Economies of Scope in Financial Services: Evidence from the Property-Liability Insurance Industry

Abstract

We use the data envelopment analysis to examine the efficiency performance and economies of scope in the U.S. property and liability insurance industry. We examine whether nonspecialized strategy dominates specialized strategy for property-liability insurers. The results suggest that nonspecialists (specialists) dominate specialists (nonspecialists) in producing nonspecialists (specialists) input–output vectors and that personal line specialists (nonpersonal line specialists) dominate nonpersonal line specialists (personal line specialists) in producing personal line specialists (nonpersonal line specialists) input–output vectors. The dominance statistics regression evidence indicates that the nonspecialized hypothesis more often applies to insurers that (1) have higher capital to asset ratio, (2) are small, and (3) are mutuals, and vice versa for the specialized hypothesis. The results provide evidence for the coexistence of economies of scope and diseconomies of scope in the U.S. Property-Liability insurance industry. Our findings thus make additional meaningful interpretations of nonspecialized strategy than provided by prior studies.

Keywords: Data Envelopment Analysis; Efficiency Performance; Specialization, Scope Economies.

1. Introduction

Many corporations have been experiencing a wave of massive diversification since 1950s (Berger and Ofek, 1995). Although numerous attempts have been made to study effect of the cross-industry diversification, the efficiency consequences of within-industry diversification is still controversial. We observe some insurers write many lines of insurance, including personal lines and commercial lines in the U.S. property-liability insurance industry, whereas we also observe some insurers focus their attention on very few personal lines or very few commercial lines. These insurers follow the focus or specialized strategy. Which strategy is better is an important question for the insurance company and its stakeholders.

The first purpose of this essay is to examine whether nonspecialized strategy or specialized strategy is more efficient for property-liability insurers. Specifically, this essay develops the *nonspecialized hypothesis* and the *specialized hypothesis*. Following Cummins, Weiss, and Zi (2003), we use data envelopment analysis to examine whether nonspecialized strategy dominates specialized strategy.

The second purpose is to examine which types of insurers are more likely to realize economies of scope. Specifically, we are interested in whether large insurers (or small insurers), insurers that have higher risk, and/or insurers that use the independent agency system are more likely to realize economies of scope. Moreover, the results can shed additional insight on why we observe the long-run coexistence of nonspecialized and specialized property-liability insurers.

Studies of economies scope have found mixed results. Yuengert (1993) finds that there is no evidence of cost economies of scope by using the U.S. life cross-sectional data. Using U.S. life and property-liability data, Berger, Cummins, Weiss, and Zi (2000) find that the conglomeration hypothesis dominates for some types of insurance firms, whereas the focus hypothesis dominates for other types. Meador, Ryan, and Schellhorn (2000) find that diversification hypothesis dominates focused hypothesis in terms of X-efficiency in the U.S. life insurance industry. Using Japanese property-liability insurance data, Jeng and Lai (2005) find that Keiretsu firms seem to be more cost-efficient than nonspecialized independent firms. On the contrary, Hirao and Inoue (2004) find the cost economies of scope exist in the Japanese property-liability insurance industry. Cummins, Weiss, and Zi (2003) use the DEA bootstrapping method to analyze the economies of scope in the U.S. insurance industry. None of the literature, though, investigates nonspecialized strategy versus specialized strategy in the U.S. property-liability insurance industry.

The data set are obtained from property-liability insurance annual statement of National Association of Insurance Commissioner (NAIC) for the sample period from 1997 to 2004.

The results indicate that nonspecialized strategy dominates for some types of property-liability insurers and specialized strategy dominates for other type. In particular, the evidence first suggests nonspecialists and specialists have different technologies. Second, personal line specialists and nonpersonal line specialists use different technologies. In addition, we find that nonspecialists dominate specialists in producing nonspecialist input–output vectors and vice versa for specialists. Moreover, personal line specialists dominate nonpersonal line specialists in producing personal line specialist input–output vectors and vice versa for nonpersonal line specialists. These results are robust with respect to different size quartiles. The dominance statistics regression evidence indicates that the nonspecialized strategy is more efficient for insurers that have higher capital to asset ratio, are small, and are mutuals, while specialized strategy is more efficient for insurers that have lower capital to asset ratio, are large, and are stocks. The results provide evidence for the coexistence of economies of scope and diseconomies of scope in the U.S.

property-liability insurance industry.

We develop hypotheses in Section 2. Section 3 describes data and methodology used in this essay. Section 4 analyzes our empirical results and Section 5 concludes.

2. Hypothesis Development

To investigate whether the nonspecialized strategy or the specialized strategy is better in terms of efficiency performance, we first need to examine the pros and cons of the two strategies. The literature[1] provides some guidance for the discussion, even though no literature addresses the issues that directly related to property-liability insurers. The four main hypotheses are proposed and discussed below.

H1: The technology of nonspecialists (personal line specialists) is the same as that of the specialists (nonpersonal line specialists).

Nonspecialists issue many different lines of property-liability insurance and may exploit cost economies of scope by sharing administrative expenses, marketing costs, and specialists may perform better than nonspecialists because they can focus on few lines of insurance. In the reality, it is very likely that the nonspecialists and specialists use different technology. For example, the nonspecialists may put more emphasis on exploiting the shared resources, such as brand name and marketing system, to sell products, whereas the specialists may adopt the best technology to produce tailored products.

In addition, it is also very likely that the personal line specialists and nonpersonal line specialists use different technology. For instance, underwriting, product pricing, claims settlement, and other functions for nonpersonal line insurer tend to be more heterogeneous whereas these functions tend to be more homogeneous for the personal line insurers.[2]

[1] See, for instance, Meador et al. (2000); Berger et al. (2000); Jeng and Lai (2005).
[2] See Cummins, Weiss, and Zi (2003).

Corporate clients often place high value on tailored products and nonpersonal line insurers are likely to adopt a technology that is best suited to this market segments served. Hence, the personal line specialists and nonpersonal line specialists may use different technologies.

H2: It is not feasible, on average, to replicate nonspecialists (specialist) input-output combination using the specialists (nonspecialist) technology.

We expect nonspecialists and specialists have different efficiency performance as discussed in hypotheses 1 and 2, because nonspecialists issue both commercial lines and personal lines, whereas specialists issue either commercial lines or personal lines. Thus, it is infeasible, on average, to replicate one group's input-output combination using other group's technology.

H3: It is not feasible, on average, to replicate personal line specialists (nonpersonal line specialists) input-output combination using the nonpersonal line specialists (personal line specialists) technology.

As mentioned above, we expect that personal line specialists and nonpersonal line specialists would have different efficiency performance as these two lines of insurance are characterized by different types of risks insured and services provided. We expect to observe personal line specialists (nonpersonal line specialists) operating in the market where personal line specialists (nonpersonal line specialists) technology dominates. Thus, it is hypothesized that it is not feasible, on average, to replicate personal line specialists (nonpersonal line specialists) input-output combination using the nonpersonal line specialists (personal line specialists) technology.

H4: Nonspecialized strategy and specialized strategy are equally efficient for property-liability insurers.

The nonspecialized hypothesis suggests that nonspecialists write many different lines of property-liability insurance and may exploit cost economies of scope by sharing administrative expenses, marketing costs, and fixed costs (e.g., depreciation expenses for computers and buildings). Nonspecialists may take advantages of revenue of economies of scope in providing various commercial lines of business. Specifically, business owners may prefer the convenience of purchasing all commercial insurance from one insurer for the convenience reason. Moreover, a nonspecialist may diversify risk through different line of insurance. Risk-sensitive policyholders may be willing to pay more for insurance policies from nonspecialists.

On the other hand, the specialized hypothesis suggests that specialists may perform better than nonspecialists because they can focus on few lines of insurance. The reasons are stated below. Managers of specialists may be able to increase efficiency performance because they can develop expertise for few lines of insurance rather than many lines of insurance. In addition, specialists can achieve cost savings through fewer costs of hiring and training of actuaries, underwriters, and claim adjusters. For example, an insurer who issues only personal auto and homeowner insurance policies should have lower costs in actuaries, underwriters, and claim adjusters than an insurer who writes various personal lines and commercial lines. Thus, we propose the null hypotheses that nonspecialized strategy and specialized strategy are equally efficient in property-liability industry. Rejection of this null hypothesis suggests one strategy dominates the other strategy in terms of efficiency.

3. Data and Methodology

3.1. Data

The data source is the National Association of Insurance Commissioner for property-liability insurer from 1997 to 2004. Firms that have negative net premium written and that have information less than 5 years are discarded. Firms (i.e., nonspecialists or specialists) that change strategy throughout the sample period are excluded. We use the average Herfindahl index of net premium over 5 years as a measurement to identify the specialists and nonspecialists. Insurers in the first quartile of Herfindahl index for all 5 years are defined as nonspecialists. Nonspecialist group includes insurers with a Herfindahl index less than 0.214 (the mean value for this variable) and specialist group includes insurers with a Herfindahl index greater than 0.747. The insurers in the bottom quartile of Herfindahl index for each of the 5 years are defined as specialists. Specialists are further defined as personal line specialists having over 80% of losses incurred in the personal line of business or as nonpersonal line specialists having over 80% of losses incurred in the nonpersonal line of business. The final sample consists of 277 property-liability insurers, that is, 133 nonspecialists and 144 specialists.

