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The effects of competition, crisis, and regulation on efficiency in insurance markets: evidence from the Thai non-life insurance industry

Abstract

This paper utilizes Data Envelopment Analysis to analyze the non-life insurance market of Thailand. In addition to being the first paper to analyze the Thai non-life market, Thailand provides a unique marketplace to study for U.S. regulators. The Thai non-life market is one that is heavily regulated, has shown significant growth (by foreign and domestic firms) and has faced a significant economy-wide financial crisis. The combination of these events and market characteristics make the Thai non-life market an interesting study. The authors apply frontier efficiency methods to the accounting data of non-life insurance firms reported to the Department of Insurance between 1997 and 2002. In addition to finding a market comparable with other larger markets, we find a market that has been largely unaffected by the Asian Financial Crisis, and one experiencing significant efficiency improvements.

Keywords: efficiency, regulation, competition.

Introduction

This paper utilizes Data Envelopment Analysis (DEA) to analyze the non-life insurance market of Thailand. In addition to being the first paper to analyze the Thai non-life market, Thailand provides a unique market place to study. The Thai non-life market is one that is heavily regulated, has shown significant growth (by foreign and domestic firms) and has faced a significant economy-wide financial crisis. The combination of these events and market characteristics make the Thai non-life market an interesting study. We apply frontier efficiency methods to the accounting data of non-life insurance firms reported to the Department of Insurance between 1997 and 2002. In addition to finding a market comparable with other larger markets, we find a market that has been largely unaffected by the Asian Financial Crisis, and one that has experienced significant efficiency improvements.

We also introduce the notion of "hierarchical efficiency" to the insurance literature. Until now, efficiency studies have ignored any differences that insurers may face, and compare all insurers to each other. Using the Thai market, we show that significant differences in insurer efficiency scores can result if we control for varying economic climates. This could ultimately be very important when considering other markets. For example, in the U.S. insurance markets, regulation varies at the state and line of business level. The results we will report may suggest that when studying insurer efficiency, it may be important to consider the various markets in which insurers operate in order to facilitate a fair and meaningful comparison.

To date the efficiency of insurance firms in Thailand has only been studied in the context of traditional measures (loss ratios, expense ratios, etc.). We study the Thai market using a frontier efficiency technique, DEA. Along the way, we are able to draw some conclusions as to the effects of various financial market events (significant interest rate reductions, regulation, and general financial crisis) on the efficiency of insurance markets.

This paper is further organized into seven remaining sections. Section 1 gives a brief overview of the Thai non-life industry. Sections 2 and 3 respectively discuss the competitive balance and regulation within the Thai non-life industry. Sections 4 and 5 respectively describe the methodology used to calculate the efficiency scores and the data used. Section 6 provides the results and the final section concludes.

1. The Thai non-life industry

The Thai non-life insurance industry underwent several changes in the latter part of the 1990s and early 2000s. The number of non-life insurance companies in Thailand increased from 67 companies in 1994 to 76 companies in 2004. The total direct premiums in the Thai non-life insurance industry increased from 44,424 million baht ($1,076.36 million) in 1994 to 70,970 million baht ($1,719.55 million) in 2003. In 2003, there were only eight companies that had direct premiums written larger than 2,000 million baht ($48.46 million). Eleven companies had direct premiums written between 1,000 ($24.23 million) and 2,000 million baht ($48.46 million); thirty three companies had direct premiums written between 200 ($4.85 million) and 1,000 million baht ($24.23 million). The remaining firms had direct premiums written lower than 200 million baht ($24.23 million). Over the following decade, the premium rate of Thai non-life insurance products increased by an average of 5.3% each year. In 2002, the Thai non-life insurance industry was

ranked as the 40th non-life insurance market out of 91 countries, and the total direct premiums of the Thai non-life insurance industry accounted for 0.13 percent of the world non-life insurance market.

In 1994, the ratio of the total non-life insurance premium to the Gross Domestic Product (GDP) of Thailand was 1.2 percent, compared to an average of 3.4 percent worldwide. This ratio did not vary much over decade (in 2003, the ratio was 1.1 percent). Per person, Thai non-life insurance premiums were approximately $24 in 2003, compared to a worldwide average of $176.

The Thai non-life insurance industry grew very rapidly during 1994 and 1995, as did the overall Thai economy during this period. Direct premiums grew at approximately 15 to 20 percent per annum. Direct premiums written from automobile insurance were a substantial part of this increase and accounted for more than half of the total direct premiums written for the entire Thai non-life insurance market. Two factors attributing to this increase in automobile premiums were the enforcement of the Protection for Motor Vehicle Accident Victims Act and the increased sales of automobiles in Thailand.

In 1996, growth in the Thai non-life insurance industry began to slow, immediately preceding the Asian financial crisis in 1997. Further, the market experienced a large drop in direct premiums during 1997 and 1999. However, the industry recovered and experienced growth in direct premiums written from 48,701 million baht ($1,180 million) in 2000 to 70,970 million baht ($1,719.55 million) in 2003 (approximately 13.4% per annum). This increase was partially due to a substantial increase in the demand for miscellaneous insurance after the 9/11 terrorist attacks. Both the number of issued policies and premium rates of industrial all-risk insurance products increased post-9/11. Total direct premium of miscellaneous insurance products increased from 17.7 percent of the total market in 2000 to 26.8 percent in 2003; and miscellaneous insurance products became the second largest line of insurance in terms of direct premium, second to automobile insurance.

