A Reexamination of Scale Economies in the Property and Casualty Insurance Industry

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As the property and casualty insurance (P/C) industry consolidates with mergers and acquisitions, we evaluated whether this consolidation from 2012 to 2017 resulted in cost efficiency gains for P/C companies. We used a translog cost function to evaluate scale economies for U.S. P/C companies, examining the relation between firm size and costs. We employed three measures of size: total assets under management, premium and annuity revenue, and total revenue. We also examined the source of cost savings with three cost measures: total operating costs, policy and benefits expenses, and other operating costs. We found that size does matter, because larger companies have significantly lower operating costs when output is measured in terms of total assets. Both policy benefits and expenses and other operating costs, including selling, general, and administrative expenses, contribute to cost efficiencies for larger companies, but a substantial source of cost efficiency for larger size firms appears to stem from other operating costs.

Keywords: economies of scale, insurance, translog cost function

INTRODUCTION

This study evaluates economies of scale in the property and casualty insurance industry over the period of 2012 to 2017. The insurance industry plays a vital role in the U.S. economy. The industry employed 2.8 million people in 2018, according to the U.S. Department of Labor, and contributed $1.2 trillion, or 3.3%, to the nation's gross domestic product (GDP) in 2018, according to the U.S. Bureau of Economic Analysis. The insurance industry's contribution to GDP has exceeded that of banks since 2015. Insurance companies also drive economic growth by investing in state and local municipal bonds and loans that help fund the building of roads, schools and other public projects. In addition, insurance companies provide capital to businesses for research, expansion, and other ventures by buying stocks ($4.5 trillion in stocks and bonds in 2017). Also, the taxes that insurers pay include special levies on insurance premiums, which amounted to $21 billion in 2017, or 2.2 percent of all taxes collected by states.

Companies in the S&P Composite 1500 insurance industry are grouped into five sub-industries, and of these, the property and casualty (P/C) industry accounts for 35.6% of the total market capitalization for the industry (Table 1). The P/C industry is an important part of the financial services sector, as it provides stability against risks and encourages resilience. As recent disasters have demonstrated, the P/C industry plays a vital role in recovery—without it, the impact of disasters on individuals, businesses, and communities can be devastating.

TABLE 1
SUMMARY OF THE S&P COMPOSITE 1500 INSURANCE INDUSTRY

Insurance Sub-Industry	Market Capitalization Weighting
Multiline Insurance	10.2%
Reinsurance	5.4%
Insurance Brokers	24.4%
Life and Health Insurance	20.0%
Property and Casualty	40.0%

With the credit crisis behind us and improvements in employment and housing markets, firms in the insurance industry have sought to improve the quality and productivity of their portfolios through merger and acquisition (M&A) activity across all insurance lines. This improvement effort has likely been due in part to competitive pressures in the industry. Despite the record levels of catastrophes, including wildfires, hurricanes, and other natural disasters, industry capital (or surplus) levels advanced by 7.5% in 2017 to $765.3 billion. The downside to this ample supply of underwriting capacity has been that premium rates for most lines of coverage remained low. An increase in demand for coverage amid an improved economic climate partly offset these competitive pricing pressures.

Against this rather mixed operating environment, insurers decided that growth through M&A was an attractive strategy. Table 2 shows mergers and acquisitions activity in the insurance sector for the period 2012 to 2018. Another factor driving M&A activity in the insurance industry was the impact of the Tax Cuts and Job Act (TCJA), which reduced the U.S. corporate tax rate from 35% to 21%. TCJA effectively closed the "Bermuda loophole" and made a Bermuda domicile less attractive from a tax perspective. This led a number of smaller Bermuda-based carriers (like Validus Re and XL Group) to enter into takeover deals with larger entities in early 2018 (CFRA Equity Research, Insurance, July 2018).

TABLE 2
MERGERS AND ACQUISITIONS ACTIVITY IN U.S. PROPERTY AND CASUALTY INSURANCE SECTOR FOR THE PERIOD 2012 TO 2018

Year	Number of Transactions	Transaction Values ($ millions)
2012	46	4,826
2013	41	4,393
2014	53	6,723
2015	35	39,970
2016	38	10,665
2017	38	8,063
2018	67	8,600

M&A has been particularly robust in the P/C insurance category, the largest sub-sector within the insurance industry, accounting for 35.6% of its total market capitalization. The P/C insurance industry is highly concentrated in nature. According to data compiled by the National Association of Insurance Commissioners (NAIC), the top 25 P/C companies controlled 75.19% of the written premiums for homeowners multiple peril and 86.13% of the written premiums for total private passenger auto sector. In recent years, it has become more consolidated. For instance, during 2018, P/C deal activity comprised 67 deals worth around $8.6 billion.