3.2. Methodology

With regard to the methodology, we use the DEA to evaluate the efficiency performance for nonspecialists and specialists.

3.2.1 Data Envelopment Analysis

There are two major efficiency methodologies — the econometric (parametric) approach and the mathematical programming (nonparametric) approach, such as DEA. We choose DEA to evaluate the efficiency performance for each firm from the input-output perspective rather than from financial ratios perspective. Additionally, DEA analysis also dominates traditional methods on examining the technology difference between different types of firms. There are three major approaches used to measure outputs in the financial service industry: the value-added approach, the asset or financial intermediary approach, and the user-cost approach. We use the value-added approach to evaluate the outputs, which is the most appropriated method for studying insurance efficiency (Cummins and Weiss, 2000). All asset and liability categories having value-added are considered important outputs in the value-added approach. To save space, we do not discuss the detail of methodology of the data envelopment analysis and the cross-frontier method. Cummins and Weiss (2000) provide a detailed review of the DEA analysis. To estimate the relative efficiency for the nonspecialists and specialists, we adopt the cross-frontier analysis used by Cummins, Weiss, and Zi (1999). We first investigate whether nonspecialists and specialists have the same technology (frontier) by using the DEA analysis. If the nonspecialists and specialists have different frontiers, we then perform cross-frontier analyses. The outputs and inputs used in this study are discussed later.

Outputs

The output variables include the loss amounts for different product lines and total invested assets. Cummins and Weiss (1993) suggest that insurers provide consumers with services associated with insured losses, risk-pooling, and risk-bearing. Following Cummins and Weiss (1993), Cummins, Weiss, and Zi (1999), and Cummins et al. (2004), we use loss incurred for different product lines as proxies for outputs[3]. We further separate the losses into four categories: losses incurred in short-tail personal lines (y1), losses incurred in long-tail[4] personal lines (y2), losses incurred in short-tail nonpersonal lines (y3), and losses incurred in long-tail nonpersonal lines (y4)[5]. Based on Berger, Cummins, and Weiss

[3] Prior studies use different proxies for outputs for insurers (Cummins and Weiss, 2000). Consistent with most of the recent insurance studies, we adopt the value-added approach to measure property-liability insurer outputs and use the losses incurred as insurance output of property-liability insurers.

[4] The terms "long-tail" and "short-tail" indicate the period length between the policy inception and loss payment dates. For instance, liability insurance is a "long-tail" line of business and auto collision is a "short-tail" line of business.

[5] Because the underwriting practice and service vary by line of insurance, according to Best's Company Report, we disaggregate lines of business into personal lines and nonpersonal lines. The lines of business for personal lines include auto physical damage, homeowners multiple peril, private passenger auto liability; the lines of business for nonpersonal lines include fire, allied lines, inland marine, financial guaranty, earthquake, group accident and health, credit accident and health, other accident and health, fidelity, burglary and theft, credit, farmowners multiple peril, commercial multiple peril, ocean marine, medical malpractice, workers' compensation, other liability, aircraft (all perils), boiler and machinery.

(1997), we also include invested assets (y5) as an output variable. All output numbers are deflated to the base year 1997 with the consumer price index.

Inputs

The inputs used in measuring the efficiency performance include labor (x1), business service (x2), equity (x3), and debt capital (x4). Labor input is the labor cost divided by average weekly employee wages. We measure the price of labor (p1) as average weekly wages for insurance agent (standard industrial classification [SIC] Class 6411) by using U.S. Department of Labor data. The second input, business services, consists of agent commissions and loss adjustment expenses. Both the business service and price of labor are deflated to the base year 1997. The price of business services (p2) is the average weekly earnings of workers in SIC 7300. The third input is the equity. We use policyholder surplus as the proxy for the equity. To avoid the problem of improper estimates, we do not take the ratio of an insurer's net income to capital (ROE) as the price of policyholder because insurers with poor performance are more likely to have negative net incomes and price cannot be negative. Consequently, we use the debt-equity ratio of the insurer as the price of equity (p3).[6] Following Cummins, Weiss, and Zi (1999) and Cummins et al. (2004), we consider debt capital as an input variable and use insurance reserves as the proxy for debt. The price of debt (p4) is the yield of one year Treasury note.

3.2.2 Dominance Statistics

We follow Cummins et al. (1999, 2003) and use F-scores to examine the dominance of specialized strategy and nonspecialized strategy. F-scores, or called dominance statistics, measure the dominance with respect to the frontiers. If the evidence that the nonspecialist technology dominates the specialist technology is found, it means that the economies of scope exist, while a finding that the specialist technology dominates the

[6] Price of equity should be a function of a firm's debt-equity ratio. See Jeng and Lai (2005) for detailed discussions.

nonspecialist technology would provide evidence of diseconomies of scope. We define F-score for production frontier for specialists relative to nonspecialists as follows:

$$F_t(Y_{sp}, X_{sp}) = 1 - \frac{T_{sp}(Y_{sp}, X_{sp})}{T_{nsp}(Y_{sp}, X_{sp})}.$$

Likewise, the F-score for production frontier for nonspecialists relative to specialists is defined as:

$$F_t(Y_{nsp}, X_{nsp}) = 1 - \frac{T_{sp}(Y_{nsp}, X_{nsp})}{T_{nsp}(Y_{nsp}, X_{nsp})}$$

A positive value of $F_t(Y_i,X_i)$ implies that the specialist technology is dominant for producing the input–output vector, where specialists includes personal line specialists and nonpersonal line specialists. A negative value of $F_t(Y_i,X_i)$ means the nonspecialist technology is dominant. The F-score estimation of cost efficiency is defined similarly. The F-score for production frontier for personal line specialists relative to nonpersonal line specialists is defined as follows:

$$F_t(Y_{psp}, X_{psp}) = 1 - \frac{T_{psp}(Y_{psp}, X_{psp})}{T_{npsp}(Y_{psp}, X_{psp})}.$$

Similarly, for nonpersonal line specialists the F-score for production frontier is estimated as:

$$F_t(Y_{npsp}, X_{npsp}) = 1 - \frac{T_{psp}(Y_{npsp}, X_{npsp})}{T_{npsp}(Y_{npsp}, X_{npsp})}$$

Similarly, a positive value of $F_t(Y_i,X_i)$ implies that the personal line specialist technology is dominant for producing the input–output vector, whereas a negative value of $F_t(Y_i,X_i)$ implies that the nonpersonal line specialist technology is dominant.

3.2.3 Regression Analysis

To investigate the relation between economies of scope and other firm characteristics, we conduct regression analysis with F-scores as dependent variables and firm characteristics as independent variables. Note these characteristics variables also serve as control variables to control differences in insurers' different characteristics. The regression model is as follow:

$$F - Scores = \beta_0 + \beta_1 Strategy + \beta_2 Rsik + \beta_3 Risk * Strategy + \beta_4 MC + \beta_5 MC * Strategy + \beta_6 Size + \beta_7 Size * Strategy + \beta_8 Stock + \beta_9 Stock * Strategy + \beta_{10} VI + \beta_{11} VI * Strategy + \varepsilon$$

Hypotheses related to the regression analysis are discussed below.

Specialized Strategy (Strategy)

The F-scores regression models include a dummy variable for distinguishing specialized and nonspecialized strategy. Specialized Strategy dummy equals 1 if insurer is specialists, 0 otherwise in the fist two equations and equals 1 if insurer is personal line specialists, 0 otherwise in the third equation. As noted, a positive value of F-scores suggests that the specialist technology is dominant for producing the input–output vector, where specialists include personal line specialists and nonpersonal line specialists. A negative value of F-scores means the nonspecialist technology is dominant. If the coefficients of specialized strategy are positively significant, it implies specialist technology is dominant for producing the input–output bundle.

Risk

There may be cost economies of scope because risk-sensitive policyholders (employees) may be willing to accept lower services (wages) from nonspecialists in return for low default risk. Policyholders also may be willing to pay more to nonspecialists for similar reasons. Thus, there may be revenue economies of scope. We use ROE standard deviation and capital to asset ratio as proxies for risk. We also include interaction term between the specialized strategy dummy and the risk variable to allow the effects of strategies to differ by level of risk.