A traditional approach to measuring the efficiency of the non-life industry would show high loss and expense to premium ratios indicating lower efficiency. For the ten years between 1994 and 2003, the average loss ratio for the non-life insurance industry was 54.2 percent. The average loss ratio increased every year between 1994 and 1998. Subsequently, the average loss ratios declined from their 1998 high (65.5 percent) to 43.8 percent in 2003. The average expense ratio shows a different pattern. Over the same time period, the average expense ratio was 34 percent. It increased from 29.6 percent in 1995 to 38.3 percent in 1999. Since the economic crisis in 1997, the expense to premium ratio has remained above the average ratio of 34 percent every year, with the exception of 2002 (33 percent). In 2003, the expense to premium ratio was still relatively high at 35.3. The relatively flat pattern of the expense ratio, coupled with the significant decrease in the loss ratio would traditionally indicate that the efficiency of the Thai non-life insurance industry has improved over the past decade. Frontier methodologies, including Malmquist indices, will allow us to comment on this apparent result.

2. Competitive balance

The Thai non-life market can be characterized as a competitive one. Out of approximately 80 firms, the five biggest non-life insurance companies – Viriya Insurance, Dhipaya Insurance, Bangkok Insurance, Sampanth Insurance, and Deves Insurance – together had market share of only 36.9% in 2003. The remainder of the industry averaged less than 5% market share and 47 companies had less than 1% market share. Thus, the Thai non-life insurance industry is mostly comprised of the medium and small companies. In contrast to the Thai non-life insurance industry, the five biggest Thai life insurance companies account for approximately 90% of the total market share. The net premiums written, the Herfindahl indices (for total premiums and each line), as well as the five-firm concentration ratios for the Thai non-life market provides evidence that the insurers are operating within a relatively competitive environment. The Herfindahl indices and five-firm concentration ratios are given in Table 1. For total premiums and all individual lines, the Herfindahl indices are well below 0.1, indicating a competitive environment. The five-firm concentration ratios are not as strong as the Herfindahl indices, yet still indicate a relatively competitive marketplace.

3. Regulation

Even though there are indications that there is a relatively significant degree of competition in the Thai non-life insurance industry, the industry is strictly regulated by the government. The regulations restrict the reserve amounts, capital funds, investment policies, insurance limits, agent commission rates, the issuance of new products, and premium rates. As a result, firms are relatively limited in their ability to compete by changing their product terms or prices. Historically, the regulation has been enforced and many non-life insurance companies have been penalized and fined for conducting business outside of the rules set by the Commissioner. Therefore, rather than competing with different products and prices, the Thai non-life insurance firms have to emphasize production and operating efficiency.

The measurement of Thai non-life insurance firm performance has been done using only conventional financial ratios such as the return on equity, return on assets, and expense to premium ratios. Frontier methodologies provide a different approach and view of the efficiency and productivity of the Thai market. Frontier methodologies provide efficiency measures by comparing firms to the efficient frontier formed by the dominant firms in the industry. Thus, it provides more meaningful and reliable measures of firm performance. Cummins and Weiss argue that "[f]rontier efficiency measures dominate under traditional techniques in terms of developing meaningful and reliable measures of firm performance" by "summarize[ing] firm performance in a single statistic that controls for differences among firms in a sophisticated multidimensional framework…" (Cummins and Weiss, 2000, p. 768). In this paper, we apply this frontier technique to measure the efficiency of non-life insurance firms in Thailand.

4. Efficiency methodology

4.1. Technical, allocative, and cost efficiency. For each year in the sample we estimate a "best practice" production and cost frontier. The computed frontiers are made up of the firms in the Thai property/liability insurance industry found to be the most technical and cost efficient. These best practice firms are assigned an efficiency score of one. All other firms in the industry are then compared to the best practice firms and are given a score between zero and one, based on their distance measured from the frontier.

In estimating the frontiers, there are two competing methodologies. The statistics-based econometric approach takes an assumed production function and measures efficiency based on both random and firm specific (in)efficiency components. This method requires assumptions to be made on the specification of the production function, the distribution of the random error component, as well as the distribution of the firm-specific inefficiency component. Unless these specifications are precisely known, the model will be mis-specified.

The alternative method for estimating firm efficiency involves mathematical programming. One such mathematical programming approach is Data Envelopment Analysis (DEA). DEA constructs a convex hull from linear combinations of the best practice firms. The remaining firms are then given efficiency scores based on their distance from the efficient frontier. DEA methodology is non-parametric and does not require any assumptions regarding the production function or error term distribution. A potential drawback of using the DEA methodology is that DEA treats all inefficiency as firm specific inefficiency. That is, unlike stochastic frontiers, DEA does not allow for any random inefficiency component.

Despite the potential drawbacks of DEA, Banker (1993) and Korostelev, Simar, and Tsybakov (1992, 1995) have shown that DEA have the properties of a maximum likelihood estimator for firm efficiency. Further, Kneip et al. (1998), Grosskopf (1996) and Korostelev, Simar, and Tsybakov (1992, 1995) have shown the DEA estimator to be consistent and converge faster than other estimators (again, the stochastic frontiers are hampered by the uncertainty over the production and error distribution functions).

We estimate input oriented technical and cost efficiency scores for firms in the Thai property/liability insurance industry. Farrell (1957) defines technical inefficiency as deviation from the production possibilities frontier. Imagine a firm using two inputs, x_1 and x_2, to produce one output, y. The most efficient production technology is given by SS' in Figure 1 (see Appendix).

