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ECONOMIES OF SCALE IN THE AUTO INSURANCE INDUSTRY

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Abstract

This thesis explores economies of scale for insurance firms. It begins with a discussion on the theory economies of scale and firm efficiency. There is also a literature review concerning previous studies on economies of scale in various insurance industries. To conclude, a sample of auto insurance firms chartered in New York over a period from 2006 to 2009 is analyzed for evidence of economies of scale. This was achieved using data from AM Best Insurance Ratings Guide. Ordinary Least Square and Fixed Effect regressions are run and provide similar results that suggest economies of scale exist for the sample of insurance firms.

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Introduction

Economies of scale play an important role in almost every industry. If a firm is able to indentify an advantage to expanding before their competition, they are able to grow their market share, and gain profits. While this advantage is easier to conceptualize in manufacturing industries, economies of scale also exist in services. In particular, an exploration of economies of scale in the insurance industry can provide specific insights. For example, relatively recent technological and product advancements make insurance an industry that could see efficiency improvements.

The insurance industry is one where profits are highly dependent on obtaining information and interpreting it properly. Therefore, information storage is of high importance, and the widespread use of computers for data storage should allow insurance industries to see major improvements in efficiency. On the other hand, insurance products have also become much more complicated at the same time. For example, universal life insurance requires a firm to track stocks or other investments, as dictated by the policyholder.[1] This product innovation could result in a decrease in efficiency, as the firm has more to do for each customer.

For the insurance industry, economies of scale have added importance as the industry is subject to more strict regulations than many other industries. Since insurance is regulated on a state level, mergers will be subject to the insurance commissioner's approval. Therefore, the policy implications of economies of scale are an important factor that would go into the decision to allow a merger or acquisition on the part of the insurance commissioner.

Previous studies have shown different results depending on the time period, sector of the industry studied, and the methodology used to determine the existence of economies of scale.

[1] Black & Skipper (2000, pp. 113-133)

The most prevalent result, however, suggests that there are economies of scale for smaller insurers until a certain point, and then the advantages to increasing returns diminish.

This paper will provide background information on economies of scale, in general and also as the topic pertains to the insurance industry. Then, a model will be developed using data from U.S. auto insurance firms to look for evidence of economies of scale. The results that are provided will be used to draw policy implications for regulation of the insurance industry.

Economies of Scale

Economies of scale refer to a situation when a given percentage increase in input will result in a greater percentage increase in output. In other words, the cost to produce a unit of a good will decrease as the volume of output increases. This can also be referred to as increasing returns to scale.[2]

In manufacturing industries, it is easy to conceptualize economies of scale by considering fixed, variable, and marginal costs. Fixed costs, such as factories or machinery, are constant no regardless of the volume of output being produced. For this reason, increasing output will allow fixed costs to be spread over a higher volume of goods. Since the marginal cost to produce each unit of a good is constant regarding variable costs, spreading fixed costs over a higher volume of output will result in a lower marginal cost.

As a result, economies of scale frequently occur in industries where there are high fixed costs. Consider a firm that produces airplanes. This firm would require extremely high facility costs as well as specialized equipment in order to begin production. If this firm produced only one airplane, all of these facility costs, or fixed costs, would count as the cost for this single plane. Therefore, each additional plane that is produced will result in a drastically reduced marginal cost, which will result in economies of scale.

On the other hand, an industry that is not capital intensive, such as computer software will have costs of production that are mostly from paying laborers to develop new software. This firm will not heavily rely on other, highly expensive, forms of capital, such as factories. Therefore, fixed costs are not very high, and each additional unit produced does not reduce the marginal cost by a large amount. In this case, constant returns to scale are more likely to be

[2] Black & Skipper (2000, pp. 7-8)

observed. This means that each percentage increase in inputs will result in an equal percentage increase in output.

Economies of scale also apply to service industries. When conceptualizing economies of scale, it is again helpful to consider fixed costs. Take, for example, a financial consulting firm. This firm will have a certain number of computers that will, in general, not change based on the number of firms they consult. Therefore, by agreeing to consult one additional firm, they are spreading their fixed cost, in this case computers, among more firms, and thus reducing marginal costs. However, in this instance, there will come a point where adding an additional customer will require the firm to hire additional labor, and thus increase variable costs. Therefore, economies of scale in service based industries will require similar considerations when compared to manufacturing industries.

