Efficiency in the Property-Liability Insurance Industry

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Abstract

The purpose of this study is to examine the cost impact resulting from P/L insurer inefficiency. A generalized Leontief profit function which allows for allocative and scale efficiency is estimated for 100 of the largest P/L insurers over the period 1980 through 1984. Excessive costs from nonoptimal use of resources are estimated by type of inefficiency. The dollar impact of this is estimated also. Estimated inefficiency costs are 12 to 33 percent of premiums.

Problems in the property-liability (P/L) insurance industry have attracted considerable attention in recent years. Price and availability crises in markets such as auto and general liability insurance have occurred, and cost pressures have continued to build as insurers compete with risk retention alternatives. Rate regulation in some states has further exacerbated these problems. Although labor saving, computer related technological changes (such as automated report writing) are available, the white collar workforce of insurers has continued to grow. Issues such as these are important not only because the P/L insurance industry is important, but because cost pressures and increasing competition exist for the growing service sector.

Premium levels have captured most of the public attention. Premiums (augmented by investment income) are designed to pay covered losses as well as insurers' administrative and underwriting expenses. Losses are the largest component of premiums. In 1988, premiums written in the P/L insurance industry was $202 billion, and incurred losses equaled $160 billion (Best's Aggregates and Averages, 1989). To deal with the large loss level in general liability some states have enacted tort reform which caps the maximum amount of noneconomic loss. Interest in no-fault auto insurance with a stringent threshold has resurfaced as a potentially more efficient compensation method and strategy to lower loss costs in automobile liability insurance.

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However, P/L insurers' administrative and underwriting expenses are not trivial either. These expenses totalled $53 billion in 1988 (Best's Aggregates and Averages, 1989), and these figures do not include profit. Given the sizable amount of these expenses, the efficiency and productivity of the P/L insurance industry have been questioned. Premium rate rollbacks in auto insurance have been legislated in some states, and interest in such initiatives is spreading to others. These events suggest the public believes that P/L insurers are earning excess profits or incurring excessive underwriting and administrative expenses. The latter outcomes are possible if the insurance market is not in a competitive equilibrium with marginal costs equated with marginal revenues. Regulation and consumer ignorance could be responsible for inefficiencies. Insurers are subject to much regulation, with the most important being rate regulation.[1]

But rate regulation alone does not explain the performance of the P/L insurance industry. For example, Prop 103 in California mandated a rate rollback for auto liability insurance (and most other P/L coverages). California did not have rate regulation at this time. California's Prop 103 also negated anti-rebate laws for commissions and allowed banks to engage in selling insurance so as to make the insurance industry more competitive. Anti-rebate laws and the selling and underwriting of insurance by banks are becoming issues in other states. Thus inefficiency may result from a wide variety of factors.

The purpose of this research is to measure the economic efficiency of P/L insurers. Behavior of a profit maximizing firm in competitive equilibrium is the basis against which P/L insurers' efficiency is measured in this study.[2] Efficiency affects more than insurance premiums and profitability; it also affects the allocation of scarce societal resources. For example, if labor input prices such as agents' commissions are not set competitively due to the protection of anti-rebate laws, then too much labor would be allocated to insurance marketing instead of other productive activities in society.

Efficiency analysis will indicate the extent of any "liability crisis" suffered by the P/L insurance industry. Specifically, the hypothesis that insurers underpriced long-tail lines such as medical malpractice, officers and directors liability, and general liability in the early 1980s will be tested. The adequacy of reserves will be examined as well. In addition, the hypothesis that regulation

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[1] Premium rates are constrained in some lines of business in some states so that insurers earn a "fair" rate of return, and the regulated rate may vary substantially from the competitive equilibrium price (see Harrington, 1984). Similar circumstances exist in other regulated industries such as utilities and has motivated research into the productivity and efficiency of these industries (see, e.g., Lovell and Sickles, 1983, Sickles, Good and Johnson, 1986, Caves, Christensen, and Tretheway, 1981, Cowing, Small and Stevenson, 1981, and Denny, Fuss, and Waverman, 1981 among others). The interaction of productivity and regulation in the P/L insurance industry is measured by Weiss (1991).

[2] The reason this basis is used is that it meets the requirements of Pareto optimality and, thus, is a welfare optimum (Henderson and Quandt, 1980, p. 293).

impacts efficiency will be tested along with the hypothesis that insurers overutilized labor or capital.

The technology of insurers is modeled with the profit function. The profit function is used because the impact of deviations from perfect competition can be quantified simply by comparing profit for an efficient firm (π^*) with that of an inefficient one (π). This methodology has been used in other regulated industries (e.g., see Lovell and Sickles, 1983, Sickles, Good and Johnson, 1986, and Yotopoulos and Lau, 1973).

The remainder of this article is organized as follows. A theoretical model of inefficiency is discussed and a functional form for P/L insurers' profit function is explored. Then discussion of the data and hypotheses are presented. The research methods are explained, empirical results are discussed and conclusions are offered.

Models of Inefficiency

This section discusses the meaning of production efficiency and categorizes inefficiency as technical, allocative, and scale. The types of inefficiency to which P/L insurers are most prone are discussed. A functional form for P/L insurers' profit function is introduced, specifically, the Generalized Leontief profit function. The Generalized Leontief profit function, amended to take account of inefficiency, is explained below.

Conditions Required for Economic (or Production) Efficiency

Efficiency can be categorized into several types. Technical efficiency exists if no more of one output type can be produced without reducing production of some other output. A firm is inefficient also if it fails to use an input and output mix leading to profit maximization. Consider the production function $F(Y_1, Y_2,..Y_m,X_1, X_2, X_3,..X_n)$, where Y_i is output type i and X_j is input j; this function indicates how input is transformed into output. The optimal (i.e., efficient) set of inputs and outputs results if three conditions are met:[3] (1) The rate of production transformation (RPT) is proportional to output price, $P_i/P_b = (\partial F/\partial Y_i)/(\partial F/\partial Y_b)$, (2) The rate of technical substitution (RTS) is proportional to input price, $W_j/W_k = (\partial F/\partial X_j)/(\partial F/\partial X_k)$, and (3) The value of marginal product is equated with input price, $-W_j/P_i = (\partial F/\partial X_j)/(\partial F/\partial Y_i)$.

These conditions can be illustrated with a simple profit maximization example:

$$\pi = P_1Y_1 + P_2Y_2 - W_LX_L - W_KX_K, \tag{1}$$

subject to: $X_L = Y_1{}^2 + Y_2{}^2$, and

$$X_k = Y_1{}^2 + Y_2.$$

[3]Under some conditions, perfect competition does not result in Pareto optimality (e.g., if consumers are satiated). (See Henderson and Quandt, 1980, pp. 296-304).

It is assumed that the firm's goal is profit maximization. In equation (1), two outputs and two inputs are assumed, although the analysis can be generalized easily to contain more outputs and inputs. The model is too simple to apply to insurers, it is used here only to portray how inefficiency alters the three conditions above.

In equation (1), profit is maximized when $Y_1 = P_1/(2W_L + 2W_k)$ and $Y_2 = (P_2 - W_k)/2W_L$. Now assume P_1 = \$200, P_2 = \$182, W_L = \$3/unit, and W_k = \$2/unit. Then the maximum profit is \$4700. The RTS for inputs X_L and X_k is equal to $W_L/W_K = 3/2$; and the RPT between outputs 1 and 2 is $P_1/P_2 = 200/182$. These facts are summarized in Table 1 for the competitive equilibrium case.