Firms (such as Q and R) on SS' are considered fully technically efficient. Firms (such as P) are inefficient in the sense that they could proportionally reduce their inputs and maintain the same level of outputs. The degree to which firm P is inefficient is the distance from P to the efficient frontier, SS'. This distance is considered to be the technical efficiency of firm P.

Further, AA' is the isocost line between inputs x_1 and x_2. Firm Q, while technically efficient, could become allocatively efficient by moving to point R. Firm R is both technically and allocatively efficient, and is said to be cost efficient. The total economic (cost) inefficiency for firm P is then given by the distance to the point T. Lastly, the degree to which P can allocate resources more efficiently can be derived as the portion of its cost efficiency not explained by its technical efficiency. Using DEA, we calculate the technical efficiency measure by constructing SS' from the best practice firms in the industry. The firms that do not make up the frontier are then given an efficiency score based upon their distance from the frontier.

4.2. Malmquist analysis. We further calculate the efficiency changes over time for the Thai non-life market. Malmquist indices are used to calculate the efficiency changes over our sample period for the Thai market. Malmquist indices allow us to determine individual efficiency improvements (declines), as well as shifts in the frontier itself. Further, using both of these measures, we can calculate total factor productivity changes. Like our previous measures of technical efficiency, Malmquist analysis also utiliz-

es distance functions. Figure 2 (see Appendix) illustrates the components used to calculate the Malmquist indices. V^t (V^{t+1}) represents the efficient frontier (assuming constant returns to scale) for the industry in period t (t + 1). Likewise, $\left(X_i^t, Y_i^t\right)$ and $\left(X_i^{t+1}, Y_i^{t+1}\right)$ represent firm i's input/output mix for years t and t + 1. In addition to using the standard technical efficiency measures discussed above, Malmquist indices are constructed by calculating the "cross-efficiency" scores of one time period, using either the technology from the time period before or after. For example, we measure the efficiency of firm i in period t, relative to both period t and period t + 1's technology. Since we measure the efficiency for a firm relative to the current year's technology as well as to the adjacent year's technology, the Malmquist index measures the total factor productivity from year t to t + 1. An index value greater (less) than one indicates total factor productivity progress (regress) from year t to t + 1. We can further decompose the total factor productivity change into efficiency change and technical change.

4.3. Hierarchical efficiency. In evaluating the efficiency of different insurers, the general underlying assumption is that the inputs and outputs of each firm and the environment in which they are utilized or produced is comparable. In other words, the inputs, outputs, and economic environment are homogenous across decision-making units (DMUs). The analysis becomes less meaningful if some insurers are in a different market environment than others. DEA with categorical DMUs is a common method used to handle situations where the operating environment of a set of DMUs differs from another set. DEA models incorporating non-controllable categorical variables were first proposed by Bankers and Morey (1986). Originally, each DMU was evaluated relative to comparable DMUs. This approach was later improved by Nakamura (1988), Rousseau and Semple (1993), and Charnes et al. (1994). Cooper, Seiford, and Tone (2000) summarize and discuss the hierarchical approach that we utilize. The hierarchical approach separates the DMUs into categories based on the need for a handicap.

Consider the example of public libraries examined in Cooper, Seiford, and Tone (2000). In Tokyo, there are libraries in the central business district, in the shopping districts surrounding the business district, and in the outlying residential areas. Since there are fewer potential library customers (residents as argued by Cooper, Seiford, and Tone (2000)) in the shopping district (relative to the residential areas) and even fewer potential customers in the business district, it would be unfair to compare the efficiency of the libraries in the business district with those in the shopping areas or residential areas. It would also be unfair to compare the libraries in the shopping areas with those in the residential areas. As such, the hierarchical method ranks the DMUs with respect to the handicap needed. Efficiency scores for those DMUs needed the largest handicap are first calculated using only the firms in need of the largest handicap as the reference set. Efficiency scores for the DMUs requiring the second largest handicap are calculated using the firms in need of the largest handicap and the second largest handicap as the reference set[1]. This procedure is applied until the group of firms requiring no handicap have their efficiency scores calculated using all of the firms as potential references.

5. Data

Measuring the output of an insurance firm, or any financial services firm, is not always easy. Berger and Humphrey (1992) suggest a method by which to measure the outputs of financial institutions that they call a "modified value-added" approach. This approach considers as outputs those functions of firms that have significant operating cost allocations. Prior literature in the US insurance industry (Berger, Cummins, and Weiss, 1997; Cummins, Eckles, and Zi, 2004; Cummins and Weiss, 1993; Cummins, Weiss and Zi, 1999; Xie, 2002) defines insurer service output as (1) risk pooling/risk bearing, (2) "real" financial services related to insured losses, and (3) intermediation.

The risk pooling/risk bearing service provided by insurers allows consumers (individuals and businesses) to minimize their idiosyncratic risk by pooling their risk with other insureds. Insurance firms incur significant expenses in this underwriting process. The capital held by insurers provides value by acting as a pool bearing the residual risk.

In addition to the risk bearing service provided, insurers often also provide "real" financial services to consumers. These "real" services are usually in the form of risk management consulting, financial planning consulting, and loss control consulting. In the case of liability coverage, insurers are also a significant provider of legal services to the insured.

Finally, insurers are much like banks in the intermediation service they provide. Instead of taking deposits, insurers take in up-front premiums that they hold and invest until a claim is made.