Costs are not the only factors that can result in economies of scale. As an example, consider a situation in which a firm can reduce cost by buying in bulk from their supplier. This is a common practice in which a supplier will give a buyer a lower per-unit cost in exchange for purchasing a large quantity of their product. In this case, input costs are lower for the same output, which contributes to increasing returns to scale. Another situation could be one in which it is advantageous to produce a product in larger batches. An example of this would be steel, in which it is easier to produce a large quantity than smaller ones. Therefore, costs will decrease as larger batches are produced, and increasing returns to scale can be achieved.

The insurance industry is a service industry that involves firms providing consumers with protection against risk in exchange for a fee. According to Katrishen and Scordis (1998)

insurance firms can achieve economies of scale in four areas: Rate making, underwriting, claims settlement, and investments.[3]

Rate making involves setting the price of an insurance policy based on estimates of its cost. Insurance firms directly benefit from these estimates by utilizing the law of large numbers. If a firm is estimating the probability that one individual will experience a loss, there is a high variance in whether that loss will occur or not, and thus whether the insurance firm must pay the claim. However, as the number of policies sold becomes very large, the variance per policy will approach zero, and firms will be able to more accurately determine what price they should charge for a policy. This also helps firms to charge less for risk, allowing them to be more competitive in the market for insurance.

Underwriting is the process of accepting or denying customers based on their history and then categorizing them into policy groups. An insurance company will not be able to charge the same premium to all customers, or they would lose low risk customers. As an example, in the life insurance industry if there are two customers applying for policies who are identical, except one is a smoker, the firm should charge the smoker a higher premium, as there is a higher chance that this customer will die earlier due to the health risks associated with smoking. If both customers were charged the same amount, and the risks of death were accurately assessed, then the non-smoker is being overcharged in order to compensate for the higher risk of the smoker. In the long run, if other insurance firms are charging less to non-smokers, this customer will choose to purchase insurance from a firm that more accurately assesses their risk characteristics, and the firm that charges an equal amount to both consumers will begin to lose low-risk customers. For this reason, it is important for insurance firms to underwrite correctly.

[3] Katrishen and Scorids (2008)

Claims settlement involves validating that the insured event occurred. While this may seem trivial, it can often be troublesome for insurance firms. For example, in life insurance the firm will have to investigate a situation in which a policyholder died soon after purchasing a policy. It could be the case that this individual falsified their application and did not mention an illness that resulted in their death. In this case, a claim would not be paid out. Another example involves casualty insurance in the case of a home burning down. If a policyholder burned down their home on purpose in order to collect the payout, the insurance firm will not make this payment, as it is not covered in standard policies. Insurance firms can improve efficiency by controlling these types of losses.

A large portion of revenue comes to insurance firms through profits made on investments. The life insurance industry, though heavily regulated in regard to in what they are able to invest, controls a huge amount of assets that make their investments a large source of income. Government regulations require slow growth in these firms in order to dissuade risky investments that could jeopardize the firm's survival. Unlike firms in other industries, societal welfare is adversely impacted by an insurance firm's insolvency. Since life insurance involves a long term contract, insolvency can result in thousands of lost dollars to a policyholder who has been paying a premium for many years. Fear of insolvency has led to regulations that restrict the risks that insurance firms are allowed to take. As far as investments, this means that firms generally invest heavily in the bonds market, as this is a less risky investment than stocks or derivatives, albeit at a smaller return. This makes it difficult for insurance firms to make large gains through investments, and has resulted in firms adopting products such as universal life insurance, which allows customers to take on the risk that the insurance company is unwilling to through allowing individuals to make investment decisions about the money they have paid for

their policy. Insurance firms must find a balance between a suitable return and an amount of risk that does not jeopardize the firm's solvency.