Given that large firms dominate P/C sub-sector of the insurance industry, and the impact of the insurance industry in general on the U.S. economy, it is important to evaluate the relationship between firm size and the cost of managing its business. It is also important to examine whether cost efficiencies are associated with larger firm size, and if so, the sources of cost efficiencies as firms continue to grow larger through M/A. Previous studies on other financial intermediaries, such as mutual funds, indicated that expenses have a direct impact on a fund's return to investors, with reduced expenses resulting in increasing returns to investors.

We examined this consolidation activity during 2012 to 2017 to evaluate whether consolidation provided economies of scale gains for P/C insurers. Our results contribute to existing literature in several areas. First, our study is the first to our knowledge that evaluates economies of scale in P/C insurance over such a recent time period. It also covers a longer sample period than previous literature on translog cost modeling in P/C insurance, spanning the years following a major financial crisis and the subsequent economic expansion. Second, our results add to the ongoing discourse over how to measure output for a services firm. Berger and Humphrey (1992) discuss firm assets as a good measure of output for a financial services firm. Hammond, Melander, and Shilling (1971) argue that premium revenue is an appropriate output measure, citing it as a representative measure of insurance protection produced. In contrast, Allen (1974) argues policyholder surplus—firm assets minus liabilities—are a good measure of output capacity. We evaluate multiple measures of output, costs, and size. Finally, this study can help the insurance industry and regulatory agencies to better understand the impact of the growth of insurance companies on their expenses and benefits to shareholders in the form of higher returns and increased wealth to shareholders.

The rest of this paper is organized as follows: Section 2 briefly reviews existing literature; Section 3 describes the model and methodology; Section 4 presents empirical results; and Section 5 concludes.

LITERATURE REVIEW

The insurance industry has a long history of cost efficiencies that have been reported in the literature. Hammond, Melander, and Shilling (1971) found evidence of economies of scale among P/C insurers for the year 1967. In contrast, Allen (1974) looked at mutually held firms and found no evidence of economies of scale among P/C insurance firms during 1967-1969; Joskow (1973) drew a similar conclusion for 1970-1971. Cummins and Weiss (1993) used a translog cost function to evaluate economies of scale in the P/C insurance industry from 1980-1988 and found that large insurers operated at an average efficiency level of about 90% relative to their cost frontier. The average efficiency in the medium sized insurer sample was 79%, and the average efficiency in the small sized firms was about 88% relative to their respective cost frontiers. The study also found mild scale diseconomies for large insurers and potentially large scale economies for smaller insurers. Hanweck and Hogan (1996) evaluated economies of scale in the P/C insurance industry for the period 1981-1985 and found evidence of economies of scale for the smallest firms in the industry. They also reported that large firms in the P/C industry exhibited statistically significant and substantial diseconomies of scale. Their results showed scale economies at lower levels of output and diseconomies for higher levels. The authors suggest these results may indicate that regulators were protecting smaller firms to enhance competition and encouraging firms to over-expand into more states and product lines than would otherwise be optimal in an uncontrolled rate-setting environment. Elango, Ma, and Pope (2008) looked at economies of scope for P/C insurers and found that greater product diversity was associated with either greater or worse firm performance, depending on geographic diversification and other factors. Cummins and Xie (2011) studied productivity, efficiency, and scale economies in the U.S. P/C insurance industry during the period 1993-2009 by using a non-parametric technique, data envelopment analysis. They found that the majority of firms in the three smallest size deciles operated with increasing returns to scale (economies of scale), while most firms in the five largest deciles operated with decreasing returns to scale (diseconomies of scale). The study recommended that the firms in the five smallest size deciles operating with increasing returns to scale may benefit from consolidation. Malhotra and Malhotra (2018) also used data envelopment analysis to examine economies of scale in property and casualty insurance companies for 2016. They found only one company showed increasing returns to scale out of 25 companies in the sample.

Numerous studies have debated the appropriate measure of output for an insurance firm, which is non-trivial because although payment terms in the event of a claim are defined, quantifying the benefit of the service provided is subjective. Cummins and Weiss (2013) provided a good overview of the literature in this area. Hammond, Melander, and Shilling (1971) advocated for measuring output by premium revenue; they also noted that operating costs may vary across insurers. Joskow (1973) also used premium revenue for output and a firm's expense ratio—expenses divided by premium revenue—to measure costs. Grace and Timme (1992) examined life insurers and also used premium revenue to measure output; the authors also included investments as output, arguing that investments "represent a major activity of most firms." Looking at mutual insurers owned by policyholders, Allen (1974) argued policyholder surplus—firm assets minus liabilities—was a good measure of output capacity. Doherty (1981) identified potential econometric issues with premium revenue as an output measure, owing to the inter-dependence of costs and premium revenue. He used claim payments to measure output and reports economies of scale. With life insurance, Geehan (1977) also argued premium revenue can give misleading results, and Hirshhorn and Geehan (1977) presented a cost-weighted index as an output measure, which Denny (1980) disputed vigorously. Yuengert (1993) and Cummins, Tennyson, and Weiss (1999) presented a measure of output based on incurred benefits—essentially, benefit payments to policyholders.