Market Concentration and Market Share (MC)

Insurers with high market concentration and market share are more likely to collude in pricing, restrain from price increases, or both (Chidambaran, Pugel, and Sauders, 1997; Nissan 2003). Recently, Santalo and Becerra (2008) discover that diversified firms perform better in industries with a small number of nondiversified competitors or, equivalently, when specialized firms have a small combined market share. Hence, the effect of diversification strategy is empirically related with market concentration and market share. We use WCONC as proxy for market concentration and market share. WCONC equals weighted sum of market share per line multiplied by line-specific Herfindahl index.

$$WCONC_{it} = \sum_{l=1}^{29} w_{ilt} \times HHI_{lt}$$

The line-specific Herfindahl Index for each line of insurance for *i*th insurer in year t is calculated as follows:

$$HHI_{lt} = \sum_{i=1}^{n} \left(P_{ilt} / P_{lt}\right)^{2}$$

where P_{ilt} is premium written for each line of business for *i*th insurer in year t. Each insurer's concentration for each line of insurance is calculated as follows:

$$w_{ilt} = P_{ilt} / P_{it}$$

Industry concentration measurement is equal to the weighted sum of market share per line multiplied by line-specific Herfindahl index. Also, the interaction term between the specialized strategy dummy and the market concentration and market share variable is included to allow the effects of strategies to differ by market concentration and market share.

Size

Cost economies of scope may be negatively related to firm size. Intuitively, the inverse relationship between insurer size and cost economies of scope is because that when a nonspecialist is small, sharing the fixed resources such as utilities, offices, and computers is beneficial. The benefits may be offset by the costs of control and coordination when a nonspecialist is large. On the other hand, there may be revenue economies of scope at large scale because a large nonspecialist can benefit from branding or large spending in advertising. It is easier for producers to increase revenues by offering a complete range of products than one or two single product. We also include interaction term between the specialized strategy dummy and the size to allow the effects of strategies to differ by size.

Stock

We also analyze the relationship between the organizational form and economies of scope. We include the organizational form dummies in the regression analysis—stock versus mutual ownership. These forms may be associated with different incentives about costs, revenues, and profits in different organizational forms. In addition, we include interaction term between the specialized strategy dummy and the stock variable to allow the effects of strategies to differ by organizational structure.

Vertical Integration (VI)

We define an insurer as vertically integrated if it distributes its product through exclusive agents, direct marketing, mass marketing, or a combination. An insurer is nonvertically integrated if it distributes its product through independent agent(s). We expect an insurer with a vertical integrated distribution system to be more likely to realize cost economies of scope because it is able to "reuse" its resources to sell multiple lines of business at any point of its distribution chain. Moreover, vertically integrated insurers are more likely to realize revenue economies of scope because vertically integrated distributed system is more likely to develop its brand. Additionally, the interaction term between the specialized strategy dummy and the distribution channel is included to allow the effects of strategies to differ by the distribution channel.

4. Empirical Results

This section reports the empirical results of DEA analysis. Table 1-1 shows the summary statistics for outputs, inputs and input prices used in the DEA analysis. It shows that nonspecialists are larger than the nonpersonal line specialists in terms of cost, revenue and profit, and are smaller than the personal line specialists in terms of cost, revenue, and profit. Personal line specialists are statistically larger than the nonspecialists in terms of personal line outputs whereas nonpersonal line specialists are larger than the nonspecialists in terms of nonpersonal line outputs.

[Insert Table 1-1 here]

Next, we provide results of the efficiency performance by conducting DEA analysis and providing the comparisons between specialists and nonspecialists. We first test whether the nonspecialized hypothesis or the specialized hypothesis validates. We compare the efficiency performance of nonspecialist and specialists to a pooled efficient frontier, assuming that nonspecialists and specialists use the same technology. Table 1-2 presents the insurance efficiency results from pooled frontier. In Panel A we compare technical and cost efficiency between nonspecialist and personal line specialist; Tp(Xnsp,Ynsp) indicates technical efficiency based on the pooled frontier for nonspecialist, whereas Tp(Xpsp,Ypsp) indicates technical efficiency based on the pooled frontier for personal line specialist; in Panel B we compare efficiency between nonspecialist and nonpersonal line specialist; Tp(Xnpsp,Ynpsp) indicates technical efficiency based on the pooled frontier for nonpersonal line specialist; finally, in Panel C we compare efficiency between personal and nonpersonal line specialist. In Panel A of Table 1-2, it shows that the average technical efficiency based on the pooled frontier for nonspecialist is 0.8906, whereas the average technical efficiency based on the pooled frontier for personal line specialist is 0.8402, implying that, on average, nonspecialists outperform personal line specialists in terms of technical efficiency. It also indicates that nonspecialist is more cost efficient than personal line specialist. Similarly, in Panel B, results indicate that nonspecialists are more efficient than nonpersonal line specialists in terms of technical and cost efficiency. In addition, in Panel C, it shows that personal line specialists are more technical and cost efficient than nonpersonal line specialists. We also conduct Tobit regression analysis (not reported) and regress efficiency scores from pooled efficient frontier on strategy dummy variable and a set of firm characteristics. The Tobit regression analysis suggests that nonspecialized strategy holds, implying that nonspecialized strategy is more efficient than specialized strategy for property-liability insurers, consistent with the univariate analysis. Moreover, personal line specialists dominate nonpersonal line specialists in terms of cost efficiency.

[Insert Table 1-2 here]

Next, we test whether the assumption that nonspecialists and specialists use the same technology is correct. We test the null hypothesis that specialists (personal line) and nonspecialists (nonpersonal line) operate on the same efficiency frontier. If nonspecialists and specialists operate on the same frontier, then it is appropriate to use a pooled frontier to analyze differences in the two types of the insurers. It reports the results of the above tests in Table 1-3. The pooled frontier of specialists consists of personal line specialists and nonpersonal line specialists. The tests are performed in two ways. First, we compare the efficiency of nonspecialist firms based on separate frontier with the efficiency of all firms based on pooled frontier. Second, we compare the efficiency of nonspecialist firms based on separate frontier with the efficiency of nonspecialist firms based on pooled frontier. In each panel, nonspecialists are compared with specialists; personal line specialists are compared with nonpersonal line specialists. The comparable tests for personal line specialist and nonpersonal line specialist are performed similarly. The technical efficiency scores based on pooled and separate frontier are shown in the Panel A and the cost efficiency are shown in the Panel B.

[Insert Table 1-3 here]

Analysis of variance (ANOVA) *F* test, Wilcoxon Z test, Median Z test, Van Der Waerden Z test, and Savage Z test for technical efficiency of nonspecialists and specialists overwhelmingly reject the first null hypothesis that the frontier of nonspecialists (specialists) is identical to the pooled frontier and that the frontier of personal line specialists (nonpersonal line specialists) is identical to the pooled frontier Thus, it is not appropriate to use a pooled frontier to compare the efficiency difference between nonspecialists (personal line specialists) and specialists (nonpersonal line specialists). In addition, the results for the personal line specialist suggest that the personal line specialist frontier is not identical to the specialist frontier. Accordingly, nonpersonal line specialist frontier primarily defines the specialist frontier. The similar finding of cost efficiency is found in Panel B. The findings of these tests generally do not support that the specialist use the same technology as nonspecialist as well as personal line specialist use the same technology as nonpersonal line specialist in the traditional insurer efficiency studies. Hence, these tests reject our third hypothesis that the technology of nonspecialists (personal line specialists) is the same as that of the specialists (nonpersonal line specialists).

Since the results in Table 1-3 implies that the personal line specialist and nonpersonal line specialist use distinctive technology, we thus compare the cross-frontier efficiency between nonspecialist and personal line specialist, between nonspecialist and nonpersonal line specialist, and between personal line specialists and nonpersonal line specialists. We test our second and third null hypothesis by estimating cross-frontiers. Cross-frontier efficiency helps us examine whether specialists' (nonspecialists') technology dominates nonspecialists' (specialists') technology for producing the particular output bundle. We calculate the cross-frontier efficiency introduced in Cummins, Weiss, and Zi (1999). These results are presented in Table 1-4. The Panel A of Table 1-4 compares nonspecialists and personal line specialists, the Panel B compares nonspecialists and nonpersonal line specialists, and the Panel C presents the comparison between personal and nonpersonal line specialist. In each panel, the technical efficiencies are presented in first four columns and are followed by cost efficiency in the last four columns.

The cross-frontier efficiency measures the efficiency of nonspecialists and specialists relative to the other group's frontiers. If cross-frontier efficiency is greater than 1, it implies that it is not feasible to replicate its own input-output combinations using other group's technology. We first test the null hypothesis that cross-frontier efficiency $\leqq 1$. Rejection of the null hypothesis implies that it is infeasible to produce its own input-output vector using the other group's technology. The results of tests are presented in Table 1-A1 in Appendix A. In Panel A, we test cross-frontier efficiency between nonspecialist and personal line specialist; in Panel B, we test cross-frontier efficiency between nonspecialist and nonpersonal line specialist; finally, in Panel C, we test cross-frontier efficiency between personal and nonpersonal line specialist. We label Tpsp(Xnsp,Ynsp) as the technical efficiencies of nonspecialist relative to the personal line specialist frontier and Cpsp(Xnsp,Ynsp) indicates the cost efficiencies of nonspecialist relative to the personal line specialist frontier. The significance test results reported in Panel A of Table 1-A1 shows that the technical efficiencies for the nonspecialists and personal line specialist samples based on their cross-frontier, headed Tpsp(Xnsp,Ynsp) and Tnsp(Xpsp,Ypsp), reject the null hypothesis that cross-frontier efficiency $\leqq 1$ for the whole sample period, implying that it is infeasible to use nonspecialist's technology to replicate personal line specialist's input-output vector and it is infeasible to use personal line specialist's technology to replicate nonspecialist's input-output vector. Similarly, the cost cross-frontier efficiencies for the nonspecialists and personal line specialist samples, headed Cpsp(Xnsp,Ynsp) and Cnsp(Xpsp,Ypsp), also reject the null hypothesis that cost cross-frontier efficiency ≦1 in 3 of 8 years on the average. The tests for comparison between nonspecialists and nonpersonal line specialist as well as the tests for comparison between personal line and nonpersonal line specialist also reject the null hypothesis that cross-frontier efficiency ≦1 on the average. Rejection of the null hypothesis in these tests supports our second and third hypothesis that it is not feasible, on average, to replicate nonspecialists (specialist) input-output combination using the specialists (nonspecialist) technology. It implies that nonspecialists and specialists have different efficiency performance, because nonspecialists issue both nonpersonal lines and personal lines, whereas specialists issue either nonpersonal lines or personal lines; personal line specialist and nonpersonal line specialist also have different efficiency performance, since they have different core competence.