Technical Inefficiency: A firm is technically inefficient if it operates below its production possibility frontier (or above the minimum cost frontier). A firm is technically inefficient if it uses excessive inputs or produces too little outputs with the inputs used. For example, if the firm above used 1,350 units

Table 1

Inefficiency Illustration

Maximize $\pi = P_1Y_1 + P_2Y_2 - W_LX_L - W_KX_K$

Production Constraints:

$$X_L = Y_1^2 + Y_2^2$$
$$X_K = Y_1^2 + Y_2$$

Exogenous Prices: $P = 200$ $P = 182$
$W_L = 3$ $W_K = 2$

Parameter	Competitive Equilibrium	Allocative Inconsistent	Allocative Consistent	Scale Inconsistent	Scale Consistent
P_1'	200	190	190	200	200
W_L'	3	3	3	2.50	2.50
Y_1	20	19	19	22.20	22.20
Y_2	30	31.05	30	30	36
X_K	430	392.05	391	522.84	528.84
X_l	1300	1325.10	1261	1392.84	1788.84
Cost	4760	4760	4565	5224.20	6424.20
Profit	4700	4691.10	4695	4675.80	4567.80

Note: A prime (') signifies a perceived price which may not equal the actual price.

Nature of Efficiency Deviation:

Allocative Inconsistent:

P_1 incorrectly perceived as 190, output mix is affected.

Allocative Consistent:

P_1 incorrectly perceived as 190 and profit function maximized with $P_1' = 190$

Scale Inconsistent:

W_L incorrectly perceived as 2.50 to determine Y_1 only

Scale Consistent:

W_L perceived as 2.50 and profit function maximized with $W_L' = 2.50$ (Y_1 and Y_2 affected) of labor to produce the optimal output, then profit would be reduced to [\$200(20) + \$182(30) − \$3(1,350) − \$2(430)] or \$4,550.

Allocative Inefficiency: A firm is allocatively inefficient if it produces a nonoptimal output mix or uses a nonoptimal input mix.[4] For example, suppose that the firm in the example above chose a nonoptimal output mix such that $Y_1 = 19$ and $Y_2 = 31.05$ (Assume also that partial units could be produced.) The cost of this output mix is still equal to the optimal value \$4,760, but revenue is reduced to \$9,451.10 yielding a profit of \$4,691.10.

In effect, the firm has behaved as *if* $P_1 = 190$, i.e., $P_1' = 190$ where the prime indicates a misperceived price. (Note that, $19 = 190/(2W_L + 2W_K)$). The optimal RPT between outputs 1 and 2 is 200/182, but the firm in the example has behaved as if the RPT is $190/182 = P_1'/P_2$. Stated another way, the firm's perceived price ratio is (200/182), where $\theta = 0.95$. But to meet condition 1, θ must equal 1.0. The fact that $\theta = 0.95$ indicates the firm underproduced Y_1. Thus θ is a measure of inefficiency.

In the scenario above, P_1 was perceived incorrectly in determining the output mix only and not total cost. In this sense, the inefficiency described above is *inconsistent*. It is possible that if the firm misperceived P_1, costs would be affected. That is, $P_1' = 190$ would be used in the profit maximization consistently so that $Y_1 = 19$, and $Y_2 = 30$ (or $(P_2 - W_K)/2W_L$). In this case total labor cost ($W_L X_L$) would be \$3,783 while capital cost ($W_K X_K$) would be \$782, resulting in profit of \$4,695. This scenario is depicted also in Table 1.

Similar reasoning can be used to analyze input mix. Inefficiency results when the RTS between two inputs is not proportional to input prices, $W_L/W_K \neq (\partial F/\partial X_L)/(\partial F/\partial W_K)$. This expression can be restated as $W_L/W_K = \delta(\partial F/\partial X_L)/\partial F/\partial X_K)$, where $\delta \neq 1$. The parameter δ is an inefficiency measure. If $\delta = 1.0$ then the firm meets condition 2. If $\delta > 1.0$ then the firm has overutilized labor relative to capital. Otherwise ($\delta < 1.0$), the firm has underutilized labor.

Scale Inefficiency: A firm is *scale inefficient* if inputs and outputs are not allocated in proportion to the correct input and output price ratios (Silberberg 1978, p. 187). Specifically, for profit maximization, the value of marginal product P_i (MP_j) = W_j, where MP_j is the marginal product created if one more unit of X_j is used.

Now assume that in optimizing equation (1), the firm produced 22.20 units of Y_1 and 30 units of Y_2. This would occur if the firm perceived the price for W_L to be \$2.50 ($W_L' = \$2.50$) in determining Y_1. Revenue and costs would increase to \$9,900 and \$5,224.20, respectively. Profit would be reduced to

[4] The expression $(\partial C/\partial W_j)/(\partial C/\partial W_k)$ indicates how input X_j can be substituted for X_k given the state of technology. This ratio is referred to as the rate of technical substitution. Optimality results when this ratio is equal to the ratio of input prices. That is, the rate at which firms can substitute inputs at the margin should be the same rate these inputs trade for in the market. Likewise, $-(\partial C/\partial Y_i)/(\partial C/\partial Y_d)$ is the ratio of marginal costs for Y_i and Y_d, respectively. Optimal allocation of outputs occurs when the rate at which these outputs can be traded for each other in the firm is the same as in the market. The ratio of marginal costs is referred to as the rate of product transformation.

\$4,675.80, as depicted in Table 1. The perceived ratio of labor cost and output price would be $W_L'/P_1 = 2.50/200$ which is not equal to the optimizing ratio of 3/200. That is the perceived price ratio is $\rho(3/200)$, where $\rho = 0.83$. The fact that $\rho < 1$ means that the value of marginal product for input j is lower than the optimum. Thus labor was overutilized.

As for allocative inefficiency, scale inefficiency can be consistent or inconsistent. In the scenario above, W_L was assumed to be misperceived to determine Y_1 only. It is possible that W_L would be misperceived consistently, thereby affecting Y_2. If W_L' was used consistently, profit would equal \$4,567.80 based on $Y_1 = 22.2$ and $Y_2 = 36$.[5] Table 1 contains the details.

Summary: In summary, technical inefficiency exists if the firm is operating below the production possibility frontier or above the cost frontier and conceptually is easy to model in this context. Allocative and scale inefficiency can be modeled via misperceptions concerning price, because prices determine optimum input and output. That is, deviations from the optimum can be expressed as if the firm used incorrect or misperceived prices.

Inefficiency Applications to P/L Insurance

Inefficiencies of the types described above may result from many factors. It is likely that regulation leads to noncompetitive pricing and inefficient production, $P_{Ri} \neq P_i$, where R indicates regulation. Also, regulation may affect output mix, input mix (through the "fair" rate of return), and input usage as insurers compete on the basis of service instead of price, thereby affecting efficiency. Regulatory inefficiencies are probably consistent because insurers are aware of these regulatory effects and adjust output (e.g., service quality) and input accordingly.

Other factors can account for inefficiencies as well. Monopolistic pricing leads to nonmarginal cost pricing, and production of output below that of a competitive equilibrium. Nonmarginal cost pricing may exist also if consumers do not understand insurance pricing and the cost of obtaining information is high. Input or output price uncertainty and errors lead to inefficiency also.

Two additonal factors affect efficiency measurement. If marginal firms earning zero profit exist in long run competition, inframarginal firms may exist which earn postive profit. These positive profits would be considered inefficient, since the three conditions for efficiency would not be met. Likewise, firms with fixed input which varies from the long run optimal level are considered inefficient by the criteria in this model.

The economic analysis outlined here must be evaluated in the context it is presented. Efforts to quantify inefficiency as discussed above rely only on the three conditions for allocative and scale efficiency. Due to regulation or uncertainty, some of this inefficiency is not under the direct control of the firm. For example, rate regulation resulting in "affordable" auto insurance

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[5] If the scale inefficiency were consistent, the perceived price ratio $W_L'/P_2 \neq W_L/P_2$; hence the other scale inefficiency measure is affected consistently.

may be deemed justified by society even if it does not result in production efficiency. The consequence is a deviation in resource allocation from the competitive equilibrium.[6] In this framework, efficiency analysis is still useful since it quantifies the cost to society of this social goal.