[1] Since the less disadvantaged firm (in theory) should be more efficient than the more disadvantaged firm, allowing the more disadvantaged firms to be part of the reference set for the less disadvantaged firm does not create any problems when calculating the score of the less disadvantaged firm. If the more disadvantaged firm is more efficient than the less disadvantaged firm, the less disadvantaged firm will be "punished" by a lower efficiency score.

In keeping consistent with the US property/liability literature, we define 5 outputs designed to proxy for the aforementioned services provided by insurers. As a proxy for the risk bearing and real services outputs, we consider the incurred losses and loss adjustment expenses for four lines of insurance (fire, marine, auto, and miscellaneous)[1]. Since incurred losses are paid as a result of providing insurance, it is a good proxy for the risk bearing service. Loss adjustment expenses are considered a reasonable proxy for the "real" services provided by insurers. We also consider a firm's invested assets as a proxy for the intermediation service provided by the insurers.

Insurers have three main inputs used in the production of their outputs. Labor, business services, and capital are all used extensively by insurers. We further distinguish between administrative labor and agent labor. We define the administrative labor input as the salary/welfare reported to the Insurance Commissioner at the Department of Insurance, Ministry of Commerce, Thailand. Agent labor input is similarly defined by the amount of commissions reported to the Commissioner. Business expenses are then defined to be the remaining expenses reported on the income statement. The capital input is given as the capital levels reported to the Commissioner. All inputs and outputs are further deflated using 1998 as the base year.

It is worth mentioning that the labor and business services inputs are not the ideal variables to use for the input calculation. The variables used here are actually the total cost of the input and not the *level* of input. Ideally, we would like to know the *price* of the input so that we could infer the level of input (total input divided by price). However, data limitations prevent us from making this calculation. Ultimately, we use the total cost of the inputs in our efficiency calculations. This is equivalent to using a unit price of 1 baht for the inputs. However, it should be noted that this limitation does not prevent us from calculating the efficiency scores. Several efficiency papers (i.e., Cummins, Eckles, Zi, 2004) make the assumption that the prices for each input are the same for each firm within a year. It seems reasonable, especially for Thailand, that every insurance firm would face the same price for labor or business services[2]. As such, the total costs of each input are essentially being scaled down by the price of the input. Since DEA is units invariant, a simple scaling of the variable (or lack thereof) will have no effect on our results.

The data used comes from statutory reporting forms reported to the Insurance Commissioner at the Department of Insurance, which is part of the Thailand Ministry of Commerce. To our knowledge, the specific data we are using has not been used in any published academic studies. However, the Thai Insurance Commissioner uses the reported data for performing audits and providing regulatory oversight of the insurance firms. The data is subject to standard accounting practices similar to those found in American (NAIC) and European financial statements.

6. Results

We estimate the cost, technical, allocative, scale, and pure technical efficiency scores for the Thai non-life insurance industry for years 1997 through 2002 (a complete list of scores is available upon request). We also calculate the total factor productivity, technical efficiency change, and technical change scores for the years 1997 through 2001. Because we do not have the data for year 2003, we are unable to calculate the components of efficiency change for year 2002. Table 2 (see Appendix) shows the summary statistics for our firms over the entire time period[3]. Efficiency scores in the Thai non-life market are very similar to those reported in the American property-casualty market.

6.1. Market events. Table 3 shows the average efficiency scores for each time period. The financial crisis in Asia began in the latter part of 1997. With the exception of the latter years in our sample, the total factor productivity index and the technical change index were on average greater than one from 1997 to 2001. This suggests that the average Thai insurer showed efficiency improvements from year to year, although the improvement was not significant every year. These efficiency improvements comport with the relatively few hardships felt by the Thai non-life market from the financial crisis. No significant insolvencies occurred (only one firm out of 80 non-life insurers became insolvent), and in fact, insurers saw their efficiency generally improve during the crisis.[4] The decline in average efficiency scores between 1998 and 1999 occur at the same time when the Thai non-life insurance industry experienced the lowest total direct premiums (45,869 million baht) and the highest expense to premium ratio (38.3). Moreover, the interest rate cut in 1999 resulted in a dramatic drop in the average investment income of the non-life insurance industry; from 5,153.8 million baht in 1998 to 2,814.8 million

[1] Each line of business is treated as a separate output.
[2] All but one of our sample firms are headquartered in Bangkok, making this assumption even less worrisome.
[3] There is one firm with capital equal to zero for a few of the years in our sample. This firm also has zero total inputs and outputs, and therefore an efficiency score of zero. We have decided to leave them in for completeness, but their inclusion does not affect the scores of the other firms.
[4] By comparison, 60% of the commercial banks (9 out of 15), became insolvent as a result of the financial crisis.

baht in 1999, a 45.4% decline in one year. Not surprisingly, there was no statistically significant efficiency progress made from 1998 to 1999, although significant progress was made from 1999 to 2000.

6.2. Company results. We first note that the most efficient firms are not always the biggest. Among the top ten largest firms in terms of written premium, only Bangkok Insurance consistently ranked as one of the most efficient firms. Conversely, Sri Muang Insurance, ranks around the 40th largest in terms of written premium, but is one of the most efficient firms in the sample. Likewise, International Assurance ranks around the 50th largest in terms of premium written, yet it has an efficiency score of one throughout the entire sample period.

We can also determine which firms are operating at constant, decreasing, or increasing returns to scale. Over the entire sample period, 41.7% of the firms are operating with constant returns to scale, 25.1% are operating with decreasing returns to scale, and the remaining 33.3% are operating with increasing returns to scale. Figure 3 (see Appendix) shows the returns to scale results by size.