Nonspecialists and Personal Line Specialists.

We next compare the separate frontier and cross-frontier efficiency for the nonspecialists and personal line specialists. In Table 1-4, the technical efficiency with respect to the nonspecialist and personal line specialist separate frontier are shown in the columns headed Tnsp(Xnsp,Ynsp) and Tpsp(Xpsp,Ypsp). It shows that nonspecialist technical efficiency (TE) averaged 90.05% and personal line specialist technical efficiency TE averaged 91.17%. The evidence suggests that nonspecialist could have reduced their inputs by 9.95% to produce the same amount of outputs, on average, if they had been operating with full efficiency and personal line specialist could have reduced their inputs by 8.83%. The results are not correctly interpreted as suggesting that personal line specialists are more technical efficient than nonspecialists. The average technical cross-frontier efficiency score (3.3487) of nonspecialist relative to personal line specialist frontier Tpsp(Xnsp,Ynsp) is greater than 1. The evidence implies that it is not feasible, on average, to replicate nonspecialist input–output combination by using the personal line specialist technology. In other words, the nonspecialist technology dominates personal line specialist technology for producing the nonspecialist‘s outputs. That Tpsp(Xnsp,Ynsp) scores are greater than 1 in all sample years strongly supports the above-mentioned conclusion. Likewise, it shows the average score (2.8161) of personal line specialist relative to nonspecialist frontier Tnsp(Xpsp,Ypsp) is greater than 1, suggesting that it is not feasible, on average, to replicate personal line specialist input–output combination by using the nonspecialist technology. Accordingly we conclude that nonspecialists and personal line specialists use distinct technologies.

[Insert Table 1-4 here]

Nonspecialists and Nonpersonal Line Specialists.

The TE of the separate frontier are shown in the first and third columns headed Tnsp(Xnsp,Ynsp) and Tnpsp(Xnpsp,Ynpsp) and TE based on the cross-frontier are shown in the second and fourth columns headed Tnpsp(Xnsp,Ynsp) and Tnsp(Xnpsp,Ynpsp) in the Panel B of Table 1-4. The data show that nonpersonal line specialist TE Tnpsp(Xnpsp,Ynpsp) averaged 73.49%. The evidence suggests that nonpersonal line specialist could have reduced their inputs by 26.51%, on average, if they had been operating with full efficiency. Both TE and CE cross-frontier efficiency for nonspecialists and nonersonal line specialists shows that it is not feasible, on average, to replicate nonspecialist input–output combination by using the nonpersonal line specialist technology and also it is not feasible, on average, to replicate nonpersonal line specialist input–output combination by using the nonspecialist technology. Specifically, the nonspecialist relative-to-nonpersonal line specialist-frontier average technical and cost scores

Tnpsp(Xnsp,Ynsp) and Cnpsp(Xnsp,Ynsp) are greater than 1. Similarly, The nonpersonal line specialist relative-to-nonspecialist-frontier average technical and cost scores Cnsp(Xnpsp,Ynpsp) and Tnsp(Xnpsp,Ynpsp) are also greater than 1. Consequently, we conclude that nonspecialists and nonpersonal line specialists use different technologies.

Thus, the evidences of nonspecialists versus personal line specialist comparison, in conjunction with the evidences of nonspecialists versus nonpersonal line specialist comparison accept the second hypothesis that the specific group's input-output combination would have been infeasible using the other group's technology. That is, it is not feasible, on average, to replicate nonspecialists (specialist) input-output combination using the specialists (nonspecialist) technology.

Personal Line Specialists and Nonpersonal Line Specialists.

In Panel C of Table 1-4, the personal line specialist relative-to-nonpersonal line specialist-frontier are shown in the columns headed Tnpsp(Xpsp,Ypsp) and Cnpsp(Xpsp,Ypsp). Both TE and CE results for personal line specialist indicate that it is not feasible, on average, to replicate personal line specialist input–output combination by using the nonpersonal line specialist technology, paralleling the nonpersonal line specialist results.

To sum up, the efficiency score presented in this section implies that, first, the nonspecialists and specialists use distinctive technology. Thus, we accept the third hypothesis that it is not feasible, on average, to replicate personal line specialists (nonpersonal line specialists) input-output combination using the nonpersonal line specialists (personal line specialists) technology.

To examine the production dominance, we present the results of F-scores. Table 1-5 presents the results of dominance statistics by size quartile. $F_t(Y_i,X_i)$ and $F_c(Y_i,X_i)$ represent F-scores for production frontiers and cost frontiers, respectively. Panels A and B in Table

1-5 show the F-scores of production frontiers and cost frontier for nonspecialist and personal line specialist; Panels C and D report the F-scores of nonspecialist and nonpersonal line specialist; Panels E and F report the F-scores of personal line specialist and nonpersonal line specialist. The results in Panel A and B show that the quartile results of $F_t(y_i,x_i)$ for nonspecialists are negative and significantly different from zero, confirming nonspecialists are superior in producing nonspecialized output vectors in terms of production frontiers and cost frontiers. The quartile results of $F_t(y_i,x_i)$ for personal line specialist are positive and significantly different zero, confirming personal line specialist are superior in producing personal line specialized output vectors in terms of production frontiers and cost frontiers. The results of panels C and D are similar to those of panel A and B. It confirms that nonpersonal line specialist are superior in producing nonpersonal line specialized output vectors in terms of production frontiers and cost frontiers. The results in Panel E and F shows that personal line specialists (nonpersonal line specialists) are superior in producing personal line specialists (nonpersonal line specialists) output vectors in terms of production frontiers and cost frontiers.

[Insert Table 1-5 here]

The above-mentioned results are based on univariate analyses. To further address whether the nonspecialist dominates the specialist or vice versa and whether the personal line specialist (nonpersonal line specialist) dominates the nonpersonal line specialist (personal line specialist), we follow Cummins et al.(1999, 2003) and regress cost F-scores on a set of independent variables representing type of strategies, risk (ROE standard deviation and financial leverage), market power, size, organizational structure, distribution channel. The sample period averages for the variables used in regression analysis are shown in Table 1-6. The asterisks in the column show that the differences between means for the nonspecialists and specialists are statistically significant for nearly all variables, except for organizational structure variable (stock).

[Insert Table 1-6 here]

The regression results for the F-scores are shown in Table 1-7. The independent variables of specialized strategy = 1 if insurer is a personal line specialist, 0 otherwise in Panel A; specialized strategy = 1 if insurer is a nonpersonal line specialist, 0 otherwise in Panel B; specialized strategy = 1 if insurer is a personal line specialist, specialized strategy = 0 if insurer is a nonpersonal line specialist in Panel C. As mentioned above, a positive value of the frontier dominance $F_t(Y_i,X_i)$ between nonspecialists and personal line specialists implies that the specialist technology is dominant for producing the input–output vector, and a negative value of $F_t(Y_i,X_i)$ implies that the nonspecialist technology is dominant for producing the input–output vector. Also, a positive value of the frontier dominance between personal line and nonpersonal line specialists implies that the personal line specialist technology is dominant for producing the input–output vector, and a negative value of the frontier dominance implies that nonpersonal line specialist technology is dominant for producing the input–output vector. To examine the effect of different strategies on the relation between the firm characteristics, we add the interaction terms between strategy dummy and other firm characteristics, such as leverage, market power, size, organizational structure, distribution channel

[Insert Table 1-7 here]

In Panel A of Table 1-7, it shows that the coefficients on specialized strategy variable is positive and significant in the cost dominance regression model, implying that personal line specialists have advantages in terms of cost dominance when they produce their own input–output vector. The capital to asset ratio /specialized strategy interaction term has significantly negative coefficient, suggesting the less the ratio of capital to assets is , the greater the dominance of the personal line specialists is in terms of cost dominance.