In the analysis below, it is not possible to completely separate the effects of regulation from all of the other forces affecting production efficiency. A theoretical and empirical analysis of rate regulation's impact on prices and capital input usage in the P/L insurance industry can be found in Weiss (1991).

The Generalized Leontief Profit Function

The inefficiencies defined above can be quantified from the profit function of P/L insurers. Little empirical evidence exists concerning this functional form. Therefore a flexible form, the Generalized Leontief, is used (see Diewert, 1971). This function can be used to reasonably estimate a wide range of profit functions because it provides a second order approximation to an arbitrary twice differential profit function using a minimum of parameters.[7] This profit function has been used to study inefficiency in other regulated industries (e.g., see Lovell and Sickles, 1983 and Sickles, Good and Johnson, 1986); thus comparisons are possible.

The Generalized Leontief profit function, amended to include parameters for allocative and scale inefficiencies, is

$$\begin{aligned}\pi(P,W,\theta,\delta,\rho) &= \sum_{i=1}^{m} P_iY_i - \sum_{j=1}^{n} W_jX_j \\ &= \sum_{i=1}^{m} \alpha_{ii}P_i + \sum_{j=1}^{n} \beta_{jj}W_j + \\ &\sum_{\substack{i=1\\i<h}}^{m}\sum_{h+1}^{m} \alpha_{ih}\, P_i^{1/2}P_h^{1/2}\,(\theta_{ih}^{1/2}+\theta_{ih}^{-1/2}) + \\ &\sum_{\substack{j=1\\j<k}}^{n}\sum_{k=1}^{n} \beta_{jk}W_j^{1/2}W_k^{1/2}(\delta_{ij}^{1/2}+\delta_{jk}^{-1/2}) + \\ &\sum_{i=1}^{m}\sum_{j=1}^{n} \gamma_{ij}P_i^{1/2}W_j^{1/2}(\rho_{ij}^{1/2}+\rho_{ij}^{-1/2})\end{aligned} \tag{2}$$

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[6] It is comonly recognized that society-wide production efficiency may result in asset allocation that society considers socially undesirable.

[7] Flexible functional forms can be used to provide reasonable second order approximations to a wide number of production, profit, and cost functions. Examples of flexible functional forms are the translog, Generalized Leontief, and generalized Box-Cox functions. The advantage of using the generalized Leontief profit function is that it does not assume exogenous output or input and for estimation purposes does not require the use of three stage least squares. (Three stage least squares' results may be sensitive to the choice of instruments, and optimal instrument selection is not easy to accomplish.) A new functional form, the Minflex Laurent, might be used also. The latter is most applicable to time series data, since its regular region expands as income (output) or costs grows (Barnett and Lee, 1985). The short time series in this sample does not warrant the Minflex Laurent.

All of the variables are defined as before, except for δ_{jk}, θ_{ih}, and ρ_{ij} which are inefficiency parameters. Under perfect competition, $\delta_{jk} = \theta_{ih} = \rho_{ij} = 1$ and allocative and scale efficiency exists, $\pi = \pi^*$.

Hotelling's lemma is applied to understand the role of the inefficiency parameters in equation (2):[8]

$$\frac{\partial \pi}{\partial P_1} = Y_i = \alpha_i + \sum_{\substack{h=1 \\ (i<h)}}^{m} \alpha_{ih}(\theta_{ih}P_i/P_h)^{-1/2} + \sum_{\substack{h=1 \\ (i>h)}}^{m} \alpha_{ih}(\theta_{ih}P_i/P_h)^{1/2} + \sum_{j=1}^{n} \gamma_{ij}\,(\rho_{ij}W_j/P_i)/^{1/2} \qquad i \neq h \tag{3}$$

$$\frac{\partial \pi}{\partial W_j} = -X_j = \beta_{jj} + \sum_{\substack{k=1 \\ (j<k)}}^{n} \beta_{jk}(\delta_{jk}W_j/W_k)^{-1/2} + \sum_{\substack{k=1 \\ (j>k)}}^{n} \beta_{jk}(\delta_{jk}W_j/W_k)^{1/2} + \sum_{i=1}^{m} \gamma_{ij}(\rho_{ij}P_i/W_j)^{1/2} \qquad k \neq j \tag{4}$$

where $\alpha_{ih} = \alpha_{hi}$, $\beta_{kj} = \beta_{kj}$, $\theta_{ih} = \theta_{hi}$, and $\delta_{jk} = \delta_{kj}$. The quantity $(\theta_{ih}P_i/P_h)$ is equivalent to the perceived price ratio for outputs i and h discussed in the prior section. P_i and P_h are actual prices; thus if θ_{ih} is one, the firm has behaved as if it accurately perceived these output prices. Otherwise, the optimal mix of outputs i and h has not been produced because Condition 1 is violated. Similar reasoning applies for the parameters δ_{jk} and ρ_{ij}. If $\delta_{jk} = 1$ for $j \neq k$, then input mix efficiency (condition 2) has been met. If $\rho_{i,j} = 1$ for all i and j, then scale efficiency (Condition 3) exists.

Finally, under the assumptions for Hotelling's lemma, if $\rho_{ij} = 1$ for all j and $\theta_{ih} = 1$ for all h, then $Y_i = Y_i^*$, which is the profit maximizing output level under perfect competition. Analogously, if $\delta_{jk} = 1$ for all k and $\rho_{ij} = 1$ for all i, then $X_j = X_j^*$. $\pi = \pi^*$ when $Y_i = Y_i^*$, and $-X_j = -X_j^*$.

However, Hotelling's lemma is valid if the firm is both an input and output price taker. In fact, this condition may not be met. It is not possible to separate this phenomenon from inefficiency.

An important feature of this efficiency model (assuming insurers are price takers) is that the dollar cost of inefficiency can be determined straightforwardly as

$$\pi^* - \pi = \sum_{\substack{i=1 \\ i<h}}^{m} \sum_{h=1}^{m} \alpha_{ih}P_i^{1/2}P_h^{1/2}\,(2-\theta_{ih}^{1/2}-\theta_{ih}^{-1/2}) + \sum_{\substack{j=1 \\ j<k}}^{n} \sum_{k=1}^{n} \beta_{jk}W_j^{1/2}W_k^{1/2}\,(2-\delta_{jk}^{1/2}-\delta_{jk}^{-1/2}) + \sum_{i=1}^{m} \sum_{j=1}^{n} \gamma_{ih}P_i^{1/2}W_j^{1/2}\,(2-\rho_{ij}^{1/2}-\rho_{ij}^{-1/2}) \tag{5}$$

[8] According to Hotelling's lemma, $\nabla_p\pi(p,w) = y(p,w)$ and $\nabla_w\pi(p,w) = -X(p,w)$, where $\nabla_m\pi = (\partial\pi/\partial m_1, \partial\pi/\partial m_2, \ldots, \partial\pi/\partial m_n)$.

In addition, the decrease in profit attributable to specific types of inefficiency can be isolated. For example, the decrease in profit due to nonoptimal output mix alone is

$$\pi^* - \pi = \sum_{\substack{i=1 \\ i<h}}^{m} \sum_{h=1}^{m} \alpha_{ih} P_i^{1/2} P_h^{1/2} (2 - \theta_{ih}^{1/2} - \theta_{ih}^{-1/2}) \tag{6}$$

That is, δ_{jk}, and ρ_{ij} are assumed to be one above to isolate the effect of output mix misallocation.