A host of studies focused on international scale economies in insurance and other financial services. Kasman and Turgutlu (2009) studied insurance companies in Turkey and reported economies of scale across the range of firm sizes there. Doherty (1981) reported economies of scale for Canadian P/C insurers during 1976-1978, arguing that results might be sensitive to the choice of output measure employed. Following this flurry of discordant studies, research on economies of scale for P/C insurers largely ceased. Bikker (2016) and Bikker and Gorter (2011) studied life and P/C insurance in the Netherlands, respectively, and both found economies of scale among small- and medium-sized firms, arguing that industry consolidation through mergers could improve market efficiency. Choo (2012) examined P/C insurance in Japan and found that scale economies increased following insurance regulatory reform in 1996 and also that scale economies increased with firm size to a point but eventually diminish. Hao and Chou (2005) looked at life insurance in Taiwan and found that larger firms were more profitable and efficient.

MODEL AND METHODOLOGY

In order to estimate economies of scale, we need a cost function. A cost function includes input prices and output quantity that tells us about the change in costs due to change in output. The value of the output quantity is the cost of making that output given those input prices. Companies use the cost function or the cost curve to minimize cost and maximize production efficiency. There are several cost functions discussed in economics literature and include CobbDouglas, Leontief, CES, and Linear cost functions. These functions, however, place a-priori restrictions on either the substitution possibilities among the factors of production or on scale economies (Segal, 2003). In this study we use the translog cost function, because it can be used to approximate any twice-differentiable function without placing a-priori restrictions on the production technology.

To examine scale economies, we first needed to estimate the translog cost function. The translog model is a common tool in financial economics for evaluating economies of scale. The model allows for a U-shaped average cost function. Another desirable feature of the model is that it allows economies of scale to vary with the size of a P/C insurer. Following Bikker and Gorter (2011), Yin (2010), Cummins and Zi (1998), and others, Equation 1 shows the translog cost function.

$$\text{LN}\, Cost_{i,t} = \beta_0 + \beta_1 \,\text{LN}\, Output_{i,t} + \frac{1}{2}\beta_2 \left(\text{LN}\, Output_{i,t}\right)^2 + \beta_3 Control_{i,t} + e_{it} \quad (1)$$

In the translog function, $Cost_{i,t}$ is the dollar amount of a fund's costs for firm i at time t, $Output_{i,t}$ is the output of firm i at time t, and $Control_{i,t}$ represents control factors that affect the costs of management and administration of company i at time t. Depending on the cost measure employed, we use total assets and total revenue as control variables.

The two main data inputs in the model are cost and output. As described in Section 2 above, extant literature has debated which measures of each are most appropriate, particularly for output. Consequently, we employed multiple measures of both output and cost. We measured costs as the dollar amount of a company's total operating expenses, policy and benefits expenses, and other operating costs. To measure output, we first used firm total assets, assuming the firm was financially sound (Berger, Cummins, and Weiss 1997, Leverty and Grace 2010). We also measured output as total revenue, and premiums and annuity revenue.

We estimated the translog cost function across all 25 firms and six years of data. When observations vary both cross-sectionally and over time, it is important to consider how disparity across individuals and through time are modeled. Panel data analysis allows for identification and measurement of effects that might not be evident in purely cross-sectional or time series data. Using the full panel mitigates potential multicollinearity problems, since explanatory variables are less likely to exhibit both high time-series and cross-sectional correlation. However, panel data also has potential econometric issues. Unobserved heterogeneity across years can yield misleading empirical estimates if such heterogeneity is not addressed (Baltagi 2008). We employed a least squares dummy variable fixed effects model to control for unobserved heterogeneity in our sample of P/C insurers.

Cost Elasticity

A widely used measure of operating efficiency and scale economies is cost elasticity of production. When costs increase at a slower rate than output, a firm or industry exhibits economies of scale. We calculated cost elasticity by taking the first derivative of the translog cost function (Equation 1) with respect to assets. The result is Equation 2.

$$\frac{\partial(\mathrm{LN}\,Cost)}{\partial(\mathrm{LN}\,Output)} = \beta_1 + \beta_2(\mathrm{LN}\,Output) \tag{2}$$

If an estimate of cost elasticity is significantly less than one, a firm's expenses increase less than proportionately with changes in output. This implies that economies of scale are present. If elasticity is greater than one, we can infer that there are diseconomies of scale. We estimated cost elasticity for the full panel of data as well as for individual years within the sample, averaging elasticities across firms to obtain a group-level measure.