Performing efficiently in these four areas will result in economies of scale for an insurance firm. In theory, recent changes in technology would allow for insurance firms to become more efficient because of the information intensive nature of insurance. Indeed, all firms that rely on data collection and interpretation should be able to observe an increase in efficiency when accounting for computers and their implementation into the workplace. Firms such as GEICO now operate primarily through the internet, an unavailable option in the past. For health insurance, the recent technological advancements have improved communication between physicians and insurance firms necessary in the underwriting process. These are among the many factors that should show increases in economies of scale.

However, there are other factors that have simultaneously occurred, primarily within the life-health industry, which decrease efficiencies, and thus economies of scale. Specifically, product advancements to more complicated products results in decreased efficiency. Universal life insurance is an example of this increased complexity since, as mentioned previously, the policy allows a customer to invest the policy reserves as desired, as opposed to a low interest rate that is based on the investments of the insurance firm as a whole. This requires tracking where the customer would like the funds to be invested, and this can change over the life of the policy. This means that the insurance firm must keep track of far more transactions and investments as each policyholder will have different investments. This would result in a decrease in efficiency as there is more work to do for a similar amount of customers. The simultaneous increases and decreases in efficiency make this something worthy of further study.

Literature Review

Cummins (1977) laid the groundwork in regard to insurance firms and economies of scale. However, the author is looking at independent insurance agencies as opposed to insurance firms. Cummins attempted to justify allowing independent insurance agencies merging. His findings, however, show that there are no cost benefits to allowing agencies to merge.

Katrishen and Scordis (1998) use data from AM Best Insurance Ratings Guide in order to analyze economies of scale relating to international insurers. The authors analyzed insurers from 1985 until 1992 who operated internationally. They implemented a log-linear model with operating expenses as the dependent variable and premiums written as the independent variable. Their findings show that international insurers experience economies of scale only up to a certain point. Additionally, they found that more internationally diverse firms may experience diseconomies of scale after expanding to a certain level, questioning the value of vast international expansions. The authors made the decision to make a tradeoff between data reliability and the amount of data the authors were able to collect. By using A.M. Best, they have very reliable data, but fewer observations for each data point, as A.M. Best does not include as much data as could be found by other means.

Khaled, Adams, and Pickford looked at scale and scope economies in New Zealand in their 2001 article. They utilized a two-input two-output generalized translog model over the period from 1988 to 1992 to test for efficiency over 135 observations. Their findings that there is an optimal size of firms and larger firms experience constant returns to scale demonstrates consistency with other studies. They also investigated economies of scope, which analyzes whether there are advantages to expanding product lines. Their findings suggest that small and medium sized firms experience diseconomies of scope, or will be at a disadvantage from offering

additional products, while large sized companies neither profit or lose from expanding their product offerings.

In a 2004 paper Hirao and Inoue looked at the property-casualty insurance industry in Japan and analyzed its cost structures. As with Khaled, Adams, and Pikford the authors analyze both economies of scale and economies of scope. They took a dataset of insurers from 1980 to 1995 and estimate a cost structure before implementing an error components model. The authors found statistically significant economies of scale for Japanese insurers over this period. Interestingly, unlike American insurers, which are tightly regulated, this study occurred over a period in which regulations of insurers were relaxed.

Bikker and van Leuvensteijn (2008) examined efficiency within the Dutch life insurance industry and determined that there are substantial returns to scale. The authors' conclusions suggest that many Dutch life insurers are well below the optimal size to maximize efficiency, and thus further consolidation should be encouraged. The efficiencies experienced in this industry are higher than other industries within the Netherlands, as well as when compared to insurers in other countries.

Bikker and Gorter (2011) analyzed the Dutch non-life insurance industry over a period from 1995 to 2005 following vast deregulation across Europe, starting in 1994. Dutch firms began to consolidate and increased in size when deregulation occurred with the Third Generation Insurance Directive which was passed by the European Union in 1994. Bikker and Gorter find that there are economies of scale across all insurers, but primarily among smaller insurers.

Data

Data were collected from the 2010 Best's Key Rating Guide for the United States & Canada. For the sample, all auto insurers based in New York were selected. There are 23 firms included, and for each data from 2006 to 2009 were collected. This is summarized with averages of relevant variables in the table below.