Panel B of Table 1-7 reports the cost dominance regression for nonspecialists and nonpersonal line specialists. The results for the dominance regression for comparison between nonspecialists and nonpersonal line specialists are similar to comparison between nonspecialists and personal line specialists. Most of the coefficients of interaction terms are similar to the results in the Panel B. We only focus on the most important results. It is observed that the specialized strategy dummy variable is positive and significant, implying that nonpersonal line specialists have advantages in terms of cost dominance when they produce their own input–output vector. Panel C reports the dominance regression for personal line specialists and nonpersonal line specialists. The personal lines strategy dummy variable is positive and significant in cost dominance regression model, implying that personal line specialist technologies are superior in producing personal line output bundles and nonpersonal line specialist technologies are superior in producing nonpersonal line output vectors. Moreover, it indicates that the nonspecialized strategy is more efficient for insurers that have higher capital to asset ratio, are small, and are mutuals, while specialized strategy is more efficient for insurers that have lower capital to asset ratio, are large, and are stocks.

These dominance regression findings in the Table 1-7, in conjunction with the dominance statistics, where there were no controls for other factors, rejecting our null hypothesis 4 that nonspecialized strategy and specialized strategy are equally efficient for property-liability insurers. The overall empirical evidence supports that both the nonspecialized hypothesis and the specialized hypothesis hold for different types of property-liability insurers and the results also provide evidence for the coexistence of economies of scope and diseconomies of scope in the U.S. property-liability insurance industry.

5. Conclusions

The efficiency effect of specialized strategy and nonspecialized strategy has been widely studied theoretically and empirically in many fields. This research extends the literature of economies of scope by testing both the nonspecialized hypothesis and the specialized hypothesis in the property-liability insurance industry by using data envelopment analysis. We believe the empirical evidence in this essay provides new insights into the insurance literature in several ways. First, to our knowledge, we are the first to examine whether specialized strategy is more efficient for the U.S. property-liability insurers. Second, we tests whether specialists and nonspecialists use the same technology and whether the technology of personal and nonpersonal line specialists is the same. If specialists and nonspecialists use different technologies and operate on different efficiency frontiers, the traditional approach to estimating efficiency based on the assumption of same technology would produce misleading results. Third, this essay examines the relationship between economies of scope and firm characteristics to provide additional evidence on nonspecialized strategy and specialized strategy.

The results indicate that the nonspecialists and specialists use different technology and operate on different efficient frontiers. The evidence of cross-frontier analysis suggests that nonspecialists (specialists) dominate specialists (nonspecialists) in producing nonspecialists (specialists) input–output vectors and that personal line specialists (nonpersonal line specialists) dominate nonpersonal line specialists (personal line specialists) in producing personal line specialists (nonpersonal line specialists) input–output vectors. These results are robust with respect to different size quartiles. The dominance statistics regression evidence indicates that the nonspecialized strategy is more efficient for insurers that have higher capital to asset ratio, are small, and are mutuals, while specialized strategy is more efficient for insurers that have lower capital to asset ratio, are large, and are stocks. The results provide evidence for the coexistence of economies of scope and diseconomies of scope in the U.S. Property-Liability insurance industry.

Our analyses in turn suggest some avenues for further research. An avenue for extending this research would be to empirically test the efficiency performance associated with both geographic diversification as well as product diversification, since the relationship between performance and product diversification may be contingent on the level of geographic diversification of property-liability insurance firms. The finding would help management in devising nonspecialized strategies for improving firm performance. Additionally, research should use longer sample periods and/or use econometric frontier approach to determine if our findings represent empirical regularities.

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Table 1-1 Summary Statistics for Nonspecialists and Specialists

	All	Nonspecialists	Personal Line Specialist	Nonpersonal Line Specialist	Nonspecialists vs. Personal Line Specialist	Nonspecialists vs. Nonpersonal Line Specialist	Personal Line Specialist vs. Nonpersonal Line Specialist
Y1= Losses incurred in short-tailed personal lines	$15.35	$9.14	$47.82	$1.62	***	***	***
Y2= Losses incurred in long-tailed personal lines	$25.83	$19.28	$77.33	$2.27	***	***	***
Y3= Losses incurred in short-tailed Nonpersonal lines	$6.00	$3.14	$3.93	$8.63		***	***
Y4= Losses incurred in long-tailed Nonpersonal lines	$22.18	$25.80	$5.15	$29.17	***		***
Y5= Total Invested Assets	$308.01	$269.39	$440.79	$259.01			
X1=Labor cost	$0.03	$0.03	$0.06	$0.02	***	***	***
X2=Business Service	$0.07	$0.07	$0.10	$0.06			**
X3=Equity	$142.26	$122.27	$242.10	$100.54	*		**
X4=Debt	$175.01	$162.19	$188.91	$174.63			
P1=Price of Labor	$435	$435	$435	$435			
P2= Price of Business Service	$280	$280	$280	$280			
P3= Price of Equity	$1.36	$1.50	$1.28	$1.33	***	**	
P4= Price of Debt	$0.04	$0.04	$0.04	$0.04			
Costs	$30.14	$27.47	$49.70	$21.30	**	**	***
Revenues	$46.72	$42.78	$73.21	$34.92	**	*	***
Profits	$16.58	$15.31	$23.50	$13.62	*		**
Number of firms	419	109	107	203			

Note: This Table presents means of output, input, and input price for firms with different strategy. All output and input values are in millions of 1997 dollars.
*** Statistically significant difference at 1% level or better; **Statistically significant difference at 5% level; *Statistically significant difference at 10% level.

Table 1-2 Insurance Efficiency Results from Pooled Frontier

Panel A: Nonspecialist v.s. Personal Line Specialist						
	(1) Tp(Xnsp,Ynsp)		(2) Tp(Xpsp,Ypsp)	(3) Cp(Xnsp,Ynsp)		(4) Cp(Xpsp,Ypsp)
Mean	0.8906	***	0.8402	0.6407	***	0.5868
1997	0.9280		0.904	0.7069	***	0.6152
1998	0.8632	***	0.8206	0.5761		0.5958
1999	0.8914	***	0.8409	0.6614		0.6409
2000	0.9204	***	0.8686	0.6767	***	0.6147
2001	0.8994	***	0.8355	0.6748	***	0.5933
2002	0.8987	***	0.854	0.681	***	0.5744
2003	0.8805	***	0.8166	0.6521	***	0.5934
2004	0.8434	***	0.7813	0.4963	*	0.4669

(Continued)

Table 1-2 (Continued)

Panel B: Nonspecialist v.s. Nonpersonal Line Specialist						
	(1) Tp(Xnsp,Ynsp)		(2) Tp(Xnpsp,Ynpsp)	(3) Cp(Xnsp,Ynsp)		(4) Cp(Xnpsp,Ynpsp)
Mean	0.8906	***	0.7684	0.6407	***	0.4291
1997	0.9280	*	0.8283	0.7069	***	0.2748
1998	0.8632	**	0.7795	0.5761	**	0.4127
1999	0.8914	***	0.7424	0.6614	***	0.4974
2000	0.9204	***	0.7621	0.6767	***	0.4886
2001	0.8994	***	0.7497	0.6748	***	0.4355
2002	0.8987		0.7614	0.681	***	0.4228
2003	0.8805	**	0.7705	0.6521	***	0.4851
2004	0.8434	**	0.7530	0.4963	***	0.4158

Table 1-2 (Continued)

Panel C: Personal Line Specialist v.s. Nonpersonal Line Specialist						
	(1) Tp(Xpsp,Ypsp)		(2) Tp(Xnpsp,Ynpsp)	(3) Cp(Xpsp,Ypsp)		(4) Cp(Xnpsp,Ynpsp)
Mean	0.8402	**	0.7684	0.5868	***	0.4291
1997	0.904	**	0.8283	0.6152	***	0.2748
1998	0.8206		0.7795	0.5958	***	0.4127
1999	0.8409	***	0.7424	0.6409	***	0.4974
2000	0.8686	*	0.7621	0.6147	**	0.4886
2001	0.8355	*	0.7497	0.5933	***	0.4355
2002	0.854		0.7614	0.5744	***	0.4228
2003	0.8166		0.7705	0.5934	***	0.4851
2004	0.7813	**	0.7530	0.4669	***	0.4158

Note: T indicates technical efficiency; C indicates cost efficiency. Subscript p on T or C signifies the pooled frontier on which the insurers are based. In panel A, Tp(Xnsp,Ynsp) = technical efficiency for nonspecialist based on nonspecialist and personal line specialist frontier; Tp(Xpsp,Ypsp)= technical efficiency for personal line specialist based on nonspecialist and personal line specialist frontier; In panel B, Tp(Xnsp,Ynsp) = technical efficiency for nonspecialist based on nonspecialist and nonpersonal line specialist frontier; Tp(Xnpsp,Ynpsp)= technical efficiency for nonpersonal line specialist based on nonspecialist and nonpersonal line specialist frontier; In panel C, Tp(Xpsp,Ypsp)= technical efficiency for personal line specialist based on personal and nonpersonal line specialist frontier; Tp(Xnpsp,Ynpsp)= technical efficiency for nonpersonal line specialist based on personal and nonpersonal line specialist frontier.
*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level; * Statistically significant difference at 10% level.