Our null hypothesis was that scale economies exist among P/C insurers. We expected cost elasticities to be less than one, meaning costs increase less than proportionately with firm size.

DATA

We obtained our data from Standard and Poor's NetAdvantage, taking financial information from each P/C company's income statement and balance sheet for the years December 2012 through December 2017. Our sample covered 25 publicly traded firms over the period 2012 to 2017, from the following indices:

- S&P 500 index (5 companies)
- S&P Mid Cap 400 (6 companies)
- S&P Small Cap 600 (14 companies).

These 25 companies controlled 73.5% of the P/C market, as measured in terms of premiums. Table 3 presents summary statistics for the sample, and a few points are noteworthy.

TABLE 3
SUMMARY STATISTICS

Variable		2012	2013	2014	2015	2016	2017
Total Operating Expenses	Mean	4,973	5,010	5,201	5,479	6,291	6,753
	Std. Dev.	(7,572)	(7,465)	(7,770)	(8,051)	(9,288)	(9,898)
Policy Benefits and Expenses	Mean	3,286	3,222	3,361	3,532	4,108	4,500
	Std. Dev.	(5,463)	(5,290)	(5,539)	(5,809)	(6,684)	(7,232)
Other Operating Expenses	Mean	1,687	1,787	1,839	1,947	2,184	2,253
	Std. Dev.	(2,236)	(2,331)	(2,382)	(2,428)	(2,809)	(2,847)
Total Assets	Mean	20,519	20,613	20,418	21,085	23,985	25,176
	Std. Dev.	(34,856)	(34,465)	(32,885)	(33,129)	(40,527)	(41,931)
Total Revenue	Mean	5,628	5,921	6,095	6,335	7,121	7,469
	Std. Dev.	(8,635)	(8,941)	(9,179)	(9,287)	(10,578)	(10,996)
Premiums and Annuity Revenue	Mean	4,924	5,188	5,419	5,719	6,476	6,758
	Std. Dev.	(7,572)	(7,823)	(8,179)	(8,455)	(9,717)	(10,061)

Table 3 shows that on average,

- Total operating expenses increased by 35.70% in 2017 relative to 2012
- Policy benefits and claims expenses increased 36.94% in 2017 relative to 2012
- Other operating costs increased 33.55% in 2017 relative to 2012
- Total assets increased by 22.70% in 2017 over total assets in 2012
- Total revenue increased by 32.71% in 2017 over 2012 total revenue
- Premiums and Annuity revenue (PAR) increased by 37.25% in 2017 relative the PAR in 2012

Growth in total operating expenses (35.7%) outpaced revenue growth (32.7%) over the sample period. Also, growth in total assets likely reflected the robust overall performance of financial markets over the sample period.

EMPIRICAL ANALYSIS

Nature of Expenses

P/C insurers face substantial challenges to sustained profitability due to low interest rate environment and price sensitivity from customers that is driven by greater transparency and regulatory changes. As a result, cost containment is becoming a more important component of a firm's competitive advantage. Like all businesses, insurers have general operating expenses, such as paying the costs of maintaining offices and staff. Insurers also pay commissions to agents, brokers, and others who market and distribute their products; these commissions typically are withheld from premiums before being remitted to insurers. Insurers pay taxes (e.g., state premium taxes and federal income tax), as well as license fees to do business in each state. In addition, they make payments into each state's guaranty fund, which provides protection to policyholders in the event of an insurance company insolvency. We classify these as other operating costs. Claims costs (policy and benefits expenses), on the other hand, are an unknown quantity. Despite the skill of insurance actuaries, actual losses fluctuate and can differ significantly from projected claims costs, because insurance involves uncertainty.

In order to evaluate economies of scale, we first estimated translog cost functions (Equation 1) using the panel data set. Next, we used the coefficient estimates along with firm output levels in Equation 2 to obtain estimates of firm cost elasticity. Again, we employed multiple measures of both costs and output. Table 4 shows estimates of the translog cost function along with the average cost elasticity across the sample firms when output is measured by total assets.

TABLE 4
COST ELASTICITY, OUTPUT MEASURED BY TOTAL ASSETS

Translog cost function estimates: output measured by total assets			
	Dependent Variable:		
Parameter	LN (Total Operating Expenses) (1)	LN (Policy Benefits and Expenses) (2)	LN (Other Operating Costs) (3)
LN (Assets)	2.82***	2.34***	2.36***
	(7.19)	(5.50)	(4.22)
½ LN $(\text{Assets})^2$	-0.25***	-0.18***	-0.20***
	(-5.33)	(-3.55)	(-2.93)
Total Revenue	0.0008***	0.0006***	0.0005***
	(7.38)	(5.54)	(3.96)
R-Squared	0.89	0.89	0.78
No. Observations	150	150	150
Cost elasticity of production			
Cost Elasticity	0.60***	0.75***	0.59***
(Total Assets)	(12.56)	(11.26)	(16.38)