Table 1: Summary of Data

	2006	2007	2008	2009
Net Premiums Written	46,597	51,408	47,876	54,699
Net Underwriting Income	-1,358	842	-1,639	-3,226
Net Investment Income	3,822	4,115	3,689	3,257
Net Income	2,864	4,784	3,072	413
Expenses	14,566	16,582	15,763	18,435

As the data had to be manually collected, the quantity of data is limited. Therefore, New York was chosen to provide consistency in the comparison of firms. New York has some of the strictest insurance regulations of the all states in America, so this was a reasonable state to analyze. While there are only 23 firms in the sample, panel data has been collected. Note that the period for which data is available includes the financial crash of 2008. There are noticeable drops in averages following this crash. However, the data from 2006 and 2007 includes more stable financial times in the sample.

Data from each firm's income statements and balance sheets were available. Net premiums written is the amount of money collected from premiums, minus any fees or reinsurance payments. This also excludes any reductions for dividends that have been paid to

shareholders. Net investment income is the amount of investment income earned minus investment expenses and depreciation on real estate. Net income is each firm's revenue that has been generated from operations and capital gains, as compiled by AM Best from each firm's NAIC annual statement.

A firm's expenses had to be calculated from other data that was present in Best's Ratings Guide. Specifically, each firm had an expense ratio, which is the ratio of underwriting expenses to net premiums written. Expenses were calculated by multiplying the expense ratio by each firm's net premiums written for each year in the sample. This is a key part of the analysis as, according to A.M. Best, "[the expense ratio] measures the company's operational efficiency in underwriting its book of business." Since efficiency is vital to looking at economies of scale, each firm's expenses and net premiums written are essential to this study. [4] [5]

[4] http://www.ambest.com/resource/glossary.html#N
[5] Graphs that look at the relationship between net premium income and expenses are provided in the appendix.

Model

One way to analyze these data to test for economies of scale is ordinary least square regression.

Equation 1: Ordinary Least Squares Regression

$$ln\,(Expenses)_i = \beta_0 + \beta_1\, ln(Net\ Premiums\ Writen_i) + \cdots + \varepsilon_i$$

$$for\ each\ observation\ i$$

$$such\ that\ i\ is\ a\ firm\ over\ one\ year$$

This is based on the model used by Katrishen and Scordis (1998). Therefore, ln(Expenses) will be the dependent variable and ln(net premiums written) will be the independent variable of interest. Logs are used to analyze how the percentage change in net premiums written will impact the percentage change in expenses. This assumes that expenses will not change linearly with premiums, but their percentage chance will be linear with respect to the percentage change in premiums.

With regression results, β_1 can be interpreted as the percentage change in expenses for a 1% change in net premiums written. Economies of scale would exist for β_1 values less than 1. In other words, if premiums increase by 1%, expenses could go up by some amount that is less than 1%.

A model that includes only net premiums written as the independent variable will be run first. A second model will include other forms of income to prevent any omitted variable bias in the regression results.

A more sophisticated model can be run due to the nature of the data that were collected. Specifically, the data are in panel form, meaning that information for each firm is available over numerous years. This allows a fixed effects model to be utilized

Equation 2: Fixed Effects Regression

$$\ln(Expenses)_{it} = \boldsymbol{X}_{it}\beta + \alpha_i + u_{it}$$

$$for\ t = 2006, 2007, 2008, 2009$$

$$for\ firms\ i = 1, 2, \ldots, 23$$

In this model, $\mathbf{X}_{it}$ is a matrix of control factors, in this case the log of net premiums written and other sources of firm income. The error terms are α_i and u_{it}, with α_i being unobservable, time-invariant effects for each firm *i*.

The fixed effects model allows for better control of unobserved heterogeneity among the variables. In other words, using this model elucidates some of the unobservable differences between the firms in the sample. In this case, the unobservable differences are represented by differences in how each of the firms operates. Ordinarily this would be difficult to quantify, but with observations from each firm over time, these differences can be controlled for in the final result. This model requires the assumption that these firms do not experience major changes over the utilized time period.

As with the OLS regression, a model that includes only net premiums written as the independent variable will be run first. A second model will include other forms of income to prevent any omitted variable bias in the regression results.