Equations (2) to (4) contain separate parameters θ, δ, and ρ for each price ratio. However, separate price ratios (e.g., P_i/W_k, W_k/W_j) contain prices common to more than one ratio. As indicated earlier, the possibility exists that if the insurer has incorrectly perceived the price W_k, then all price ratios containing W_k will be consistently perceived incorrectly. Consistent inefficiency implies the following constraints: $\theta_{ih} = \theta_{id} \times \theta_{dh}$; $\delta_{jk} = \delta_{je} \times \delta_{ek}$; and $\rho_{ij} = \rho_{ib} \times \rho_{bj}$. The presence of consistent inefficiency can be determined by incorporating constraints like the one above in the system of equations (2) to (4) (see Lovell and Sickles, 1983, p. 54.)[9]

One additional feature of profit functions must be noted. Because π is linearly homogeneous in prices, the factor demands ($-X_j$) are homogeneous of degree zero in prices and are unaffected by returns to scale. That is, proportional increases in all W_j and P_i result in proportional increases in profit as computed from the profit function. If nonconstant returns to scale exist, then some parameters in the model would vary with the output levels (i.e., $\beta_{jk} = \beta_{jk}(Y)$). Geehan (1986) surveys the major economies of scale studies for insurers. The conclusion overall is that constant returns to scale appear to exist, at least for large insurers. Therefore, returns to scale are assumed to be constant in this study.[10]

Data

The sample consists of 100 of the largest P/L insurers in 1984, and the sample period covers 1980 to 1984. Data availability determined the sample period. Data for output and input were obtained primarily from the 1980 to 1984 Annual Statements of these insurers and *Best's Executive Data Service* (*BEDS*), annual. Price indexes to adjust output and input levels to real dollars were obtained from the *Survey of Current Business, Statistical Abstract,* and Masterson (1985). Output and inputs are summarized in Table 2. The remainder of this section discusses these data in more detail.

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[9] The number of prices the insurer must observe is $(n+m)$. Only $(n+m-1)$ of the price ratios containing P_i and W_j are independent if consistent inefficiency is assumed.

[10] In a competitive environment each firm should operate at constant returns to scale (Baumol, Panzar, and Willig, 1982, p. 47). Thus in a competitive market, all firms should grow until scale economies are exhausted.

Table 2

Output and Input Specification

OUTPUT AND OUTPUT PRICES	
Y_{it}	= (Incurred Losses) $_{it}$/(Claim Index) $_{it}$
P_{it}	= (Premiums $_{it}$ - (Losses Incurred)$_{it}$)/Y_{it}
	$i = 1, \ldots, 4$
	Y_{it} = Incurred losses in competitive states except for those lines noted below for Y_{2t}.
	Y_{2t} = Incurred losses in competitive states for workers' compensation, auto liability, general liability, and malpractice in year t
	Y_{3t} = Incurred losses in regulated states except for those lines noted below for Y_{4t}.
	Y_{4t} = Incurred losses in regulated states for workers' compensation, auto liability, general liability, and malpractice in year t
	The Claim indexes are weighted average indexes of claims cost inflation over the period studied (available from *Best's Review* by Masterson (1985))
Y_{5t}	= (Loss Reserves + Loss Adjustment Expense Reserve + Unearned Premium Reserve)$_t$/ CPI_t
P_{5t}	= Average rate of return on a 3 month Treasury bill in year t
INPUT AND INPUT PRICES	
X_{1t}	= Real dollar labor expense in year t
W_{1t}	= Wage index in year t
X_{2t}	= Real dollar intermediate expense in year t
W_{2t}	= Price index for intermediate goods in year t
X_{3t}	= Real dollar capital in year t
W_{3t}	= Observed return to capital in year t

Sources: *Best's Executive Data Service, Survey of Current Business*, and Annual Statements

Capital = Average of (Surplus + Contingency Reserves + Borrowed Money + Excess of Statement over Statutory Reserves).

Observed Return = Net Income/Capital.

Output Data

Output volume and prices are needed to determine profit.

Output Volume: For insurers, output consists of service. These services can be broadly classified as underwriting (and administrative) services and intermediary services. Underwriting and administrative services, although unobservable, are assumed to vary directly with expected losses; hence expected losses are used as a proxy for these services (D'Arcy and Doherty, 1988, p. 15). Loss levels may vary over time due to inflation and other trends; therefore expected losses are deflated by claims cost indexes obtained from Masterson (1985).

Some underwriting services vary by line of business, hence a distinction is made between some lines. "Long-tail lines" refers to business for which a considerable time lag may exist between premium receipt and loss payments. Services provided in these lines are expected to vary from those of short-tail lines. Long-tail lines include workers' compensation, automobile liability, general liability, and medical malpractice. Short-tail lines are comprised of all other lines (e.g., fire, homeowners' peril, and automobile physical damage).

A further distinction between real losses in rate regulated versus competitive states is made to draw conclusions concerning output mix efficiency under these two regimes. States were categorized generally into competitive versus regulated states based on the type of regulatory law (Rand, 1985, p. 48). States with the following rate regulation laws were considered as competitive or open rate: advisory/ file and use, advisory/ use and file, advisory/no file, and no law (Illinois).[11] (Further distinctions among output by line are not made, since price data by state and by line are probably not accurate.)

Intermediary services are unobservable also, however they are assumed to be proportional to real policyholders' funds held by the insurer (e.g., see Pedoe, 1961). Policyholders' funds are estimated as the sum of loss reserves, loss adjustment expense reserves, and unearned premium reserves. (The unearned premium reserves are adjusted for the insurer's equity in these reserves.)[12] The funds are deflated by the Consumers Price Index (CPI) to ensure comparability from year to year.

In summary, five categories of output have been identified. These are underwriting and administrative service volume in (1) open rate states, short-tail business; (2) open rate states, long-tail business; (3) rate regulated states, short-tail business; and (4) rate regulated states, long- tail business. Output (5) is intermediary services. Output units in categories one through four are real (deflated) incurred losses, while the volume of intermediary services is assumed to be directly related to real (deflated) funds invested for policyholders.

Output Prices: The value of underwriting and administrative expenses are estimated as the difference between premiums earned and losses incurred by short-tail versus long-tail line and by regulated versus nonregulated states.[13] These values are used to determine prices as follows. The total value of administrative and underwriting expenses applicable to each output category (one through four) is divided by real incurred losses for that category. For example if real incurred losses are $100 million and underwriting and

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[11] The following states were considered open rate: Illinois, Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Hawaii, Idaho, Kentucky, Minnesota, Missouri, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, and Wisconsin.

[12] Specifically, the insurer's expense ratio is multiplied by the unearned premium reserve to obtain an estimate of expenses already paid by the insurer to acquire this business.

[13] Insurers do report expenses by state and investment income by line. However, these are subject to allocation techniques specified by the National Association of Insurance Commissioners (NAIC) and rely on accounting and regulatory considerations rather than economic principles. For some lines of business, particularly short-tail, underwriting profit is included in this price measure.

administrative expenses are \$30 million, then the price paid by the policyholder per \$1 of real losses incurred is \$0.30 (i.e., 30/100).

The value of intermediary services is estimated as the rate of return on a riskless asset multiplied by policyholders' funds.[14] The average three month Treasury bill rate for each year is used as an estimate of the riskless rate.

Input Data

Input volume and prices are needed to determine profits.

Input Volume: Input consists of labor, material, and capital. Labor input consists of agents' input, supervisory labor input, and nonsupervisory labor input. Materials consists of items such as published materials, lawyers' services, medical fees, and communications (e.g., telephone and postage). Capital input is proxied by the real surplus of the insurer.[15]

Input levels must be measured consistently to make reliable input usage comparisons. The volume of labor input is measured as the deflated value of salaries, including employee benefits costs (i.e., current dollar labor expense/labor wage index). Likewise, the volume of materials input is the real dollar value of this expense. The materials deflator used by the Bureau of Economic Analysis (BEA) to estimate gross product originating (GPO) for insurance is used to deflate materials input in this study. Average capital or surplus is deflated by the CPI in each year to determine its real value. In addition, surplus was adjusted to include certain statutory liabilities which are considered to be elements of surplus by generally accepted accounting principles (GAAP) (e.g., contingency reserves, reserves for excess of statutory over statement reserves, and equity in the unearned premium reserve). Average surplus is defined as one half of the sum of the beginning- and end- of-year surplus.