This table presents estimates of the translog cost function and cost elasticity of production, where output is measured by total assets. The sample period covers 2012-2017. Regressions are estimated using ordinary least squares and include year fixed effects. T-tests are in parentheses. In Panel B, t-tests are presented for the null hypothesis of constant returns to scale (i.e., cost elasticity=1). ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Translog regressions do a good job in explaining variation in costs, as evidenced by R-squared ranging from 0.87 to 0.99 for the three models. Also, we found that coefficients on output terms were consistent with economies of scale. Our analysis revealed that across cost measures, costs increase as log assets increase, and the negative coefficient on the quadratic log output term suggests that costs increase less as the level of output increases.

The estimated cost elasticities illustrate this. Cost elasticities ranged between 0.59 and 0.75 across the three cost measures that included total operating costs, policy benefits and expenses, and other operating costs, and all three elasticity estimates were significantly less than one, meaning that costs increased less than proportionately with output. Column 1 in Table 4 showed that the average cost elasticity of total operating costs with respect to total assets was 0.60, meaning that for a 1 percent increase in output (total assets), total operating costs increased by only 0.60 percent across the sample of P/C insurance firms. Table 4 shows that there were higher economies of scale in other operating costs relative to policy benefits and expenses, because the average cost elasticity of other operating costs was 0.59, while the average cost elasticity of policy benefits and expenses was 0.75 with respect to total assets of the firm. When measuring output by total assets, results were consistent with economies of scale in the P/C insurance industry.

However, revenue-based measures of output provided more mixed evidence. Table 5 presents estimates of cost functions and elasticities when output was measured by total revenue.

TABLE 5
COST ELASTICITY, OUTPUT MEASURED BY TOTAL REVENUE

Translog cost function estimates: output measured by total revenue

	Dependent Variable:		
	LN (Total Operating Expenses)	LN (Policy Benefits and Expenses)	LN (Other Operating Costs)
Parameter	(1)	(2)	(3)
LN (Total Revenue)	1.24***	0.66	1.71***
	(13.21)	(1.3)	(6.00)
½ LN (Total Revenue)^2	-0.024*	0.04	-0.08**
	(-1.88)	(-0.52)	(-2.18)
Total Assets	-5.1*	-4.05	-5.18
	(-1.70)	(-1.22)	(-0.96)
R-Squared	0.99	0.87	0.95
No. Observations	150	150	150

Cost elasticity of production

Cost Elasticity (Total Revenue)	1.05***	0.97***	1.09***
	(18.81)	(6.03)	(9.23)

This table presents estimates of the translog cost function and cost elasticity of production, where output is measured by total revenue. The sample period covers 2012-2017. Regressions are estimated using ordinary least squares and include year fixed effects. T-tests are in parentheses. In Panel B, t-tests are presented for the null hypothesis of constant returns to scale (i.e., cost elasticity=1). ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Here, significance of the output coefficients was not as robust, and elasticities for the three cost measures gave conflicting results. When measuring costs as policy and benefit expenses in Column 2, cost elasticity was 0.97 and significantly less than one, consistent with economies of scale. In contrast, measuring costs as total operating expense in Column 1 or other operating costs in Column 3, cost elasticities were significantly greater than one, implying that costs increased faster than output. Table 5 shows that, on average, with every 1% increase in total revenue, policy benefits and expenses increased by 0.97% for the property and casualty insurance industry. Table 5 also shows that, on average, with 1% increase in total revenue, other operating costs increased by 1.09% and contributed to diseconomies of scale. It seems that, on an average, companies were spending more to bring in a dollar of extra revenue, and if they could control the other operating costs, it generated economies of scale for the total revenue also.

Table 6 indicates that measuring output as premiums and annuity revenue provides very similar results, with evidence of economies of scale when measuring costs as policy and benefit expenses and diseconomies of scale for total operating expenses and other operating costs.

TABLE 6
COST ELASTICITY, OUTPUT MEASURED BY PREMIUMS AND ANNUITY REVENUE

Translog cost function estimates: output measured by Premiums and annuity revenue			
	Dependent Variable:		
	LN (Total Operating Expenses)	LN (Policy Benefits and Expenses)	LN (Other Operating Costs)
Parameter	(1)	(2)	(3)
LN (Premiums and Annuity Revenue)	1.08***	0.95***	1.10***
	(110.03)	(17.11)	(34.35)
½ LN (Premiums and Annuity Revenue)^2	-0.0014*	-0.0014	0.009**
	(-1.12)	(-0.21)	(2.14)
Total Assets	-5.21***	5.05**	-5.45***
	(-5.32)	(2.27)	(-3.57)
R-Squared	0.99	0.87	0.95
No. Observations	150	150	150
Cost elasticity of production			
Cost Elasticity	1.09***	0.97***	1.06***
(Premiums and Annuity Revenue)	(14.75)	(4.44)	(3.95)

This table presents estimates of the translog cost function and cost elasticity of production, where output is measured by premiums and annuity revenue. The sample period covers 2012-2017. Regressions are estimated using ordinary least squares and include year fixed effects. T-tests are in parentheses. In Panel B, t-tests are presented for the null hypothesis of constant returns to scale (i.e., cost elasticity=1). ***, **, and * indicate statistical significance at the 0.01, 0.05, and 0.10 levels, respectively.