As expected, as firms get larger (as measured by total assets), more and more of them operate with decreasing returns to scale. Conversely, those firms operating with increasing returns to scale tend to be the smaller ones.

6.3. Competitive differences and regulation. During the ten years under consideration, automobile insurance accounted for the largest proportion of total non-life insurance premiums in Thailand, more than half of the entire non-life market. As a result, Thai insurance firms have largely depended on automobile insurance market expansion to increase their total market share. Although there officially existed strict regulation over automobile insurance pricing preventing firms from gaining market share through drastic price reductions, many firms had effectively lowered their premiums below the minimum premium rate allowed by the Department of Insurance[1]. Recently, the Department of Insurance took action against those firms violating the price regulation, discouraging firms from reducing rates below the regulated price floor. Increased foreign investment has also become an important factor within the Thai non-life insurance market. Before the Asian economic crisis in 1997, both the life and non-life insurance markets in Thailand were essentially closed, with only limited investment by foreign insurers. As a result of the crisis, insurance firms sought additional capital from foreign insurers whom were eventually allowed to invest in Thai insurance firms or open foreign branches in Thailand.

Compulsory insurance regulation requires every car owner to have a minimum level of liability insurance protection. This regulation coupled with an increasing number of new and used cars sold across the country (409,000 cars were sold in 2002, compared to 146,000 in 1998) contributed to increased demand for automobile insurance (Thai auto-insurers sold 11.7 million compulsory policies in 2002, compared to 8.6 million policies in 1998). Non-life insurance firms seeking growth opportunities have put tremendous effort in expanding their automobile insurance market share. Most have done so by improving their service quality, hoping to compete for the segment of customers who view reputation and service as a more important factor than price. Of course, many customers still choose low cost insurance carriers. Non-life insurance firms in Thailand target these segments of customers differently. The largest firms in Thailand, firms with better reputations, target high-end customers, those who are willing to pay more for better services and coverage. This high-end segment of customers includes those who have new or expensive cars, and those who seek voluntary, comprehensive coverage. The top five Thai automobile insurers are indeed the largest and the most reputable firms. These firms further increase their quality by contracting with more reliable garages for vehicle repair. The mid-size firms tend to target some high-end customers and some low-end customers while most of the small firms, those firms with less than one percent market share, tend to target the low-end customers. One reason for this market segmentation is the high cost of market penetration through service quality improvement. This high cost includes the set-up cost for new branches, increased cost for additional agents, and increased costs for expanding the list of repair-garages under the firm's coverage. Small firms appear to have less bargaining power to negotiate with both agents and garages. For these reasons, firms operating in one segment do not view firms operating in other segments as their true competitor. In other words, changes in strategy by firms in one segment will have little impact on firms in other segments, and will have a much larger impact on firms in the same segment.

As an example of the different competitive environments, in 2005, the Department of Insurance announced an amendment to the regulated automobile premium tariff. The amendment allowed for a wider range of rating factors to be used, as well as a wider range of minimum and maximum rates. Only one of the top five automobile insurers lowered its premium for comprehensive automobile insurance

[1] Although the official premium charged is not below the rate imposed by the Department of Insurance, insurers use other incentives such a commission rebates and gift certificates to department stores in order to reduce the effective rate paid by consumers.

(the reduced premium was still not lower than the minimum regulated premium). The remaining four top five insurers subsequently experienced a large drop in automobile insurance premiums written. Of these remaining four firms, one has since announced a premium reduction of one hundred million baht each quarter. Firms operating in the low-end customer segment have less room to compete along the price dimension because the premiums charged are already low and close to the regulated minimum premium rate. As such, firms with higher proportions of written premium in automobile insurance are in a more price competitive environment. Treating all non-life insurance firms the same in efficiency score evaluation would be unfair to those firms in this competitive environment and would be too generous to firms in a less competitive environment.

One way to allow for a handicap, proposed by Cooper, Seiford, and Tone (2000), is to apply hierarchical categories to the firms in our sample. That is, firms can be separated into categories according to their market environment. Firms in the first category are firms in the most severe competitive environment. Firms in the subsequent category levels are firms in an increasingly less competitive environment. The evaluation of efficiency scores will be done at the top level of the hierarchy only within the first category. Then, firms in the next level of the hierarchy are evaluated with reference to its own category and all category sets above them. By taking into account such non-controllable factors, each firm is being evaluated for its efficiency score based on its actual performance.

6.3.1. Hierarchical data. Each year, firms are separated into three hierarchical categories based on their automobile insurance premiums. Firms in the top level of the hierarchy, category 1, are those with more than 1,000 million baht[1] ($24.23 million) in automobile insurance premium, and thus are firms in the most severe competitive environment. Recall that these large firms are high cost/high service providers catering to the voluntary market. Firms in the next level, category 2, are those with automobile insurance premium between 500 ($12.11 million) to 1,000 million baht ($24.23 million), and are firms in a moderately competitive environment. These are the firms writing a mix of voluntary and compulsory business. Finally, firms in the lowest level, category 3, are firms with less than 500 million baht ($12.11 million) in automobile insurance premium, and thus are firms in the least competitive environment. These are firms mainly writing compulsory business and are considered low cost/low service providers. Ultimately, three different efficiency frontiers are created based on data for firms in category 1, on firms in category 1 and category 2, and on all firms in the Thai non-life insurance industry. Firms in category 1 and 2 for each year are shown in Tables 3 and 4. In 2002, for example, twenty out of seventy-six non-life insurance firms have direct premiums from automobile insurance of more than 500 million baht ($12.11 million) while only eight out of seventy-six non-life insurance firms have direct premiums from automobile insurance of more than 1,000 million baht ($24.23 million). Thus, there are eight firms in category 1, twelve firms in category 2, and fifty-six firms in category 3. Table 4 provides summary statistics of the inputs and outputs by category over the sample period.

