0.187	1.348	***	–0.410	***
1997	0.612	**	1.412	0.383	***	0.234	1.240	***	–0.372	***
1998	0.685	**	1.388	0.447	***	0.277	0.937	***	–0.378	***
1999	0.700		0.878	0.480		0.410	0.256	**	–0.167	***
2000	0.872	**	1.219	0.613		0.490	0.392	**	–0.206	***
2001	0.735	*	1.099	0.577		0.480	0.471	*	–0.170	**
2002	0.622		0.906	0.445		0.402	0.452	*	–0.147	
2003	0.667		0.770	0.435		0.570	0.290	***	0.094	***
2004	0.790		0.864	0.451		0.630	0.029		0.336	

(continued)

TABLE A1
(Continued)

Panel C: Revenue Efficiency

Year	$R_{od}(X_{od}, Y_{od})$ (1)		$R_n(X_{od}, Y_{od})$ (2)	$R_n(X_n, Y_n)$ (3)		$R_{od}(X_n, Y_n)$ (4)	Cross-to-Own $F_n(X_{od}, Y_{od})$ (5)	(6)	Cross-to-Own $F_{od}(X_n, Y_n)$ (7)	(8)
1990	0.668	***	10.795	0.367		0.068	14.344	***	–0.875	
1991	0.716	***	8.334	0.381	**	0.067	10.824	***	–0.846	*
1992	0.721	***	5.094	0.611	**	0.089	6.182	***	–0.840	**
1993	0.687	***	3.687	0.447	***	0.077	4.459	***	–0.800	***
1994	0.771	***	2.946	0.632	***	0.154	2.894	***	–0.749	***
1995	0.664	***	2.092	0.406	***	0.164	2.241	***	–0.599	***
1996	0.636	***	1.875	0.468	***	0.184	2.016	***	–0.581	***
1997	0.595	**	1.441	0.366	*	0.198	1.353	***	–0.077	**
1998	0.653	***	1.868	0.656	***	0.263	1.998	***	–0.568	***
1999	0.680		0.991	0.514		0.406	0.432	**	–0.170	***
2000	0.836	**	1.209	0.639		0.499	0.466	**	–0.208	**
2001	0.719	*	1.079	0.608	**	0.354	0.495	*	–0.346	***
2002	0.556		0.722	0.332		0.308	0.183	*	0.448	
2003	0.552		0.730	0.400	*	0.330	0.158		–0.336	***
2004	0.585		0.630	0.416		0.409	–0.332	***	0.239	***

Note: X_{od}, Y_{od} = input and output for old domestic firms, respectively, and X_n, Y_n = input and output for new firms (including both new domestic and foreign firms), respectively. Subscript on T (technical efficiency), on C (cost efficiency), and on R (revenue efficiency) indicate the frontier on which the firms are based. Subscript od = old domestic firms frontier and n = new firms frontier. Because of the small sample size, nonparametric Wilcoxon signed-rank test is used to test the differences between columns (1) and (2) and between columns (3) and (4).
$F_n(X_{od}, Y_{od}) = T_n(X_{od}, Y_{od})/T_{od}(X_{od}, Y_{od}) - 1$, and $F_{od}(X_n, Y_n) = T_{od}(X_n, Y_n)/T_n(X_n, Y_n) - 1$. Column (6) tests whether column (5) is significantly different from zero, and column (8) tests whether column (7) is significantly different from zero. Nonparametric Wilcoxon signed-rank test is used in both columns (6) and (8) because of the small sample size.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

as the second output. The price of the first output is defined as total premiums minus total outputs divided by total outputs. For the inputs used, we aggregate the first two inputs in previous sections, number of home office labor and number of agent labor into one input, number of labor. We keep unit of business service as another input.

We discuss our analysis as following. The results of 2–2 analyses are generally consistent with the results of four-input/five-output model reported in the text of the current version. Specifically, the counterpart results of Tables 2, 3, and 4 based on 2–2 analyses are very similar to the reported results of Tables 2, 3, 4, and 6 in the text.[12] The cross-frontier results (Table A1) based on the 2–2 analysis are slightly different from the results in Table 5.

[12] The results of other tables are available from the authors.

We summarize our results in Table A1 as follows. Our results show that the dominance of old domestic firms relative to new firms persists throughout our sample period in terms of technical, cost, and revenue efficiency. Specifically, the scores of F_n (X_{od}, Y_{od}) are positive and significant for all efficiency until at least 2002 in terms of technical, cost, and revenue efficiency, respectively. However, the scores of F_{od} (X_n, Y_n) are negative and mostly significant in terms of technical, cost, and revenue efficiency, respectively. Although such results are slightly different from the results in previous sections, we believe they provide even stronger evidence for our conclusions in previous sections.

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