Table 6 shows that the cost elasticity of policy benefits and expenses was 0.97 with respect to premiums and annuity revenue, meaning that for every 1% increase in premiums and annuity revenue, policy benefits and expenses increased by 0.97% and contributed to the profitability of the firms. However, on average, for every 1% increase in premiums and annuity revenue, other operating costs increased by 1.06%, contributing to diseconomies of scale in total operating costs with respect to premiums and annuity revenues.

Next, we looked closely at cost elasticities for the individual firms in the sample. Although not presented, cost elasticities for each firm exhibited little time-series variation. Firms that exhibited scale economies in one year tended to do so throughout the sample period.

TABLE 7
COST ELASTICITIES FOR SAMPLE FIRMS

Output Measure:	Total Assets			Total Revenue		
Cost Measure:	Total Operating Expenses	Policy Benefits & Expenses	Other Operating Costs	Total Operating Expenses	Policy Benefits & Expenses	Other Operating Costs
Firm	(1)	(2)	(3)	(4)	(5)	(6)
Ahalife Holdings Ltd.	0.49	0.66	0.5	1.03	0.98	1.04
Allstate Corp.	-0.08	0.25	0.03	0.96	1.14	0.78
Amerisafe, Inc.	1	1.03	0.9	1.09	0.87	1.23
AXA XL	0.1	0.38	0.18	1	1.06	0.92
Chubb Ltd.	-0.09	0.24	0.03	0.97	1.11	0.83
Cincinnati Financial	0.36	0.57	0.39	1.01	1.02	0.98
Employers Holdings	0.77	0.86	0.72	1.07	0.91	1.17
First American Financial	0.58	0.73	0.57	1.01	1.02	0.98
Hanover Insurance Group	0.43	0.62	0.45	1.02	1.02	0.98
HCI Group Inc.	1.23	1.19	1.06	1.11	0.84	1.28
Infinity Property & Casualty	0.88	0.94	0.81	1.05	0.95	1.1
Mercury General Corp.	0.71	0.82	0.67	1.03	0.99	1.03
Navigators Insurance	0.72	0.82	0.68	1.06	0.93	1.13
Old Republic International	0.37	0.58	0.4	1.01	1.03	0.96
ProAssurance Corp.	0.69	0.8	0.66		0.91	1.16
Progressive Corp.	0.25	0.49	0.31	0.97	1.11	0.84
RLI Corp.	0.84	0.91	0.77	1.07	0.91	1.17
Safety Insurance Group, Inc.	0.96	0.82	0.87	1.07	0.91	1.16
Selective Insurance Group	0.61	0.75	0.59	1.04	0.97	1.07
Stewart Information Services	1.02	1.04	0.92	1.04	0.96	1.07
Travelers Companies Inc.	-0.06	0.26	0.05	0.96	1.12	0.81
United Fire Group, Inc.	0.75	0.85	0.71	1.06	0.93	1.14
United Insurance Holdings	1.14	1.13	1.02	1.09	0.86	1.24
Universal Insurance Holdings	1.08	1.08	0.97	1.08	0.89	1.2
W. R. Berkley Corp.	0.32	0.54	0.36	1	1.05	0.94

Table 7 shows that when we measured cost in terms of total operating costs and output in terms of total assets, Chubb, Ltd, Allstate Corporation, and Travelers Companies, Inc. were the most efficient with a cost elasticity of -0.09, -0.08, and -0.06, respectively, which meant that with every $1 increase in total assets, operating costs declined for these companies. The least efficient company was HCI Group, Inc. with a cost elasticity of 1.23, which meant for every 1% increase in total assets, total operating cost increased by 1.23%. United Insurance Holdings Corporation, Universal Insurance Holdings, Inc., and Stewart Information Services Corporation also showed average cost elasticity of more than 1.0 for total operating costs relative to total assets over the sample period of 2012 to 2017. Main source of cost efficiency for Chubb, Ltd., Allstate Corporation, and Travelers Companies, Inc. seemed to be other operating costs, because cost elasticity of operating costs with respect to total assets was 0.03, 0.03, and 0.05, respectively.