Results

The results of the OLS regression can be seen in the following table. The estimate for each coefficient β for each independent random variable is shown, with the standard error of each coefficient in parentheses beneath it.

Table 2: Ordinary Least Squares Regression on ln(Expenses)

	Model 1	Model 2
ln(Premiums Written)	0.7171077*	0.5362622*
	(0.0552572)	(0.0785603)
ln(Net Investment Income)	-	0.2803904*
	-	(0.0947534)
Net Underwriting Income	-	-0.0000138*
	-	(3.21×10^{-6})
Constant	6.512669*	6.166907*
	(0.5831308)	(0.4271251)
R^2	0.8252	0.8793

*** Significant at the 5% Level**

The results of the fixed-effects regression can be seen in the following table. The coefficient for each independent random variable is shown, with the standard error of each coefficient in parentheses beneath it.

Table 3: Fixed Effect Regression on ln(Expenses)

	Model 1	Model 2
ln(Premiums Written)	0.7349981*	0.7165077*
	(0.2170308)	(0.2317663)
ln(Net Investment Income)	-	0.0372073
	-	(0.0864785)
Net Underwriting Income	-	-3.81×10^{-6}
	-	(2.53×10^{-6})
Constant	6.300126	6.202681*
	(2.107248)	(2.079435)
R^2 Overall	0.8252	0.8401

*** Significant at the 5% Level**

Interpretation

From Table 2 in the previous section, the percentage increase in expenses based on a 1% increase in net premiums written can be calculated. These results, based on the OLS regression, are presented in the following table.

Table 4: Percentage Increase in Expenses (Ordinary Least Squares)

Model 1	Model 2
0.7171077	0.5362622

These results suggest the presence of economies of scale. If a firm increases net premiums written by 1%, it would then expect to see only a 0.72% increase in expenses, based on Model 1. Similarly, Model 2, which includes additional variables, shows that for an increase in net premiums written by 1%, it would expect to see a 0.54% increase in expenses. This second model includes additional income variables to help control for omitted variable bias.

This model assumes that firms control their net premiums written. As an example, firms instruct agents to sell more policies. These policies result in higher expenses, since the firm must now provide service to all of these new policies. These results suggest that these expenses will not increase by as much as the increase in net premiums written.

This example illustrates that a firm is more efficient if they increase sales. In other words, these efficient firms are exhibiting economies of scale, since as they increase their size, they are able to increase expenses at a lower rate, and thus improve profits.

From Table 3 in the previous section, the percentage increase in expenses based on a 1% increase in net premiums written can be calculated. These results, based on the fixed effects regression, are presented in the following table.

Table 5: Percentage Increase in Expenses (Fixed Effects)

Model 1	Model 2
0.7349981	0.7165077

As with the OLS results in Table 4, these results suggest the existence of economies of scale. If a firm increases net premiums written by 1%, it would then expect to see a 0.73% increase in expenses, based on Model 1. Similarly, Model 2 shows that for an increase in net premiums written by 1%, it would expect to see a 0.72% increase in expenses.

These results are quite similar to each other, and also to Model 1 of the OLS regression. This would indicate that auto insurers in New York are relatively homogenous, as adding differences among the firms does not greatly alter the result. Due to the heavy regulation of the insurance industry, this is not surprising.

Utilizing the fixed effects model does not result in greatly different results from the ordinary least squares regression. This suggests that differences between these firms are adequately represented in the variables present in the ordinary least squares model. The graph in Appendix C shows that ln(net premiums written) and ln(expenses) are quite linear, suggesting that the ordinary least squares regression may be adequate.

Model 2 from the OLS regression is a different result from the other three regressions. This could be caused by multicollinearity between net premiums written and net underwriting income. In other words, adding net underwriting income could be correlated with net premiums written. Adding this to the model would result in an inaccurate estimation of the coefficient of the natural log of net premiums written.

An additional concern in Model 2 is that net underwriting income comes out to be negative, but significant in both regressions. This result suggests that ln(expenses) would

decrease as net underwriting income increases, which does not make sense. While this is not the variable of interest, this result raises questions about the accuracy of the second model.

These results suggest evidence of economies of scale, which implies that, on an individual basis, firms could increase profits from expansion. Each individual firm could expect to see a positive return on their expenses on the margin. This would indicate that firms could achieve higher profits by either expanding or merging.