6.3.2. Hierarchical results. Firms in category 1 will have efficiency scores calculated based only on firms in category 1. Firms in category 2 will then be evaluated with reference to firms in both category 1 and category 2. Finally, firms in category 3 are evaluated based on all firms in the non-life insurance industry.

Table 5 shows technical efficiency scores of firms in category 1 by year. Again, technical efficiency scores in this table are evaluated based on only firms in category 1. Technical efficiency scores of firms in category 2 shown in Table 5 are evaluated based on firms in both category 1 and category 2. Finally, technical efficiency scores of firms in category 3 are evaluated based on all firms in the industry.

When firms are evaluated using hierarchical categories, firms in category 1 and category 2 improve their scores when compared to the entire sample. For example, the technical efficiency score of Safety Insurance in 1997 is 1 using the hierarchical method as opposed to 0.7647 using the traditional method. Similarly, the technical efficiency score of Liberty Insurance in 1997 is 1 by the hierarchical method as opposed to 0.9872 by the traditional method. In fact, the average technical efficiency score of firms within category one increased from 0.9226 to 0.9971 after applying the hierarchical screen. That is, when compared only to the other firms operating within the highly competitive automobile line, the efficiencies rose significantly[2]. When considering only category one firms, there is little discernable difference between them, and with the exception of 2001 and 2002, the frontier is made up of these six firms. This result is not particularly surprising when dealing with small groups of firms. This result also high-

[1] The cutoffs for market segmentation of 1,000 and 500 million baht are used as a result of interviews of several committees of the General Insurance Association of Thailand and several other employees of non-life insurance firms.

[2] A two-sided t-test for differences in means yields a t-statistic of 3.5221 and a p-value of .0010.

lights the potential problem with comparing these category one firms with the other firms. The results are even starker when considering category 2 (and category 1) firms. When compared to only other category one and two firms, the mean efficiency score again increased significantly from 0.8736 to 0.9538[1].

These improvements in technical efficiency scores reflect the fact that hierarchical approach may provide more appropriate results for firms in the highly competitive environment. At the very least, the use of the hierarchical ranking shows a potential bias when estimating efficiency scores for firms whose members are not all operating within a homogenous economic environment. Failing to recognize the differences across different lines of non-life insurance lines in Thailand would cause firms operating in the highly competitive line of automobile insurance to have scores reported that would not accurately reflect their "true" efficiency (that is, when measured against their true peer set). We recognize that using smaller reference sets for calculating efficiency scores can, by itself, create higher efficiency scores. Although the actual value of the score is of some importance, the ranking of the firms is more so. The purpose of hierarchical efficiency is to compare firms in similar environments to each other. The results reported here suggest that when compared to different reference sets, insurers in Thailand received different rankings of efficiency scores. This result is important in that some firms are ranked lower when compared to firms facing different business environments.

Conclusion

This paper accomplishes several objectives. In addition to providing an introduction of modern frontier efficiency methodology into the Thai non-life insurance industry, we also show how heterogeneity within a particular insurance market can substantially impact the efficiency scores of firms operating within the market. We also provide some evidence that the effect of the Asian financial crisis on Thai insurers was not particularly severe.

In general we show that Thai firms are not unlike most firms, in terms of scale economies. For instance, the larger the firm, the more likely they are to be operating with decreasing returns to scale. Conversely, the smaller firms are more likely to be operating with increasing or constant returns to scale.

Lastly, we calculate hierarchical results of technical efficiency scores to allow for non-controllable factors, in this case, market environment. In this paper, firms are separated into three categories based on their competitive condition. The results reflect more accurate scores for firms operating within the different competitive environments of automobile insurance. These results are important to consider as firms all over the globe enter into markets whose competitiveness (or other economic factors) differs from other markets in which they operate. Failing to consider the differences in economic conditions could possibly bias the results of firms operating in multiple markets, as well as firms whose domestic market is characterized by differing characteristics (regulations, competition, etc.).

This is particularly true for U.S. insurers. Differences in regulation across different states, different lines, etc. can affect the performance of insurers. When comparing insurers (in particular, when estimating efficiency scores), researchers must be careful to account for these factors. We have shown that outcomes of comparisons can significantly vary if these differences are not considered.

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[1] A two-sided t-test for differences in means yields a *t*-statistic of 6.0647 and a *p*-value of less than .0001.