When output was measured in terms of total revenue, only 4 of the 25 firms showed economies of scale with cost elasticity below 1.0. Allstate Corporation, Travelers Companies, Inc., Chubb, Ltd., and Progressive Corporation had a cost elasticity of 0.96, 0.96, 0.97, and 0.97, respectively, for total operating expenses relative to total revenue. Again, their main source of operating cost efficiency with respect to revenue was from other operating costs. The average cost elasticity of other operating costs for these 4 firms was the lowest among all firms in the sample for the period 2012 to 2017. Results are similar when output is measured as premiums and annuity revenue.

Table 8 shows the trends in cost elasticities of total operating costs, policy benefits and expenses, and other operating costs with respect to total assets, total revenue, and premiums and annuity revenue over the sample period of 2012 to 2017.

TABLE 8
COST ELASTICITIES BY YEAR

Panel A: Output measured by total assets

Variable	2012	2013	2014	2015	2016	2017
Cost Elasticity:	0.637***	0.624***	0.612***	0.603***	0.586***	0.563***
Total Operating Costs	(-4.41)	(-4.74)	(-5.01)	(-5.14)	(-5.29)	(-5.77)
Cost Elasticity:	0.768***	0.759***	0.75***	0.744***	0.732***	0.715***
Policy Benefits and Expenses	(-3.91)	(-4.22)	(-4.48)	(-4.61)	(-4.76)	(-5.23)
Cost Elasticity:	0.613***	0.603***	0.594***	0.586***	0.573***	0.554***
Other Operating Costs	(-5.87)	(-6.25)	(-6.56)	(-6.7)	(-6.83)	(-7.36)

Panel B: Output measured by total revenue

Variable	2012	2013	2014	2015	2016	2017
Cost Elasticity:	1.057***	1.055***	1.053***	1.052***	1.05***	1.049***
Total Operating Costs	(7.77)	(7.76)	(7.8)	(7.68)	(7.31)	(7.11)
Cost Elasticity:	0.964***	0.967***	0.97***	0.973**	0.976**	0.977**
Policy Benefits and Expenses	(-2.9)	(-2.7)	(-2.56)	(-2.38)	(-2.07)	(-1.91)
Cost Elasticity:	1.101***	1.094***	1.088***	1.083***	1.077***	1.074***
Other Operating Costs	(4.12)	(3.97)	(3.87)	(3.7)	(3.38)	(3.21)

Panel C: Output measured by premiums and annuity revenue

Variable	2012	2013	2014	2015	2016	2017
Cost Elasticity:	1.09***	1.09***	1.09***	1.09***	1.09***	1.09***
Total Operating Costs	(211.46)	(221.18)	(228.47)	(232.44)	(227.84)	(226.76)
Cost Elasticity:	0.939***	0.939***	0.939***	0.939***	0.939***	0.939***
Policy Benefits and Expenses	(-141.34)	(-147.95)	(-152.91)	(-155.66)	(-152.67)	(-151.99)
Cost Elasticity:	1.167***	1.168***	1.168***	1.169***	1.17***	1.17***
Other Operating Costs	(60.82)	(63.87)	(66.16)	(67.51)	(66.36)	(66.15)

This table presents estimates of cost elasticity by year for different measures of output and costs. Elasticities are estimated from a translog cost function. ***, **, and * indicate differences from 1 that are statistically significant at the 0.01, 0.05, and 0.10 levels, respectively.

Panel A of Table 8 shows that the average cost elasticity of total operating costs, policy benefits and expenses, and other operating costs with respect to total assets consistently declined since 2012, meaning that property and casualty insurance companies were improving their productive efficiency, and this contributed to their profitability and health.

Panel B of Table 8 shows average cost elasticity of total operating costs, policy benefits and expenses, and other operating costs with respect to total revenue. Although the cost elasticities were greater than one in each year during the sample when size was measured in terms of revenue, the elasticities showed a declining trend for total operating costs, policy benefits and expenses, and other operating costs throughout the sample period of 2012 to 2017.

Panel C of Table 8 shows average cost elasticity of total operating costs, policy benefits and expenses, and other operating costs with respect to premiums and annuity revenue. The cost elasticities for total operating costs, policy benefits and expenses, and other operating costs with respect to premiums and annuity revenues were constant throughout the sample period.

Finally, we divided our sample of firms according to total assets to see how cost elasticity varied by size and to possibly find some evidence of a minimum efficient scale. We found that as size increased, cost elasticity declined (Table 9).