Table 1-3 Tests of The Null Hypothesis that The Pooled and Separate Frontiers are Identical by Using Value-Added Approach

Population Comparison	ANOVA F (Prob > F)	Wilcoxon Z (Prob > Z)	Median Z (Prob > Z)	Van Der Waerden Z (Prob > Z)	Savage Z (Prob > Z)
Panel A: Technical Efficiency					
Nonspecialist v.s. Specialist					
109 Nonspecialist separate efficiency vs. 419 efficiency from pooled frontier***	876.1314	28.8130	27.3862	27.0380	25.8532
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
109 Nonspecialist separate efficiency vs. 109 Nonspecialist efficiency from pooled frontier***	1309.965	28.6911	28.4689	27.3653	24.9934
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
310 Specialist separate efficiency vs. 419 efficiency from pooled frontier***	316.8387	15.1001	11.6795	16.0882	12.4190
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
310 Specialist separate efficiency vs. 310 Specialist efficiency from pooled frontier***	215.8739	11.4102	8.3043	12.6943	8.0612
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Personal Line Specialist v.s. Nonpersonal Line Specialist					
107 Personal line specialist separate efficiency vs. 310 efficiency from pooled frontier***	581.1420	22.0771	21.4624	21.1868	19.1365
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
107 Personal line specialist separate efficiency vs. 107 Personal line specialist efficiency from pooled frontier***	161.8672	11.1599	9.9148	11.4325	9.3479
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
203 Nonpersonal line specialist separate efficiency vs. 310 efficiency from pooled frontier***	0.2690	-0.1974	-0.9460	-0.1948	0.8904
	(0.6040)	(0.8435)	(0.3442)	(0.8455)	(0.3733)
203 Nonpersonal line specialist separate efficiency vs. 203 Nonpersonal line specialist efficiency from pooled frontier***	37.2504	6.3183	5.7167	5.9557	6.0530
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

(continued)

Table 1-3 (Continued)

Panel B: Cost Efficiency

	Nonspecialist v.s. Specialist				
109 Nonspecialist separate efficiency vs. 419 efficiency from pooled frontier***	515.2811	23.6509	22.8297	21.4993	23.2606
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
109 Nonspecialist separate efficiency vs. 109 Nonspecialist efficiency from pooled frontier***	434.8841	-21.0846	-19.5062	-19.5037	-19.4952
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
310 Specialist separate efficiency vs. 419 efficiency from pooled frontier***	137.0847	9.7478	5.8567	11.4101	7.9330
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
310 Specialist separate efficiency vs. 310 Specialist efficiency from pooled frontier***	89.0629	8.1259	5.2235	9.5144	5.6127
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	Personal Line Specialist v.s. Nonpersonal Line Specialist				
107 Personal line specialist separate efficiency vs. 310 efficiency from pooled frontier***	745.3810	25.2875	22.7711	24.1233	22.5327
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
107 Personal line specialist separate efficiency vs. 107 Personal line specialist efficiency from pooled frontier***	159.6908	12.1889	10.4710	12.1180	10.4673
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
203 Nonpersonal line specialist separate efficiency vs. 310 efficiency from pooled frontier***	4.4381	-2.7728	-2.2259	-2.4717	-0.7525
	(0.0352)	(0.0056)	(0.0260)	(0.0134)	(0.4518)
203 Nonpersonal line specialist separate efficiency vs. 203 Nnonpersonal line specialist efficiency from pooled frontier***	30.3816	5.1598	4.5106	5.0313	5.9798
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)

Table 1-4　Insurance Efficiency Results

Panel A: Nonspecialist and Personal Line Specialist Comparison

Year	(1) Tnsp(Xnsp,Ynsp)		(2) Tpsp(Xnsp,Ynsp)	(3) Tpsp(Xpsp,Ypsp)		(4) Tnsp(Xpsp,Ypsp)	(5) Cnsp(Xnsp,Ynsp)		(6) Cpsp(Xnsp,Ynsp)	(7) Cpsp(Xpsp,Ypsp)		(8) Cnsp(Xpsp,Ypsp)
Mean	0.9005	***	3.3487	0.9117	***	2.8161	0.6364	***	1.1699	0.7185	***	1.1076
	(0.1218)		(5.4295)	(0.1099)		(3.9196)	(0.2413)		(0.6779)	(0.1814)		(0.6143)
1997	0.9310	**	1.3459	0.8518	***	2.6561	0.7060	***	0.9095	0.6791	***	1.1133
	(0.0670)		(2.1042)	(0.1469)		(3.5703)	(0.1616)		(0.3390)	(0.1961)		(0.8772)
1998	0.9184	***	2.0461	0.9252	***	2.9246	0.5872	***	1.2686	0.6928	***	0.9012
	(0.1152)		(2.6045)	(0.0925)		(4.1458)	(0.1584)		(0.6041)	(0.1730)		(0.4272)
1999	0.8679	***	2.7877	0.9156	***	2.1100	0.6971	***	1.0565	0.7565	***	1.0927
	(0.1533)		(5.1658)	(0.0901)		(2.6604)	(0.1939)		(0.3936)	(0.1503)		(0.5928)
2000	0.9395	***	4.8525	0.9648	***	2.7352	0.6658	***	1.5922	0.8294	***	1.0233
	(0.0673)		(7.0814)	(0.0611)		(3.8253)	(0.2203)		(0.9303)	(0.1182)		(0.3755)
2001	0.8619	***	2.1936	0.9562	***	3.5696	0.6315	***	1.5113	0.7720	***	1.2762
	(0.1641)		(0.7680)	(0.0631)		(5.0309)	(0.3095)		(0.5284)	(0.1650)		(0.4723)
2002	0.8290	***	4.9904	0.9506	***	2.6434	0.5816	***	1.0591	0.7527	***	0.9953
	(0.1581)		(6.0634)	(0.0826)		(3.5060)	(0.2840)		(0.6765)	(0.1958)		(0.4845)
2003	0.8890	***	4.0318	0.9087	***	3.3888	0.6101	***	1.1667	0.7078	***	1.1977
	(0.1164)		(5.7579)	(0.0987)		(5.0629)	(0.2847)		(0.7918)	(0.1800)		(0.6089)
2004	0.9410	***	4.6498	0.8735	***	2.9248	0.5848	***	1.0762	0.6332	***	1.2985
	(0.0595)		(7.3775)	(0.1259)		(3.7441)	(0.2743)		(0.7301)	(0.1793)		(0.6312)

(continued)

Table 1-4 (Continued)

Panel B: Nonspecialist and Nonpersonal Line Specialist Comparison

Year	(1) Tnsp(Xnsp,Ynsp)	(2) Tnpsp(Xnsp,Ynsp)	(3) Tnpsp(Xnpsp,Ynpsp)	(4) Tnsp(Xnpsp,Ynpsp)	(5) Cnsp(Xnsp,Ynsp)	(6) Cnpsp(Xnsp,Ynsp)	(7) Cnpsp(Xnpsp,Ynpsp)	(8) Cnsp(Xnpsp,Ynpsp)
Mean	0.9005	3.2393	0.7349	3.3945	0.6364	1.1172	0.4899	1.0736
	(0.1218)	(5.3923)	(0.2080)	(5.3466)	(0.2413)	(0.9748)	(0.2164)	(1.4151)
1997	0.9310	1.9892	0.7464	2.9134	0.7060	1.0743	0.4935	1.0829
	(0.0670)	(3.2900)	(0.1654)	(5.0437)	(0.1616)	(0.4989)	(0.1941)	(1.1728)
1998	0.9184	2.7011	0.7180	2.2977	0.5872	1.5741	0.4840	1.0675
	(0.1152)	(3.8005)	(0.1947)	(3.5260)	(0.1584)	(0.9858)	(0.2058)	(1.8680)
1999	0.8679	4.3292	0.7615	2.9287	0.6971	1.6798	0.4962	1.0277
	(0.1533)	(5.0325)	(0.1821)	(3.9435)	(0.1939)	(0.8458)	(0.1814)	(1.5561)
2000	0.9395	0.1146	0.7653	4.2324	0.6658	0.0693	0.5085	0.7855
	(0.0673)	(0.0370)	(0.2022)	(6.0499)	(0.2203)	(0.0364)	(0.2008)	(0.2971)
2001	0.8619	0.5809	0.7784	2.5474	0.6315	0.0667	0.5925	1.2409
	(0.1641)	(3.4882)	(0.1894)	(3.1163)	(0.3095)	(0.0323)	(0.2192)	(0.8254)
2002	0.8290	4.4151	0.7299	3.5771	0.5816	1.3336	0.5267	1.4363
	(0.1581)	(5.6525)	(0.2128)	(5.4683)	(0.2840)	(1.0140)	(0.2159)	(1.9773)
2003	0.8890	3.6279	0.6848	2.9134	0.6101	0.5023	0.3642	1.1432
	(0.1164)	(6.4941)	(0.2427)	(5.0437)	(0.2847)	(0.3047)	(0.2306)	(0.5609)
2004	0.9410	5.6022	0.6954	2.2977	0.5848	1.6075	0.4661	0.8313
	(0.0595)	(7.6187)	(0.2536)	(3.5260)	(0.2743)	(1.1830)	(0.2275)	(0.3866)