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Appendix

Table 1. Herfindahl indices and concentration ratios

	All lines		Fire		Cargo		Automobile		Miscellaneous	
	Herfindahl	5-firm	Herfindahl	5-firm	Herfindahl	5-firm	Herfindahl	5-firm	Herfindahl	5-firm
1997	0.036	0.477	0.048	0.492	0.040	0.502	0.062	0.562	0.087	0.578
1998	0.031	0.435	0.050	0.482	0.046	0.509	0.057	0.520	0.087	0.557
1999	0.033	0.412	0.049	0.480	0.046	0.525	0.056	0.479	0.036	0.465
2000	0.030	0.397	0.044	0.463	0.044	0.509	0.052	0.453	0.033	0.436
2001	0.028	0.398	0.040	0.455	0.043	0.514	0.048	0.449	0.036	0.456
2002	0.026	0.380	0.036	0.467	0.046	0.531	0.047	0.434	0.025	0.396

Table 2. Descriptive statistics

	Mean	Median	Std. dev.	Min	Max
Outputs (baht)					
Fire	12914.980	4288.726	28863.210	0	263051.200
Marine	4466.320	831.019	10789.250	0	88389.640
Automobile	266199.700	68082.460	662991.200	0	6757039.000
Miscellaneous	22826.880	4644.416	50862.350	0	488736.200
Invested assets	724828.600	329675.700	1127223.000	0	7282349.000
Inputs (baht)					
Salary/welfare	70984.570	38794.730	307054.900	0	6545315.000
Agent commissions	52350.950	10003.160	133884.800	0	1126180.000
Business expenses	79966.020	41738.070	121615.300	0	957092.000
Capital	470934.900	186141.100	850040.300	0	5964515.000
Efficiency scores					
Technical efficiency	0.76805	0.79432	0.23519	0	1
Pure technical efficiency	0.83458	0.93871	0.20220	0	1
Cost efficiency	0.53921	0.48128	0.23698	0.02803	1

Table 2 (cont.). Descriptive statistics

	Mean	Median	Std. dev.	Min	Max
Allocative efficiency	0.70195	0.69596	0.19658	0.03593	1
Scale efficiency	0.91851	0.99584	0.15432	0.02803	1
Technical change	1.16108	0.99620	1.65383	0	30.17196
Technical efficiency change	1.11349	1.00000	0.70442	0	12.31430
Total factor productivity change	1.14215	0.98282	0.96446	0	14.16943

Table 3. Average efficiency scores

	Technical efficiency	Pure technical efficiency	Scale efficiency	Cost efficiency	Allocative efficiency	Total factor productivity change	Technical efficiency change	Technical change
1997	0.70014	0.82005	0.85350	0.52418	0.76590	1.36514***	1.40403***	1.12459**
1998	0.79092	0.85753	0.91755	0.52727	0.66881	1.07731	0.94417	1.44432
1999	0.72039	0.82783	0.86031	0.42774	0.59409	1.24334***	1.27181***	1.08856
2000	0.82212	0.86525	0.95035	0.57364	0.69282	1.09583	0.99162	1.14274
2001	0.81151	0.85145	0.95318	0.61103	0.75108	0.92521**	0.95217**	1.00060
2002	0.76581	0.78510	0.97977	0.57502	0.74165			

Notes: *** Significantly different from 1 at the 1% level (one-tailed test). ** Significantly different from 1 at the 5% level (one-tailed test).

Table 4. Descriptive statistics by category

Panel A: Category 1 firms (N = 43)	Mean	Median	Std. dev.	Min	Max
Outputs (baht)					
Fire	40887.9	10192.0	79765.6	0.0	272258.0
Marine	11800.9	2178.0	23097.6	0.0	92102.0
Automobile	1674249.0	1104449.0	1441369.0	300463.0	6250261.0
Miscellaneous	32966.1	14723.0	38796.2	1026.0	141796.0
Invested assets	2433560.0	2091161.0	2202971.0	82476.0	7144195.0
Inputs (baht)					
Salary/welfare	184402.7	148182.0	141640.4	40415.0	596947.0
Agent commissions	343407.2	264266.0	306389.6	0.0	1173479.0
Business expenses	326777.8	245131.0	232644.9	71130.0	957092.0
Capital	1305772.0	807706.0	1667767.0	30542.0	5993904.0
Panel B: Category 2 firms (N = 53)	Mean	Median	Std. dev.	Min	Max
Outputs (baht)					
Fire	17279.2	12421.0	17585.7	0.0	70877.0
Marine	5528.8	1871.0	10573.3	0.0	56640.0
Automobile	430775.6	410391.0	143074.8	98717.0	832328.0
Miscellaneous	28792.8	8587.0	39144.2	0.0	185416.0
Invested assets	835768.9	683133.0	621219.2	123493.0	2839337.0
Inputs (baht)					
Salary/welfare	98302.0	88716.0	38363.7	42336.0	190822.0
Agent commissions	70129.6	74591.0	46206.8	0.0	221518.0
Business expenses	148151.6	133260.0	83907.5	15647.0	435304.0
Capital	409629.0	316527.0	382124.4	28760.0	1688020.0
Panel C: Category 3 firms (N = 374)	Mean	Median	Std. dev.	Min	Max
Outputs (baht)					
Fire	9140.9	3141.0	13932.1	0.0	101184.0
Marine	3506.4	532.0	8078.0	0.0	65120.0
Automobile	80124.0	33343.5	178715.7	0.0	2360329.0
Miscellaneous	20911.5	3142.5	53010.0	0.0	452081.0
Invested assets	517094.1	291176.0	791682.8	0.0	5401752.0
Inputs (baht)					
Salary/welfare	9140.9	3141.0	13932.1	0.0	101184.0
Agent commissions	3506.4	532.0	8078.0	0.0	65120.0
Business expenses	80124.0	33343.5	178715.7	0.0	2360329.0
Capital	20911.5	3142.5	53010.0	0.0	452081.0