Input Prices: Labor input price is defined as a labor wage index for employees and agents of insurers. The labor wage index is defined as (average hourly wages)$_t$/(average hourly wages)$_b$, where b is the base year. Thus, labor price multiplied by labor volume is $W_{1t}\, X_{1t}$ = (labor wage index)$_t$ $\times$ (labor volume)$_t$ = (labor wage index)$_t$ $\times$ [(Current dollar labor expense)$_t$/ (labor wage index)$_t$], and this is the actual amount of labor expense incurred for year t. The deflator for wages is computed from wage trends for SIC 633, the Fire, Marine, and Casualty sector. Changes in commissions per agent was used to

[14] This rate is commonly used in discounting losses to determine premiums (e.g., Fairley, 1979).

[15] The insurance industry and other financial intermediaries have substantially different types of capital than other firms. These consist primarily of financial assets rather than equipment and machines. Thus real capital is determined differently. All capital investment represents consumption foregone in favor of increased consumption in the future. Hence a consumer's price index could theoretically be used to find real capital in all industries. This approach is not taken in most industries. Rather real capital is stated in terms of "own-units". The "own-unit" for insurers' capital is the real purchasing power of these investments.

compute the agents' compensation index.[16] From these a composite wage index was compiled.

A composite price for materials is defined as the current dollar value of materials input divided by its real value. The reasoning is the same as used for labor price. Finally, actual return to capital is estimated as net income divided by average surplus.

Hypotheses

The period 1980 to 1984 is associated with a liability crisis. News accounts indicate that P/L insurers underpriced liability coverages such as product liability, officers' and directors' liability, and medical malpractice during this period. One reason for the possible underpricing is larger than anticipated losses.

In addition, cash flow underwriting may have resulted in premium levels that were too low as insurers discounted premiums too heavily in anticipation of high investment return. The latter would most likely apply to the last years of the sample period, since interest rates fell over the period.[17] Underwriting standards may have been relaxed, resulting in lower utilization of underwriting services (e.g., investigations, inspections).

These considerations suggest the following hypotheses:

Hypothesis 1: P/L insurers overproduced long-tail business (liability insurance) relative to short-tail business over the sample period. The output mix efficiency factors θ_{12} and θ_{34} should be less than one if this hypothesis is accurate.

Hypothesis 2: P/L insurers produced an inadequate amount of reserves for long-tail business during the sample period. Specifically, the efficiency parameters θ_{25} and θ_{45} should be greater than one if this hypothesis is true.

Hypothesis 3: P/L insurers overutilized capital (by writing a large amount of liability insurance at reduced prices) and underutilized labor and other input. The efficiency parameters δ_{31} and δ_{32} should be greater than one if this hypothesis is correct. These hypotheses can provide clear evidence as to whether a liability crisis occurred and the extent of this crisis.

Regulation is likely to have an impact on output and input allocation. Competing theories exist concerning the nature of the deviation. Through rate regulation, for example, insurance regulators might effectively export some insurance costs to other states. Peltzman (1976) for instance asserts that political pressure from consumers may dampen regulated rates. Low profitability might exist also in rate regulated states in periods of inflation if rate adjustments lag loss costs (i.e., regulatory lag hypothesis) (e.g., Hiebert, 1976).

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[16] The agents' commission index was estimated from total commissions for P/L insurance and life insurance. The numbers of agents and level of commissions are available from the Bureau of Labor Statistics, *Insurance Fact Book*, and *The Life Insurance Fact Book*.

[17] The average rate of return on three month Treasury bills decreased from a high of 0.1471 to 0.0985 during the period 1980 to 1984 (Ibbotson Associates, 1987).

The alternative hypothesis states that regulation may serve the regulated industry by keeping profits and prices too high. Inefficient firms which might otherwise be driven out of existence are protected (Stigler, 1974 and Posner, 1974). The issue is ultimately an empirical one, and actual results may vary over different time periods depending upon the relative balance of power between consumer interest groups and the lobbying power of the insurance industry (Joskow, 1974).

Since interest rates were lower in the later part of the period, it is likely that regulatory lag affected prices. Specifically, regulatory rates were eroded over the course of the period as investment income declined and unanticipated losses were incurred. For example, a recent study by Grabowski, Viscusi, and Evans (1989) suggests that the impact of regulation during this period dampened automobile liability premiums. This suggests the following hypothesis concerning regulation:

Hypothesis 4: Rate regulation dampened insurance prices in rate regulated states (in rate regulated lines). Specifically, the efficiency parameter θ_{24}should be less than one. (Short-tail lines do not receive much regulatory scrutiny, if they are scrutinized at all.)

Research Methods

Equations (3) and (4) form a system of equations which contain all relevant information from the profit function. The allocative and scale efficiency parameters can be obtained by estimating these equations as a system of seemingly unrelated regressions (SUR) (Lovell and Sickles, 1983, p. 54- 55).[18] A time trend variable was added to each equation to incorporate productivity and other time related effects. The SUR method assumes that the error terms corresponding to each equation are homoscedastic (i.e., $\epsilon_{it} \sim N(0, \sigma^2)$). The hypothesis of homoscedasticity can be tested using the Goldfeld-Quandt test (Judge, 1985, p. 449).[19]

[18] Lovell and Sickles [1983] estimate technical inefficiency by introducing a parameter affecting the intercept terms in equations (3) and (4). The intercepts are amended to $(\alpha_{ii} - \mu_i)$ and $(\beta_{jj} - \psi_j)$ for output and input, respectively. The μ_i and ψ_j are shift factors which measure profit decrease due to technical inefficiency. The μ_i and ψ_j are estimated from the residuals obtained by estimating each equation in the system separately by nonlinear OLS. A similar analysis was conducted with these data, but the results were disappointing. Unreasonably high technical inefficiency was measured. More sophisticated techniques for determining technical efficiency have been proposed since Lovell and Sickles (1983). For example, Battese and Coelli (1988) criticize Lovell and Sickles' methodology and propose alternative methods to estimate technical efficiency. Unfortunately, this method cannot be applied to multi-product firms such as insurers.

[19] The possibility exists that the error terms for each company in each equation are serially correlated. The data are insufficient to test for this potential problem since only five observations of ϵ_{it} per company are available. Even if autocorrelation is severe enough to affect the estimation, the parameter estimates would still be unbiased and consistent but not efficient. The variance estimates for the parameters would be larger than if autocorrelation could be adjusted for. One consequence of this is that the significance of the hypotheses tests would be lower than would otherwise be the case.

The significance of specific allocative or scale inefficiency parameters can be determined from the mean squared errors (MSEs) of the full system and a restricted system in which individual efficiency parameters are restricted to be one. For example, to test whether some efficiency parameter δ_{jk} is significantly different from one, the full system is estimated (including δ_{jk}); then a restricted version of the system is run in which δ_{jk} is assumed to be one. The ratios of the MSEs for the full model and restricted model are distributed asymptotically as a X^2 statistic with the degrees of freedom equal to the difference in the number of parameters in each model (Gallant and Jorgenson, 1979).

Results

The Goldfeld-Quandt test for heteroscedasticity indicated that heteroscedasticity was present (i.e., $\epsilon_{it} \sim N(0,\sigma i^2)$). The variances were related to the amount of reserves the insurers held; that is larger insurers exhibited relatively larger ϵ_{it}.[20] Therefore, the variable Y_{5t} was used as a weight in each equation, and SUR was conducted on the system of weighted equations.

The SUR results are contained in Table 3. Results for inconsistent and consistent inefficiency are presented.[21] In initial estimates of these models, some efficiency parameter estimates were biased due to multicollinearity.[22] A number of methods may be used to assess multicollinearity, including examination of the eigenvalues (characteristic roots) and principle components of the variables in the model. If a small eigenvalue is coupled with a component which is associated with the variance of two or more variables, it can be assumed that multicollinearity is affecting the parameter estimates (Judge, 1985). To deal with the problem, the efficiency parameter strongly associated with the variance of two or more components was deleted. (Only one efficiency parameter was deleted at a time.) After the deletion, the model was re-estimated and the degree of multicollinearity was evaluated again. This sequence of steps was repeated until the severe multicollinearity problems were resolved. In effect, this process constrains each omitted efficiency parameter to be one. Constraining parameters is one of the recommended methods to deal with multicollinearity (Judge, 1985, pp. 904–08).