（*continued*）

Table 1-4 (Continued)

Panel C: Personal Line Specialist and Nonpersonal Line Specialist Comparison

Year	(1) Tpsp(Xpsp,Ypsp)	(2) Tnpsp(Xpsp,Ypsp)	(3) Tnpsp(Xnpsp,Ynpsp)	(4) Tpsp(Xnpsp,Ynpsp)	(5) Cpsp(Xpsp,Ypsp)	(6) Cnpsp(Xpsp,Ypsp)	(7) Cnpsp(Xnpsp,Ynpsp)	(8) Cpsp(Xnpsp,Ynpsp)
Mean	0.9117***	6.9999	0.7349***	5.3928	0.7185***	3.4679	0.4899***	2.0780
	(0.1099)	(5.7224)	(0.2080)	(6.4117)	(0.1814)	(2.5064)	(0.2164)	(2.3184)
1997	0.8518***	5.1555	0.7464***	3.512449	0.6791***	2.6339	0.4935***	1.7126
	(0.1469)	(5.7590)	(0.1654)	(5.0748)	(0.1961)	(2.7350)	(0.1941)	(2.2280)
1998	0.9252***	6.3740	0.7180***	4.433871	0.6928***	3.4107	0.4840***	1.7866
	(0.0925)	(5.4230)	(0.1947)	(5.7522)	(0.1730)	(1.8917)	(0.2058)	(1.8709)
1999	0.9156***	8.9971	0.7615***	4.139512	0.7565***	4.0285	0.4962***	1.6279
	(0.0901)	(5.2760)	(0.1821)	(5.7490)	(0.1503)	(1.8878)	(0.1814)	(2.1072)
2000	0.9648***	7.5131	0.7653***	6.708254	0.8294***	3.6094	0.5085***	2.4507
	(0.0611)	(4.7220)	(0.2022)	(7.2880)	(0.1182)	(1.9532)	(0.2008)	(2.5327)
2001	0.9562***	7.4196	0.7784***	6.812926	0.7720***	3.8567	0.5925***	2.8747
	(0.0631)	(4.4151)	(0.1894)	(6.9775)	(0.1650)	(2.2096)	(0.2192)	(3.3160)
2002	0.9506***	7.9603	0.7299***	7.207143	0.7527***	3.4072	0.5267***	2.3636
	(0.0826)	(6.1818)	(0.2128)	(7.0400)	(0.1958)	(1.5250)	(0.2159)	(2.5715)
2003	0.9087***	4.2028	0.6848***	6.041495	0.7078***	1.2908	0.3642***	2.2925
	(0.0987)	(5.9376)	(0.2427)	(6.2958)	(0.1800)	(0.6404)	(0.2306)	(2.1727)
2004	0.8735***	8.8228	0.6954***	5.202451	0.6332***	5.3567	0.4661***	1.7646
	(0.1259)	(5.7208)	(0.2536)	(6.2782)	(0.1793)	(3.3438)	(0.2275)	(1.1302)

Numbers in parentheses are standard deviations.

Note: Tpsp(Xpsp,Ypsp) = technical efficiency based on personal line specialist frontier; Tnpsp(Xnpsp, Ynpsp) = technical efficiency based on nonpersonal line specialists frontier; Xsp,Ysp = input and output for specialist producer, respectively.

*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level; * Statistically significant difference at 10% level.

Table 1-5 Dominance Statistics by Size Quartile

This table reports Dominance Statistics by size quartile with quartile 1indicating the smallest size quartile; numbers in parentheses are t-tests of the null hypothesis that the means are equal to zero.

		Panel A: Production Frontiers $F_t(y_i,x_i)$		Panel B: Cost Frontiers $F_c(y_i,x_i)$		Panel C: Production Frontiers $F_t(y_i,x_i)$		Panel D: Cost Frontiers $F_c(y_i,x_i)$	
		Nonspecialist	Personal Line Specialist	Nonspecialist	Personal Line Specialist	Nonspecialist	Nonpersonal Line Specialist	Nonspecialist	Nonpersonal Line Specialist
Quartile 1	Mean	-5.27***	0.56***	-0.65***	0.38***	-5.59***	0.63***	-0.70***	0.48***
	T-Test	-8.45	32.61	-11.85	21.07	-8.89	30.69	-8.39	24.33
Quartile 2	Mean	-3.77***	0.52***	-0.73***	0.38***	-2.96***	0.56***	-0.75***	0.45***
	T-Test	-7.04	41.46	-15.39	23.33	-6.47	34.80	-8.68	26.76
Quartile 3	Mean	-1.41***	0.54***	-0.85***	0.40***	-1.24***	0.51***	-0.81***	0.43***
	T-Test	-6.28	38.45	-16.73	29.79	-5.40	24.59	-8.95	21.97
Quartile 4	Mean	-1.11***	0.55***	-0.99***	0.38***	-0.95***	0.51***	-0.74***	0.42***
	T-Test	-14.42	58.75	-18.50	30.38	-6.71	42.68	-7.87	36.43

(continued)

Table 1-5 (Continued)

		Panel E: Production Frontiers $F_t(y_i,x_i)$		Panel F: Cost Frontiers $F_c(y_i,x_i)$	
		Personal Line Specialist	Nonpersonal Line Specialist	Personal Line Specialist	Nonpersonal Line Specialist
Quartile 1	Mean	0.78***	-7.71***	0.60***	-3.38***
		57.64	-19.52	27.60	-18.77
Quartile 2	Mean	0.76***	-5.87***	0.67***	-3.53***
		55.56	-18.59	31.52	-22.49
Quartile 3	Mean	0.77***	-5.12***	0.66***	-3.39***
		58.14	-18.50	28.76	-22.88
Quartile 4	Mean	0.81***	-3.81***	0.75***	-2.72***
		89.76	-20.64	71.63	-19.98

Note: Top number for each quartile is the average of Ft(yi,xi) (production) and Fc(yi,xi) (cost). Bottom number is t-tests of the null hypothesis that the average of dominance statistics is equal to zero.
*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level;
* Statistically significant difference at 10% level

Table 1-6 Summary Statistics

	Nonspecialists			Specialists		Personal Line Specialists			Nonpersonal Line Specialists	
	Mean	STD		Mean	STD	Mean	STD		Mean	STD
Log Asset	$18.26	$1.96	***	$17.87	$1.92	$18.04	$1.83	***	$17.77	$1.96
ROE Standard Deviation	7.16%	8.28%	***	8.63%	19.21%	8.50%	12.62%		8.70%	22.14%
WCONC	1.8E-04	6.2E-04	***	3.6E-04	1.7E-03	2.1E-04	1.5E-03	***	4.5E-04	1.8E-03
Capital to Asset Ratio	45.45%	20.42%	**	47.18%	20.67%	46.30%	17.81%		47.69%	22.15%
Agent balance ratio	17.97%	16.71%	**	16.57%	15.91%	16.57%	15.73%		16.57%	16.02%
Stock	72.19%	44.83%		74.75%	43.45%	73.88%	43.96%		75.25%	43.17%
Vertical Integration	9.06%	28.72%	***	25.68%	43.70%	29.97%	45.85%	***	23.16%	42.20%

Note. STD= Standard deviation. Nonpersonal line Insurance Output % is the loss incurred in the nonpersonal line of insurance divided by total loss incurred. Cost efficiency is product of technical efficiency and allocative efficiency based on DEA. WCONC is industry concentration measurement and it equals weighted sum of market share per line multiplied by line-specific Herfindahl. The line-specific Herfindahl for each line of insurance for *i*th insurer in year t is calculated as follows:

$HHI_{lt} = \sum_{i=1}^{n} \left(P_{ilt} / P_{lt}\right)^2$ where P_{ilt} is premium written for each line of business for *i*th insurer in year t. Each insurer's concentration for each line of insurance is calculated as follows:

$w_{ilt} = P_{ilt} / P_{it}$ Industry concentration measurement is equal to the weighted sum of market share per line multiplied by line-specific Herfindahl.

$WCONC_{it} = \sum_{l=1}^{29} w_{ilt} \times HHI_{lt}$ Capital to asset ratio is policyholder surplus to total asset ratio. Agent balance ratio= Agent balance /direct premiums written. Stock Dummy = 1 if insurer is stock insurer, 0 for mutuals. Vertical Integration Dummy =1 if insurer distributes its product through exclusive agents, direct marketing, mass marketing, or a combination.*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level.