Table 5. Technical efficiency results by category

Panel A: Category 1 firms (N = 43)	Mean	Median	Std. dev.	Min	Max
1997	1	1	0	1	1
1998	1	1	0	1	1
1999	1	1	0	1	1
2000	1	1	0	1	1
2001	0.9888	1	0.0297	0.9215	1
2002	0.9932	1	0.0179	0.9526	1
Panel B: Category 2 firms (N = 53)	Mean	Median	Std. dev.	Min	Max
1997	0.9721	1	0.0776	0.7658	1
1998	0.9666	1	0.0745	0.8000	1
1999	0.9602	1	0.0975	0.7612	1
2000	0.9551	1	0.1187	0.6860	1
2001	0.9166	1	0.1166	0.7173	1
2002	0.9160	1	0.1290	0.6295	1
Panel C:Category 3 firms (N = 374)	Mean	Median	Std. dev.	Min	Max
1997	0.6448	0.7564	0.3797	0	1
1998	0.7233	0.7688	0.3295	0	1
1999	0.6830	0.7597	0.3143	0	1
2000	0.7492	0.8202	0.3009	0	1
2001	0.7486	0.8156	0.2887	0	1
2002	0.7585	0.8275	0.2862	0	1

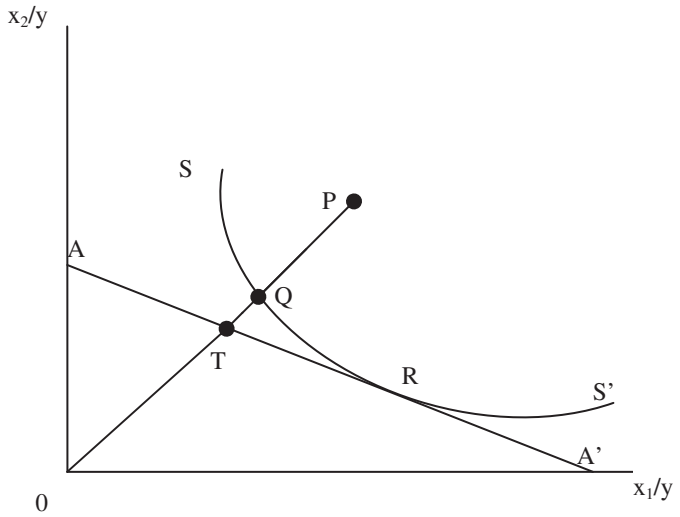


Fig. 1. Efficient production technology

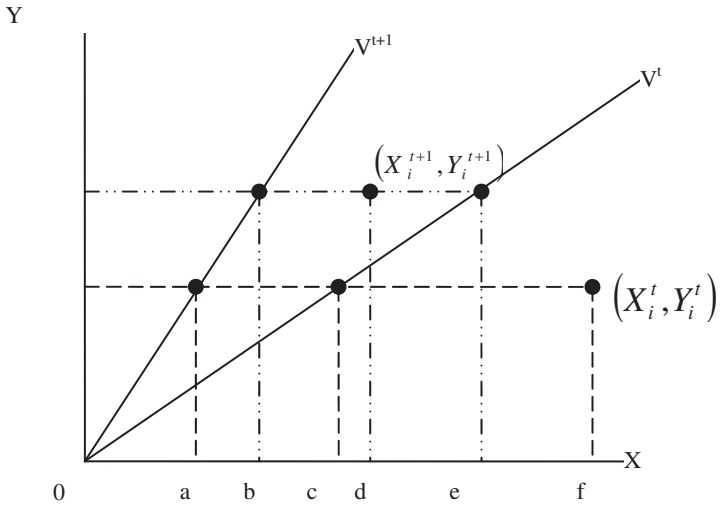
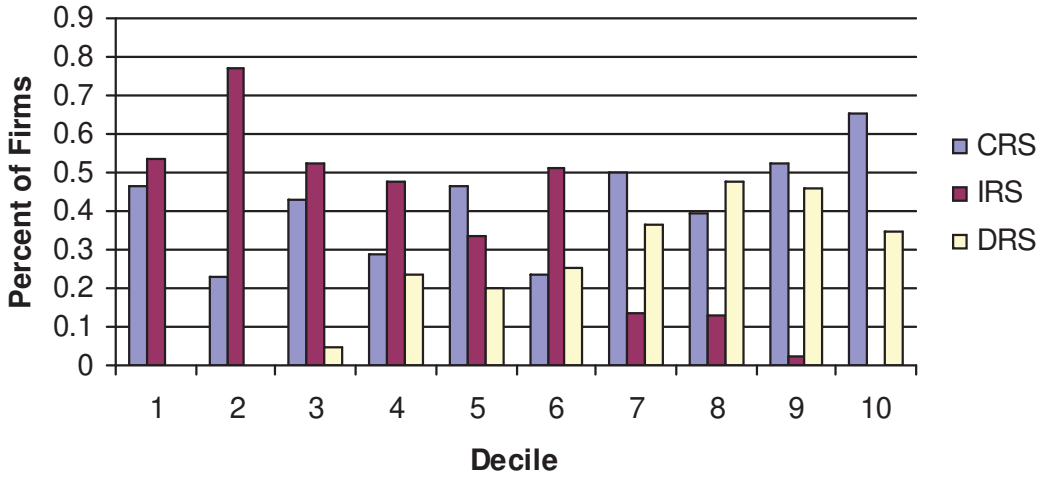


Fig. 2. Components of Malmquist indices



Notes: CRS = Constant returns to scale, IRS = Increasing returns to scale, DRS = Decreasing returns to scale.

Fig. 3. Returns to scale by decile