TABLE 9
COST ELASTICITY BY FIRM SIZE

	Cost Measure:		
Firm Size: Total Assets	Total Operating Expenses	Policy Benefits and Expenses	Other Operating Costs
Less than $1 billion	1.198***	1.172***	1.062***
	(8.18)	(9.87)	(3.24)
$1 to $3 billion	0.945***	0.99	0.86***
	(-4.19)	(-1.03)	(-13.42)
$3 to $6 billion	0.727***	0.833***	0.685***
	(-47.37)	(-40.23)	(-68.19)
$6 to $20 billion	0.484***	0.658***	0.491***
	(-31.47)	(-28.96)	(-38.8)
$20 to $100 billion	0.2***	0.453***	0.264***
	(-28.49)	(-27.03)	(-32.76)
Greater than $100 billion	-0.089***	0.244***	0.032***
	(-103.56)	(-99.65)	(-114.96)

This table presents estimates of cost elasticity of production, dividing the sample according to firm size. Elasticities are estimated from a translog cost function. ***, **, and * indicate differences from 1 that are statistically significant at the 0.01, 0.05, and 0.10 levels, respectively.

Across all three cost measures, elasticities were significantly less than one for all size groups greater than $1 billion in total assets. Moreover, all cost elasticity estimates decreased as total assets increased. These results imply that scale economies are greater for larger firms. For the smallest firms with less than

$1 billion in assets, elasticities are significantly greater than one, consistent with diseconomies of scale for the smallest firms. This evidence on size and cost elasticity is consistent with the presence of fixed costs in the P/C insurance industry. It is conceivable that fixed costs exist in the areas of policy and claim software systems, client management infrastructure, marketing initiatives, and network effects, among other possible areas. Regardless of the specific drivers of the fixed costs, it appears likely that larger P/C insurers enjoy greater economies of scale.

SUMMARY AND CONCLUSIONS

Property and casualty insurance provides a risk transfer service of tremendous financial importance in the U.S. economy. Recent disasters have demonstrated the vital role the industry plays in recovery and painstakingly illustrate the negative financial impacts stemming from inadequate insurance. Like other industries, the P/C industry has undergone substantial change in recent years and continues to evolve. The way that costs and revenues combine to shape efficiency in the market for P/C insurance is a topic of interest to practitioners, academics, and policymakers, particularly given the economic importance of the industry. Any threat to the financial health of insurance companies could disrupt bond markets and negatively impact the availability of credit in the market for the business sector in general. Lack of credit would negatively impact business, economic growth, and overall societal welfare (Malhotra and Malhotra, 2018).

In this study, we evaluated economies of scale in the P/C industry for the years 2012 to 2017. Although previous literature in evaluating economies of scale in P/C insurance dates back to Hammond, Melander, and Shilling (1971), the literature is discontinuous in the time periods it covers, and current research spanning the recent period of technological disruption and climate change is sparse. We used a translog cost function to evaluate economies of scale in property and casualty insurance companies. We employed three different measures of size: total assets under management of the firm, total revenue, and premium and annuity revenue generated by the firm. We also utilized three cost measures: total operating expenses, policy benefits and claims expenses, and other (non-benefit) expenses. Cost efficiencies were measured using all three size and cost measures. We found evidence of cost efficiencies among property and casualty insurance firms during 2012-2017.

We examined cost elasticity of size for 25 firms in the P/C insurance industry, employing multiple measures of both costs and output. We measured costs as total operating expenses, policy and benefit expenses, and other operating costs. Output was measured by total assets, total revenue, and premiums and annuity revenue. When output was measured by total assets, we found robust evidence consistent with economies of scale across all measures of cost. However, with the revenue-based output measures, cost elasticities were greater than one except when cost was measured by policy benefits and expenses. Clearly, the choice of output measure affects results, consistent with discourse in extant literature. At the firm level, 20 of the 25 firms had average cost elasticity less than one, indicating that costs increase proportionally less than size. Scale economies were robust among firms with assets greater than $3 billion, and as firm size increases scale economies continue to grow. For the largest firms in the sample with over $100 billion in assets, cost elasticities were between 0.24 and -0.09. The study also found that average cost elasticities for total operating costs, policy benefits and expenses, and other operating costs showed a declining trend with respect to output as measured by total assets, total revenue, and premiums and annuity revenue.

The property and casualty insurance industry continues to make productivity gains. These scale economies are present among most firms in the industry, with the exception of small firms with assets under $1 billion. Further research could enhance our understanding of cost efficiencies among P/C insurers. One important area of exploration is how the industry will respond to the COVID-19 pandemic. Some P/C insurers offer supplemental health insurance and will certainly be directly impacted. However, all insurers will surely suffer from the pandemic’s tremendous economic impact. Because the industry is far-reaching in its influence on the economy, a better understanding of firm size and efficiency in the face of a significant shock like this would be highly relevant and illuminating. Possible extensions include evaluating mergers as a vehicle to improve efficiency following systemic shocks, building on the work of Chamberlain and Tennyson (1998) in the context of scale economies. Another possible area of exploration relates to the ongoing discourse in the literature over how best to measure output and costs. More detailed data linking assets, operating costs, and revenues could shed light on how best to measure efficiency.

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