One consideration in this is that profits will not be captured if all firms expand simultaneously. This would result in an oversaturation of the market which has many implications, such as an increase in supply that results in lower prices for insurance. These lower prices could have a negative impact on the profitability of each firm. Therefore, expansion is only beneficial when considering each individual firm.

A second consideration is that these results are accurate at the margin. This means that there will be diminishing returns on profits when increasing expenses. In other words, a firm can only increase expenses to a certain point before they stop experience economies of scale. While this is not reflected in the model, it cannot be the case that firms would be able to infinitely expand and continue to make profits. At some point a 1% increase in net premiums written will result in a 1% increase in expenses. Further research can build off this research to find this value.

Conclusion

The analysis of economies of scale is a way to look at firm efficiency, which is important for the growth of firms. The results of this study apply to both firms and policymakers. In order to stay ahead of their competition, firms must always look for means to improve efficiency at a rate faster than other firms in the market. That an individual firm can earn higher profits through expansion is one such way of outpacing the competition

These advantages are particularly important in insurance firms, where there is not a high degree of product differentiation. In auto insurance a certain type of policy, such as collision coverage, is the same no matter which firm an individual purchases from. There may be minor differences in claims services or the availability of help services, but overall the product is identical. This contrasts significantly from other industries where firms can compete on the quality of their product. This eliminates one of the key methods for competition that exists in other markets, making all other means of competing all the more important. Thus, information on the value of expansion should be valued highly by executives at insurance firms.

Policymakers have an interest in economies of scales in order to temper firm growth. Firms that are expanding too quickly could be doing so by taking too many risks. The risk-reward relationship could result in high profits for firms early in their expansion, but at some point the risks could lead to insolvency in these firms. This situation is highly unfavorable for everyone, as state governments require individuals to own auto insurance. Insolvency would then leave individuals searching for alternative coverage. Studies of economies of scale can show policymakers to what degree insurance firms can expand without increasing the risk of insolvency.

Policymakers also have an interest in monitoring monopolies in the insurance industry. Firms often use an argument of economies of scale when applying for merger approval from the government. The results of this study suggest that mergers result in improved efficiency. However, these results do not provide information on the effects of monopolistic behavior from insurance firms.

Numerous areas could be improved upon in future studies in the area of economies of scale. The main limitation presented in this study was data acquisition. Numerous studies in the past were able to implement more rigorous econometric methods when testing for economies of scale. The method of data collection and the metrics that are available precluded the application of these methods.

Another area of expansion could be to analyze a larger cross section of firms. Expanding the number of firms from the 23 studied here would test if there are interstate differences that result from different regulations. Having firms across a larger period of time could also provide more rigorous results.

Exploration of different areas of the insurance industry would also provide interesting points of comparison. For example, firms that operate in the life and/or health sectors of the insurance industry could have very different results when examined for economies of scale. Additionally, as studies have done in the past, future research could analyze multinational insurers to see if modern firms benefit from technological improvements.

A final way in which future studies could improve is to also analyze economies of scope. The data available in this study were not sufficient to test for benefits to firm profits from expanding product line offerings, but this is a concept that is closely tied to economies of scale, and is worth analyzing as technological improvements could result in higher benefits to firms.