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[20] Reserves represent an estimate of incurred losses which have not been paid as of the financial statement date. For the P/L insurance industry as a whole, over 70 percent of these reserves are attributable to long-tail business, and losses for these lines are difficult to estimate accurately. Hence large variation is possible in larger insurers. Reserves are strongly correlated with asset size and premium volume.

[21] Consistent inefficiency refers to assumptions concerning the ratios of relative prices (see endnote (9)). It does not refer to the statistical properties of the estimator. Both models satisfied monotonocity; convexity was satisfied at the sample mean.

[22] Linear dependencies were identified by the SAS routine used to compute the system (See SAS/ETS User's Guide – Version 5, SAS Institute Inc., Cary, NC, 1985, p. 522). In cases of severe multicollinearity, some parameter estimates were denoted as BIASED with a STD ERROR of 0 in the SAS output.

Table 3

Estimates of Efficiency Parameters for Five Output Model

	Inconsistent Inefficiency		Consistent Inefficiency	
Variable	**Coefficient**	**Efficiency Parameter**	**Coefficient**	**Efficiency Parameter**
P_1	82.515		4.033	
	(1.57)		(0.08)	
P_2	208.125		183.529	
	(8.20)		(7.34)	
P_3	77.177		57.266	
	(2.90)		(2.40)	
P_4	93.526		66.951	
	(3.39)		(2.43)	
P_5	1928.140		441.738	
	(1.63)		(0.38)	
W_1	-99.818		-254.660	
	(-0.92)		(-3.11)	
W_2	-193.280		-24.062	
	(-2.28)		(-0.38)	
W_3	-897.780		-587.330	
	(-7.60)		(-4.77)	
P_2/P_3	-67.900	0.869	-60.182	0.762
	(-5.94)	(2.89)	(-5.91)	(2.46)
P_2/P_4	-75.733	0.625	-62.776	0.895
	(-7.09)	(3.65)	(-5.19)	(1.78)
P_2/P_5	-273.72	2.403	-285.160	0.053
	(-2.03)	(1.77)	(-3.49)	(0.08)
P_2/W_1	127.339	0.584	128.287	0.093
	(4.99)	(2.18)	(4.45)	(-.85)
P_2/W_3				0.184
				(1.75)
P_3/P_4	-29.862	2.559	-25.090	0.503
	(-2.66)	(1.06)	(-2.60)	(2.06)
P_3/P_5	-185.080	3.128		
	(-1.45)	(0.70)		
P_3/W_1			-48.057	0.062
			(-2.19)	(0.53)
P_3/W_2	77.731	0.172		
	(2.89)	(1.19)		
P_4/P_5	-298.000	2.143	-485.660	1.454
	(-2.73)	(1.40)	(-5.57)	(2.47)
P_4/W_1	133.522	0.605	186.974	1.464
	(5.18)	(2.10)	(7.08)	(1.53)
P_4/W_3			35.718	0.174
			(3.59)	(2.08)
P_5/W_3	77.539	10.299	225.848	0.363
	(0.57)	(0.28)	(8.64)	(3.30)

Table 3 (Continued)

Variable	Inconsistent Inefficiency Coefficient	Inconsistent Inefficiency Efficiency Parameter	Consistent Inefficiency Coefficient	Consistent Inefficiency Efficiency Parameter
P_5/W_1	630.254	0.593		
	(1.91)	(1.02)		
P_5/W_2	315.088	0.394		
	(1.19)	(0.88)		
W_3/W_1	-28.930	4.436	107.710	3.789
	(-0.95)	(0.59)	(6.87)	(2.88)
W_1/W_2	-271.820	0.322		
	(-4.19)	(1.76)		

Note: Efficiency coefficients correspond to θ_{ih}, δ_{jk}, and ρ_{ij}.
t-statistics are in parenthesis below each coefficient.

Chi-squared tests to determine the statistical significance of the inefficiency parameters are reported in Table 4.[23] The cost in dollars of the inefficiency measured is presented in Table 5. The remainder of this section discusses the results of the hypothesis tests and the dollar amount of profit loss at mean output levels.

Results of Hypothesis Tests

Hypothesis 1: According to Hypothesis 1, the efficiency parameters corresponding to long- and short-tail output prices (θ_{12} and θ_{34}) should be less than one. The results for the inconsistent efficiency model do not support this hypothesis. Specifically, the efficiency parameter for short and long-tail business in rate regulated states (θ_{34}) is greater than one in the inconsistent efficiency model but is not significant; the corresponding efficiency parameter for regulated states is less than one and significant in the consistent efficiency model, in accordance with the hypothesis. In both models, the inefficiency parameter for short-tail and long-tail output in competitive states was not significantly different than one.[24]

However, these results are based on the assumption that losses incurred and prices for long- and short-tail business are accurate. But this period is associated with underreserving. If underreserving occurred, then the measured output price (based on premiums minus losses incurred) would be overstated. Correction for this error is required for an ex post assessment of inefficiencies for long and short tail lines. That is, adjustment for reserving errors eliminates

[23] The approximation to the profit function assumes that return to capital is positive for each company. (That is, square roots are taken in the course of estimating equations (3) and (4).) Actual results from 1984 for some sample insurers reflect negative income. Hence these observations could not be used.

[24] The efficiency parameter for long- and short-tail business in competitive states (Θ_{12}) was restricted to be one to reduce multicollinearity. That is, this parameter was highly correlated with other variables in the model.

Table 4

Results of Chi-Squared Tests

Price Ratio	Inefficiency Parameter	Chi-Squared Results: Inconsistent Inefficiency	Chi-Squared Results: Consistent Inefficiency
Output Mix (Allocative):			
P_2/P_3	θ_{23}	0.64	6.96
P_2/P_4	θ_{24}	3.79	0.91
P_2/P_5	θ_{25}	0.01	4.96
P_3/P_4	θ_{34}	0.55	6.82
P_3/P_5	θ_{35}	0.23	–
P_4/P_5	θ_{45}	0.27	13.44
Input Mix (Allocative):			
W_3/W_1	δ_{31}	1.23	6.44
W_1/W_2	δ_{12}	2.75	–
Scale:			
P_2/W_3	ρ_{23}	–	6.90
P_2/W_1	ρ_{21}	6.39	4.97
P_3/W_1	ρ_{31}	–	6.74
P_3/W_2	ρ_{32}	8.70	–
P_4/W_3	ρ_{43}	–	0.17
P_4/W_1	ρ_{41}	2.66	0.58
P_5/W_3	ρ_{53}	10.36	7.90
P_5/W_1	ρ_{51}	0.12	–
P_5/W_2	ρ_{52}	0.19	–

$X^2_{1,.01} = 6.63$
$X^2_{1,.05} = 3.84$
$X^2_{1,.10} = 2.71$

this error from the price and output estimates and indicates actual resource allocation.

Unfortunately, data to compute loss reserving errors by company and by state are unavailable for this study. Loss reserving data by line and by company is available from Schedule P of the Annual Statements of these insurers. However, reserving errors can only be asessed by future Schedule P reports, which are unavailable *for this study*. However, average reserving errors for the entire P/L insurance industry are available from *Best's Aggregates and Averages*.[25] Analysis of the latest available data indicate that losses incurred were understated by –0.2 percent, 1.0 percent, 5.2 percent, 9.1 percent and 11 percent of the originally reported loss levels from 1980 through

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[25] *Best's Aggregates and Averages* reports consolidated P/L insurers' results, including a consolidated Schedule P. Errors in reserves can be tabulated by finding the difference between ultimate losses and the original estimate for incurred losses in each year.