Table 1-7 Regression Analysis：Cost Dominance Statistics for Nonspecialists v.s. Specialists

	Panel A: Nonspecialists vs. Personal line specialists		Panel B: Nonspecialists vs. Nonpersonal line specialists		Panel C: Personal line specialists vs. Nonpersonal line specialists	
Independent variables	Coefficient	T stat	Coefficient	T stat	Coefficient	T stat
Intercept	-1.2454***	-4.84	-1.6171***	-4.52	-8.8014***	-8.41
Specialized Strategy	1.9276***	5.29	3.5476***	7.44	10.4462***	6.23
ROE Standard Deviation	0.2592	0.88	-2.9202***	-7.05	-0.5432*	-1.70
ROE Standard Deviation*Specialized Strategy	-0.1592	-0.48	2.9953***	7.08	0.1317	0.16
Capital to Asset Ratio	1.5652***	11.90	1.5050***	8.22	2.5246***	6.05
Capital to Asset Ratio*Specialized Strategy	-1.8138***	-10.40	-1.7472***	-7.78	-3.2829***	-4.62
WCONC	3.2652	0.11	21.8639	0.51	-61.9114	-1.35
WCONC*Specialized Strategy	-1.3702	-0.04	-13.9976	-0.31	54.8097	0.69
Log Asset	-0.0044	-0.36	0.0112	0.66	0.2523***	4.98
Log Asset*Specialized Strategy	0.0061	0.35	-0.0786***	-3.43	-0.2587***	-3.20
Stock	0.1305***	3.15	0.3067***	5.32	0.4813***	2.96
Stock*Specialized Strategy	-0.0703	-1.17	-0.3434***	-4.49	-0.4612*	-1.68
Vertical Integration Dummy	-0.1070*	-1.70	0.1159	1.33	-0.1919	-1.10
Vertical Integration Dummy *Specialized Strategy	0.0937	1.23	0.0965	0.93	0.1787	0.64
Adjusted R-square	0.6548		0.5940		0.4134	

Note. Specialized Strategy equals 1 if insurer is specialist, 0 otherwise in the fist two equations and equals 1 if insurer is personal line specialist, 0 otherwise in the third equation. WCONC is industry concentration measurement and it equals weighted sum of market share per line multiplied by line-specific Herfindahl. The line-specific Herfindahl for each line of insurance for *i*th insurer in year t is calculated as follows: $HHI_{lt}=\sum_{i=1}^{h}\left(P_{ilt}/P_{lt}\right)^2$ where P_{ilt} is premium written for each line of business for *i*th insurer in year t. Each insurer's concentration for each line of insurance is calculated as follows: $w_{ilt}=P_{ilt}/P_{it}$ Industry concentration measurement is equal to the weighted sum of market share per line multiplied by line-specific Herfindahl. $WCONC_{it}=\sum_{l=1} w_{ilt}\times HHI_{lt}$; Log Asset= log of total assets. Stock Dummy = 1 if insurer is stock insurer, 0 for mutual. Vertical Integration Dummy =1 if insurer distributes its product through exclusive agents, direct marketing, mass marketing, or a combination. Year dummies not are shown.*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level.

Appendix A

Table 1-A1 Test of Insurance Cross-Frontier Efficiency Results

Panel A: Efficiency Results from Cross Frontier：Nonspecialist and Personal Line Specialist Comparison

	(1) Tpsp(Xnsp,Ynsp)		(2) Tnsp(Xpsp,Ypsp)		(3) Cpsp(Xnsp,Ynsp)		(4) Cnsp(Xpsp,Ypsp)	
Mean	3.3487	***	2.8161	***	1.1699	***	1.1076	***
	(5.4295)		(3.9196)		(0.6779)		(0.6143)	
1997	1.3459	**	2.6561	***	0.9095		1.1133	
	(2.1042)		(3.5703)		(0.3390)		(0.8772)	
1998	2.0461	***	2.9246	***	1.2686	***	0.9012	
	(2.6045)		(4.1458)		(0.6041)		(0.4272)	
1999	2.7877	***	2.1100	***	1.0565	*	1.0927	*
	(5.1658)		(2.6604)		(0.3936)		(0.5928)	
2000	4.8525	***	2.7352	***	1.5922	***	1.0233	
	(7.0814)		(3.8253)		(0.9303)		(0.3755)	
2001	2.1936	***	3.5696	***	1.5113	***	1.2762	***
	(0.7680)		(5.0309)		(0.5284)		(0.4723)	
2002	4.9904	***	2.6434	***	1.0591		0.9953	
	(6.0634)		(3.5060)		(0.6765)		(0.4845)	
2003	4.0318	***	3.3888	***	1.1667	**	1.1977	***
	(5.7579)		(5.0629)		(0.7918)		(0.6089)	
2004	4.6498	***	2.9248	***	1.0762		1.2985	***
	(7.3775)		(3.7441)		(0.7301)		(0.6312)	

Table 1-A1 (Continued)

Panel B: Efficiency Results from Cross Frontier：Nonspecialist and Nonpersonal Line Specialist Comparison								
	(1) Tnpsp(Xnsp,Ynsp)		(2) Tnsp(Xnpsp,Ynpsp)		(3) Cnpsp(Xnsp,Ynsp)		(4) Cnsp(Xnpsp,Ynpsp)	
Mean	3.2393	***	3.3945	***	1.1172	***	1.0736	**
	(5.3923)		(5.3466)		(0.9748)		(1.4151)	
1997	1.9892	***	2.9134	***	1.0743	**	1.0829	
	(3.2900)		(5.0437)		(0.4989)		(1.1728)	
1998	2.7011	***	2.2977	***	1.5741	***	1.0675	
	(3.8005)		(3.5260)		(0.9858)		(1.8680)	
1999	4.3292	***	2.9287	***	1.6798	***	1.0277	
	(5.0325)		(3.9435)		(0.8458)		(1.5561)	
2000	0.1146		4.2324	***	0.0693		0.7855	
	(0.0370)		(6.0499)		(0.0364)		(0.2971)	
2001	0.5809		2.5474	***	0.0667		1.2409	**
	(3.4882)		(3.1163)		(0.0323)		(0.8254)	
2002	4.4151	***	3.5771	***	1.3336	***	1.4363	***
	(5.6525)		(5.4683)		(1.0140)		(1.9773)	
2003	3.6279	***	2.9134	***	0.5023		1.1432	**
	(6.4941)		(5.0437)		(0.3047)		(0.5609)	
2004	5.6022	***	2.2977	***	1.6075	***	0.8313	
	(7.6187)		(3.5260)		(1.1830)		(0.3866)	

(continued）

Table 1-A1 (Continued)

Panel C: Efficiency Results from Cross Frontier：Personal Line Specialist and Nonpersonal Line Specialist Comparison								
	(1) Tnpsp(Xpsp,Ypsp)		(2) Tpsp(Xnpsp,Ynpsp)		(3) Cnpsp(Xpsp,Ypsp)		(4) Cpsp(Xnpsp,Ynpsp)	
Mean	6.9999	***	5.3928	***	3.4679	***	2.0780	***
	(5.7224)		(6.4117)		(2.5064)		(2.3184)	
1997	5.1555	***	3.512449	***	2.6339	***	1.7126	***
	(5.7590)		(5.0748)		(2.7350)		(2.2280)	
1998	6.3740	***	4.433871	***	3.4107	***	1.7866	***
	(5.4230)		(5.7522)		(1.8917)		(1.8709)	
1999	8.9971	***	4.139512	***	4.0285	***	1.6279	***
	(5.2760)		(5.7490)		(1.8878)		(2.1072)	
2000	7.5131	***	6.708254	***	3.6094	***	2.4507	***
	(4.7220)		(7.2880)		(1.9532)		(2.5327)	
2001	7.4196	***	6.812926	***	3.8567	***	2.8747	***
	(4.4151)		(6.9775)		(2.2096)		(3.3160)	
2002	7.9603	***	7.207143	***	3.4072	***	2.3636	***
	(6.1818)		(7.0400)		(1.5250)		(2.5715)	
2003	4.2028	***	6.041495	***	1.2908	***	2.2925	***
	(5.9376)		(6.2958)		(0.6404)		(2.1727)	
2004	8.8228	***	5.202451	***	5.3567	***	1.7646	***
	(5.7208)		(6.2782)		(3.3438)		(1.1302)	

Note: T indicates cross-frontier technical efficiency; C indicates cross-frontier cost efficiency. Subscript on T or C signifies the frontier on which the efficiency score are based. In panel A, Tpsp(Xnsp,Ynsp) = technical efficiency for nonspecialist based on personal line specialist frontier; Tnsp(Xpsp,Ypsp) = technical efficiency for personal line specialist based on nonspecialist frontier; In panel B, Tnpsp(Xnsp,Ynsp) = technical efficiency for nonspecialist based on nonpersonal line specialist frontier; Tnsp(Xnpsp,Ynpsp) technical efficiency for nonpersonal line specialist based on nonspecialist frontier; In panel C, Tnpsp(Xpsp,Ypsp) = technical efficiency for personal line specialist based on nonpersonal line specialist frontier; Tpsp(Xnpsp,Ynpsp) = technical efficiency for nonpersonal line specialist based on personal line specialist frontier.

*** Statistically significant difference at 1% level or better; ** Statistically significant difference at 5% level; * Statistically significant difference at 10% level.