Appendix A: List of Firms used in the Study

A. Central Insurance Company

Adirondack Insurance Exchange

American Transit Insurance Co

Business Alliance Insurance Company

Castlepoint Florida Ins Co

Country-Wide Insurance Co

Driver's Insurance Company

Eveready Insurance Company

Executive Insurance Company

Generali USB

Global Liberty Ins Co of NY

Hereford Insurance Company

Kingstone Insurance Company

Lancer Insurance Company

Maya Assurance Company

New York Municipal Ins Recip

North East Insurance Company

Park Insurance Company

Preferred Mutual Ins Co

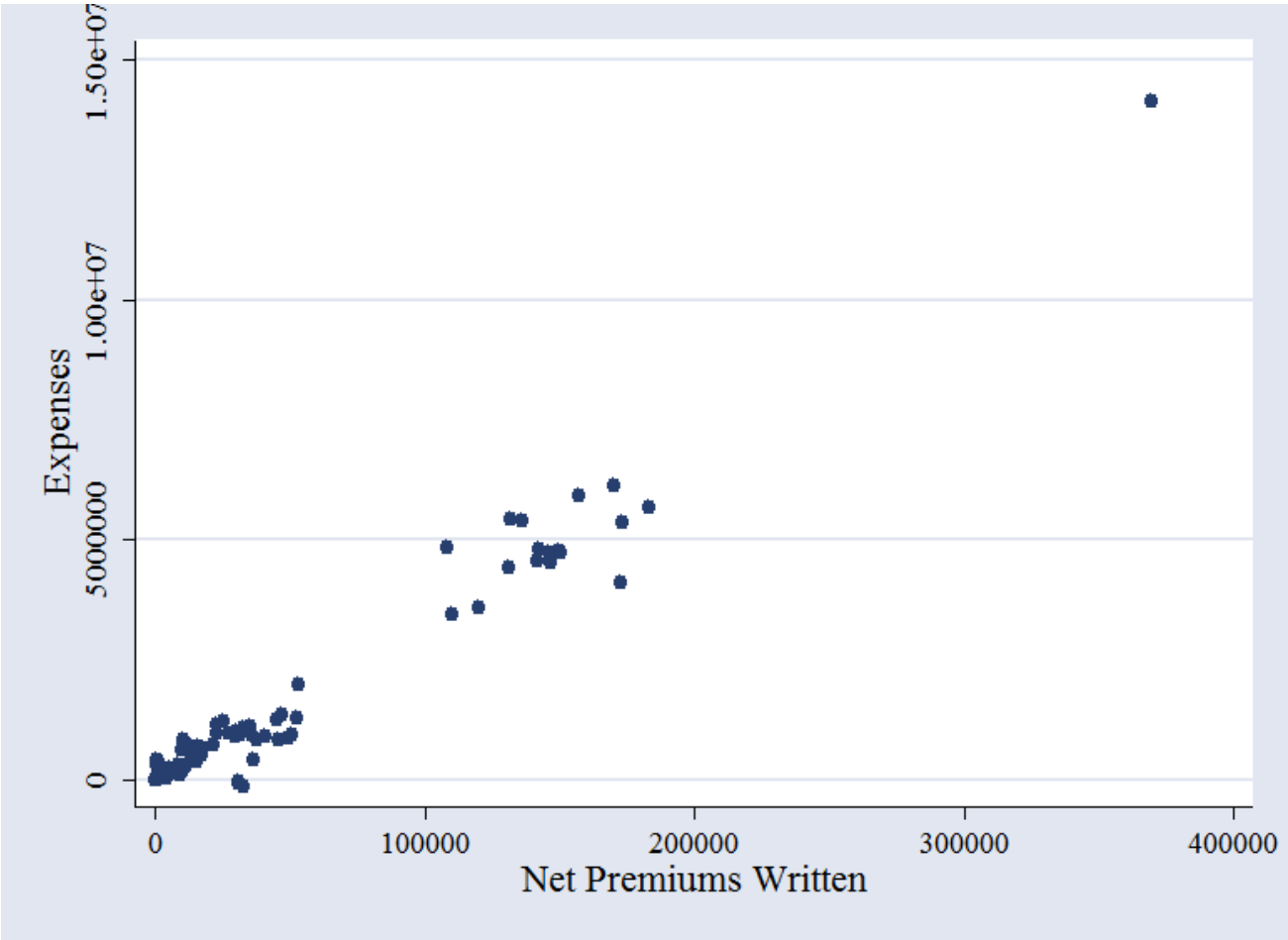
PURE Insurance Company

QBE Insurance Corporation

State-Wide Insurance Company