1984, respectively. If these insurers misstated losses according to the average for the industry, then the effect of loss reserving errors on efficiency can be assessed. Thus, adjustments to reserves (Y_5), surplus (X_3), long-tail losses incurred (Y_2, Y_4) and net income were made to include the cumulative effect of these average errors.[26] Because reserving practices may vary by state, long-tail business in regulated and non-regulated lines were combined. Similarly, all business in short-tail lines were combined.

The results from this three output model (with correction for average reserving errors) is contained in Appendix Table 3.[27] The inefficiency parameter θ_{SL}, corresponding to the price ratio for short-tail and long-tail business (P_S/P_L), is unexpectedly greater than one and significant. (S and L refer to short-tail business and long-tail business, respectively). Thus reserving errors do not explain the results in Table 3.

Hypothesis 2: The underreserving problem noted above theoretically may be reflected in the relationship between long-tail business and total reserve levels. The evidence from the models in Table 3 support this contention. Specifically, overproduction of long-tail buiness in rate regulated states relative to reserves (output 5) are indicated in the models. The inefficiency parameter θ_{45} is greater than one and statistically significant in the consistent inefficiency model. Hypothesis 2 is not supported in the results for competitive states; the parameter θ_{25} is not significant (inconsistent inefficiency model) or does not have the hypothesized value (consistent inefficiency model).

This result for competitive states ($\theta_{25} < 1$) may be explained by cross subsidization of costs from regulated states to competitive ones. (Specifically, reserve bolstering in competitive states may be used to offset deficiencies in reserve levels in regulated states.) This behavior, however, would not be consistent with "competitiveness" in these states.

Several other reasons may exist for this. For example, a monopolistic firm would appear to produce too little output because the output price would be greater than marginal cost (i.e., $P \neq MC$). In addition, many states have compulsory insurance laws for coverages such as workers' compensation and automobile liability. Demand for these coverages would be inelastic so that increases in premiums may not result in decreases in the quantity of coverage purchased.

Hypothesis 3: Table 3 indicates that a nonoptimal input mix was used; specifically, capital was overutilized relative to labor. The inefficiency parameters δ_{31} in both models exceed one, and δ_{31} is statistically significant at the .01 level in the consistent inefficiency model. The efficiency parameter δ_{12}

[26] Specifically, the cumulative reserving error was subtracted from surplus and added to Y_5 in each year. The price corresponding to long-tail business was reduced by adding the loss reserve error to losses incurred in each year. Return to capital (profit) was decreased by the same amount.

[27] P_L is defined as the difference between premiums earned and adjusted losses incurred per \$1.00 of incurred loss for workers' compensation, automobile liability, general liability, and malpractice insurance; P_S is defined similarly for all other lines of business. In the three output models, adjusted losses incurred for long-tail lines incorporates average reserving errors, and the corresponding price for long-tail business is decreased.

corresponds to the price ratio for labor and intermediate input, respectively. This coefficient is less than one and almost statistically significant in the inconsistent efficiency model, indicating an overutilization of material input relative to labor input.

Hypothesis 4: Evaluation of relative output production in competitive versus rate regulated states can be made from the inefficiency parameters θ_{13} and θ_{24} Hypothesis 4 states that the price of long-tail business was dampened in rate regulated states (compared to competitive ones), and the results are consistent with this hypothesis. The inefficiency parameter corresponding to P_2/P_4 is less than one in both models and is almost significant in the inconsistent inefficiency model. These results do not extend to short-tail business; the parameter θ_{13} is not significantly different from one in either model.

Other Result: In addition to the parameters discussed above, some scale inefficiencies exist in the consistent inefficiency model. Specifically the inefficiency parameters correspong to short tail output price in regulated states/labor price (P_3/W_1) and long tail output price in competitive states/labor price (P_2/W_1) are less than one (ρ_{31}, $\rho_{21} < 1.0$), indicating that too much labor relative to these outputs were utilized. For long-tail output in regulated states, the results indicate that relatively too little labor was used for this output ($\rho_{41} > 1.0$), although the latter results are not statistically significant.

Scale inefficiency related to capital is detected also in the model. The scale inefficiency parameters ρ_{23} and ρ_{43} are less than one, and the coefficient ρ_{43} is statistically significant. That is, the long run optimal level of capital input was not achieved. These results suggest that too little long-tail output was produced relative to the capital base. The inefficiency parameter ρ_{53} is less than one in the consistent inefficiency model indicating that reserves were underproduced relative to capital. The latter is consistent with a liability crisis.

Measurement of Profit Deviations from the Maximum

The impact of inefficiency on profit can be estimated by substituting the relevant parameter estimates into equation (5). Table 5 contains estimates of profit loss using average prices of the sample insurers. The analysis focuses primarily on output allocation inefficiencies. It is this behavior which is most frequently cited as the reason for the liability crisis (i.e., excessive production of long-tail output at inadequate prices).

The totals in Table 5 indicate that inefficiency (defined as deviation from marginal cost pricing) resulted in a profit loss of \$318 million if consistent inefficiency is assumed to exist and \$121.8 million if inconsistent inefficiency is assumed. These represent 14.9 percent and 5.6 percent, respectively, of average total assets for the sample insurers. Regulation frequently concerns premium levels. The profit loss in the consistent efficiency model is 33 percent of average total net premiums earned for the sample, and in the inconsistent inefficiency model profit loss is estimated to be 12.6 percent of total net premiums earned. These findings support the dramatic increase in premiums

Table 5
Estimated Profit Loss from Inefficiency

Price i	Price j	Inconsistent Inefficiency Profit Loss	Consistent Inefficiency Profit Loss
		(Dollars in millions)	
P_2	P_3	—	$ 1.4
P_2	P_4	$ 7.7	0.3
P_2	P_5	12.0	264.4
P_3	P_4	14.2	4.6
P_3	P_5	31.2	—
P_4	P_5	10.9	7.4
W_3	W_1	23.4	39.9
W_3	W_2	22.4	—
	Total	$121.8	$318.0

Note: Prices are defined in Table 2.

in the years immediately following 1984. It is interesting to note that premiums in many lines of insurance have been increasing at rates slightly larger than the 13 percent rate presented in the inconsistent inefficiency model (e.g., automobile liability). Correction of these inefficiencies can help to stem the tide of premium rate increases.[28]

Conclusion

Many economic analyses rely on the assumption of perfect competition. Due to uncertainty, regulation, and other factors, this outcome may not be achieved. To evaluate allocation of resources among industries and within firms, the cost associated with inefficiency must be known. This research provides estimates of profit loss for a sample of large P/L insurers. The results indicate that excessive costs of $121.8 to $318 million occurred on the average. This cost represents 12.6 to 33 percent of average net premiums and is roughly comparable to the increase in premium rates in sensitive liability lines (e.g., auto insurance).

Regulators must evaluate the performance and stability of P/L insurers. These factors are evaluated through direct examinations of insurers, audits of financial statements and financial ratio tests. Regulators are interested also in keeping premiums at adequate but not excessive levels. Analysis of the latter usually focuses on loss ratios and underwriting profit margins. This research exemplifies a more sophisticated methodology for evaluting resource usage and can pinpoint more precisely how an insurer is inefficient (e.g., over-

[28] Recall that in this model the effects of monopolistic pricing are included in the profit loss estimate.

expansion of production, excessive labor usage, nonoptimal mixes of output and input). Excessive profit margins is just one type of inefficiency; other sources of inefficiency may be just as costly or more costly to consumers than high profit levels.