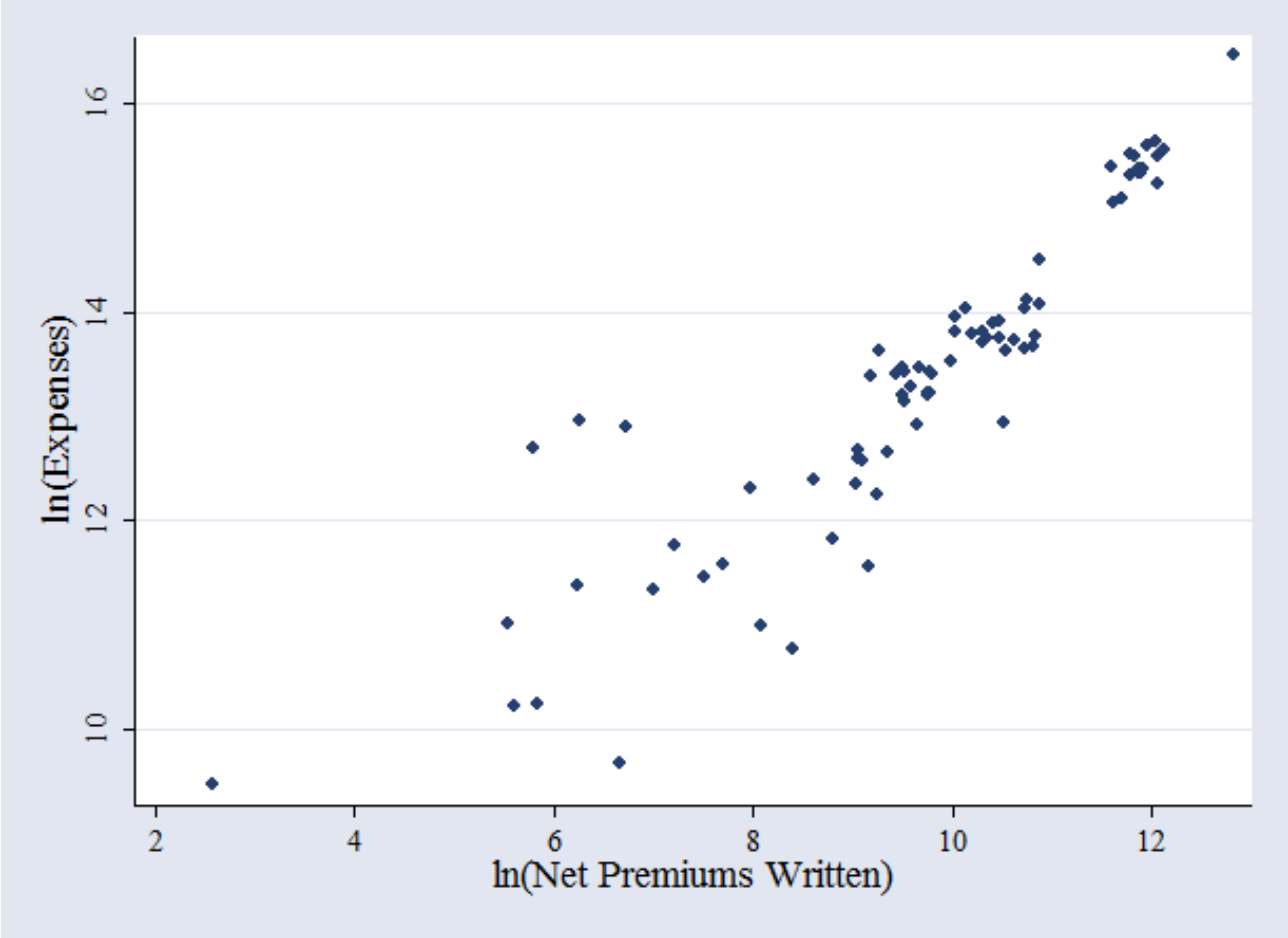
Tri-State Consumer Ins Co

Appendix B: Net Premiums and Expenses



Graph Created in STATA

Appendix C: ln(Net Premiums Written) and ln(Expenses)



Graph Created in STATA

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Summer Research Fellow for the Penn State Institute for Sports Law, Policy and Research
- Created an annotated bibliography of Sports Economics literature
- Worked under Professor Stephen Ross in Summer 2011

Teaching Assistant-Intermediate Macroeconomics August 2010-May 2011
- Work with Dr. Russell Chuderewicz to assess student performance
- Assist students during learning labs to help understanding