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Table A.1

Regression Results

Inconsistent Inefficiency - 5 Output Model

Variable	Coefficient	Variable	Coefficient	Efficiency Variable	Parameter Coefficient
P_1	82.52	P_2/W_1	127.34	P_2/P_3	0.87
	(1.57)		(4.99)		(2.89)
P_2	208.12	P_2/W_2	33.59	P_2/P_4	0.63
	(8.20)		(1.85)		(3.65)
P_3	77.18	P_3/P_4	-29.86	P_2/P_5	2.40
	(2.90)		(-2.66)		(1.77)
P_4	93.53	P_3/P_5	-185.08	P_2/W_5	0.58
	(3.39)		(-1.45)		(2.18)
P_5	1928.14	P_3/W_3	13.89	P_3/P_4	2.56
	(1.63)		(1.27)		(1.06)
W_1	-99.82	P_3/W_1	-45.38	P_3/P_5	3.13
	(-0.92)		(-1.31)		(0.70)
W_2	-193.28	P_3/W_2	77.73	P_3/W_2	0.17
	(-2.28)		(2.89)		(1.19)
W_3	-897.78	P_4/P_5	-298.00	P_4/P_5	2.14
	(-7.60)		(-2.73)		(1.40)
P_1/P_2	-22.22	P_4/W_3	5.18	P_4/W_1	0.61
	(-1.32)		(0.53)		(2.10)
P_1/P_3	-7.75	P_4/W_1	133.52	P_5/W_3	10.30
	(-0.43)		(5.18)		(0.28)
P_1/P_4	-7.34	P_4/W_2	55.17	P_5/W_1	0.59
	(-0.45)		(2.97)		(1.02)
P_1/P_5	-109.95	P_5/W_3	77.54	P_5/W_2	0.88
	(-0.74)		(0.57)		(0.88)
P_1/W_3	25.91	P_5/W_1	630.25	W_3/W_1	4.44
	(1.23)		(1.91)		(0.59)
P_1/W_1	58.84	P_5/W_2	315.08	W_3/W_2	0.32
	(1.47)		(1.19)		(1.76)
P_1/W_2	51.24	W_3/W_1	-28.93		
	(2.09)		(-0.95)		
P_2/P_3	-67.90	W_3/W_2	-17.86		
	(-5.94)		(-1.36)		
P_2/P_4	-75.73	W_1/W_2	-271.82		
	(-7.09)		(-4.19)		
P_2/P_5	-273.72				
	(-3.03)				
P_2/W_3	20.25				
	(2.08)				

Time Trend Parameters

P_1	26.06	(1.94)
P_2	-4.49	(-0.54)
P_3	3.25	(1.79)
P_4	-11.15	(-1.74)
P_5	246.38	(1.65)
W_1	-25.31	(-1.63)
W_2	-11.00	(-1.65)
W_3	-100.66	(-3.09)

Note: t-statistics are in parenthesis below each coefficient. Variables are defined in Table 1. Efficiency coefficients correspond to θ_{ih}, σ_{jk}, and ρ_{ij}.

Table Table A.2
Regressions Results
Consistent Inefficiency - 5 Output Model

Variable	Coefficient	Variable	Coefficient	Efficiency Parameter Variable	Efficiency Parameter Coefficient
P_1	4.03 (0.08)	P_2/W_1	128.29 (4.45)	P_2/P_3	0.76 (2.46)
P_2	183.53 (15.33)	P_2/W_2	40.93 (1.60)	P_2/P_4	0.90 (1.78)
P_3	57.27 (6.26)	P_3/P_4	-25.09 (-2.60)	P_2/P_5	0.05 (0.08)
P_4	66.95 (2.43)	P_3/P_5	-167.92 (-1.88)	P_2/W_3	0.18 (1.75)
P_5	441.74 (1.33)	P_3/W_3	53.07 (8.62)	P_2/W_1	0.90 (0.85)
W_1	-254.66 (-3.11)	P_3/W_1	-48.06 (-3.78)	P_3/P_4	0.50 (2.06)
W_2	-24.06 (-0.38)	P_3/W_2	46.12 (1.13)	P_3/W_1	0.06 (0.53)
W_3	-587.33 (-4.77)	P_4/P_5	-485.66 (-5.57)	P_4/P_5	1.45 (2.47)
P_1/P_2	-27.82 (-1.88)	P_4/W_3	35.72 (3.59)	P_4/W_3	0.17 (2.08)
P_1/P_3	-28.86 (-1.77)	P_4/W_1	186.97 (7.08)	P_4/W_1	1.46 (1.53)
P_1/P_4	-10.499 (-0.76)	P_4/W_2	16.15 (1.03)	P_5/W_3	0.36 (3.30)
P_1/P_5	-125.93 (-1.21)	P_5/W_3	225.85 (8.64)	W_3/W_1	3.79 (2.88)
P_1/W_3	-91.70 (-5.99)	P_5/W_1	911.57 (3.58)		
P_1/W_1	-3.04 (-0.14)	P_5/W_2	511.34 (2.46)		
P_1/W_2	59.50 (2.37)	W_3/W	-107.71 (-6.87)		
P_2/P_3	-60.18 (-5.91)	W_3/W_2	-43.06 (-6.54)		
P_2/P_4	-62.78 (-5.19)	W_1/W_2	-337.93 (-6.34)		
P_2/P_5	-285.16 (-3.49)				
P_2/W_3	11.56 (-0.15)				

Time Trend Parameters	
P_1	42.96 (3.36)
P_2	4.19 (0.51)
P_3	20.70 (2.97)
P_4	-9.12 (-1.44)
P_5	324.13 (2.28)
W_3	-134.19 (-4.08)
W_1	-30.57 (-2.04)
W_2	-11.76 (-1.68)

Note: t-statistics are in parenthesis below each coefficient.
Variables are defined in Table 1.
Efficiency coefficients correspond to θ_{ih}, δ_{jk}, and ρ_{ij}.

Table A.3.A

Regression Results
Consistent Inefficiency - 3 Output Model
(Adjustment for Reserving Errors)

Variable	Coefficient	Variable	Coefficient	Efficiency Parameter Variable	Efficiency Parameter Coefficient
P_S	131.24	P_S/P_5	-101.48	P_S/P_L	11.32
	(1.84)		(-0.67)		(0.40)
P_L	122.69	P_S/W_3	117.70	P_L/W_1	0.251
	(2.37)		(3.87)		(0.53)
P_5	295.91	P_S/W_1	-49.37	W_1/W_2	0.22
	(0.28)		(-0.77)		(2.11)
W_1	-205.87	P_S/W_2	97.60		
	(-1.87)		(4.12)		
W_2	-325.84	P_L/W_3	25.84		
	(-4.14)		(1.31)		
W_3	-307.59	P_L/W	182.09		
	(-2.89)		(4.55)		
P_S/P_L	46.18	P_L/W_2	189.11		
	(-0.71)		(7.44)		
P_L/P_5	-851.66	P_5/P_3	81.50		
	(-7.42)		(1.03)		
W_3/W_1	-62.56	P_5/W_1	1516.28		
	(-2.53)		(5.43)		
W_1/W_2	-271.84	P_5/W_2	277.46		
	(-3.77)		(2.54)		
		W_3/W_2	-25.83		
			(-2.36)		

Time Trend Parameters	Coefficient	t-statistic
P_S	69.16	(3.50)
P_L	-5.49	(-0.37)
P_5	216.23	(1.46)
W_1	-16.91	(-1.11)
W_2	-8.92	(-1.35)
W_3	-134.15	(-4.21)

Note: t-statistics are in parenthesis below each coefficient. Variables are defined in Table 1 except P_S and P_L. These are weighted averages of short-tail and long-tail business, respectively. Short-tail business is averaged over openrate and regulated states. P_l is defined similarly. Efficiency coefficients correspond to θ_{ih}, δ_{jk}, and ρ_{ij}.

Table A.3.B

Results of Chi-Squared Tests — 3 Output Model

Price Ratio	Inefficiency Parameter	Results of Chi-Squared Tests
P_S/P_L	θ_{SL}	17.93
P_L/W_1	ρ_{L1}	41.85
W_{1/W_2}	δ_{12}	13.03