Causal Relationships Between Premiums and Losses, and Causes of the Underwriting Cycles

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Underwriting Cycles and Dynamic Relationships Between Premiums and Other Financial Variables

Recent empirical work shows that property-liability industry underwriting returns are cyclical. The evidence from these studies suggests that underwriting-profit rates follow a second order autoregressive process. The exact causes of the underwriting cycle, however, have never been agreed upon in the insurance-economics literature.

Various hypotheses have been proposed and tested to explain the insurance underwriting cycle. Some of these hypotheses include: (1) the extrapolation hypothesis by Venezian (1985), (2) rational-expectations/institutional-intervention hypothesis by Cummins and Outreville (1987), (3) the fluctuation-in-interest-rates hypothesis suggested by Doherty and Kang (1988), (4) the capacity-constraint hypothesis by Winter (1988, 1989)[1], and (5) the change-in-expectations hypothesis by Lai and Witt (1990 and 1992).[2]

Although all the above hypotheses, except for the change-in-expectations hypothesis, have been empirically tested, some unresolved issues and problems still remain. Most of the studies do not simultaneously test all of the proposed hypotheses, and the omission of some relevant variables may cause variable specification errors and ignore some relevant hypotheses as a consequence. However, a recent study has resolved some of these problems. Niehaus and Terry (1993), utilizing existing theoretical models, developed a comprehensive set of testable hypotheses and used Granger causality tests to evaluate these hypotheses about determinants of insurance premiums and causes of the underwriting cycles.

The empirical evidence provided by Niehaus and Terry (1993) sheds some light on the insurance underwriting cycle. However, by using regression analysis they only document the results of simple statistical hypothesis tests for causal relations. Such an analysis may not provide

[1]Similar arguments can be found in Cummins and Danzon (1991) and Gron (1990, 1992). Gron (1990) tests the capacity constraint hypothesis and provides empirical evidence which is consistent with Winter's hypothesis.
[2]For a detailed review of underwriting cycles, see Cummins, Harrington, and Klein (1992).

a complete description and analysis of the data.[3] For example, they report that the coefficients on several lagged variables have opposite signs in some of their models, such as surplus lagged for one and two periods (see Panel B, Table 4, Niehaus and Terry, 1993). Clearly, a meaningful conclusion is difficult to reach about the effect of surplus on premiums when lagged surplus variables have opposite signs. Furthermore, Granger causality tests do not shed light on the response of premiums to shocks in other relevant variables over a long period of time. Such premium responses over time may be important to test for and may help to explain institutional lags and cyclical trends. Finally, Niehaus and Terry did not test the change-in-expectations hypothesis.

This research assesses two major issues: (1) the "causal" relations and dynamic interactions between premiums and losses are evaluated by using a vector autoregressive model (VAR) which includes lagged values of the variables; and (2) how premiums respond to shocks in selected variables including surplus, interest rates, the variance of losses, and the variance of interest rates is examined.

More specifically, this research extends the existing literature on underwriting cycles in several ways. First, it develops results for the decomposition of variance which tend to provide more information than a simple statistical hypothesis test for rejection or non-rejection of a null hypothesis. Second, the evaluation of new results generated by impulse response functions of premiums to shocks in variables other than surplus provides more information and insights about the rational-expectations/institutional-intervention hypothesis and possible causes generating cyclical trends in premiums. Third, this cycle study is the first to include uncertainty measures based on the variance of losses and the variance of interest rates in the time-series models and to provide some empirical evidence about the change-in-expectations hypothesis.

The remainder of this paper is organized as follows. The following section briefly summarizes the hypotheses to be tested. The next section describes the data and the vector autoregressive

[3] Similar arguments can be found in Lee (1992).

(VAR) methodology. The subsequent section contains results of the VAR analysis (variance decompositions and impulse response functions). Finally, the concluding section summarizes and concludes the study.

Hypotheses

Niehaus and Terry (1993) have carefully reviewed and specified a relatively comprehensive set of hypotheses on underwriting cycles from the insurance-economics literature. The hypotheses are briefly summarized below and then test results are presented in the next section.

HYP.1: Past losses can explain current premiums.

Venezian (1985) proposed a loss extrapolation hypothesis which is based on the observation that insurers and rating bureaus set rates (premiums) to a certain extent by using regression results derived from past losses. He suggested that the premiums set by this method would create "a quasi-cyclical pattern" of underwriting profit margins.[4] That is, past losses may explain current premiums because premiums are partially set by using regression results based on past losses. A hypothesis of rational expectations with institutional lags advanced by Cummins and Outreville (1987) suggests that underwriting cycles may be due to the presence of data collection lags, regulatory lags, and policy renewal lags in a rational expectations framework. Moreover, they suggest that in such a rational expectations framework, premiums are set based on expected future losses and expenses. Niehaus and Terry (1993) have argued that any measure of expected losses may be subject to measurement error which may be correlated with past losses. Therefore, it can be hypothesized that past losses may predict premiums in a rational expectations framework with various lags and institutional factors because of measurement error.

HYP.2: Premiums are informationally efficient predictors of future losses.

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[4]Brockett and Witt (1982) made a similar suggestion in response to a comment by Venezian (1982) on the underwriting risk and return paradox discussed by Hedges (1981) and Witt (1981).

Financial models applied to insurance pricing, such as those by Kraus and Ross (1982), Fairley (1979), Hill (1979), Myers and Cohn (1987), Moridaira, Urrutia, and Witt (1992), suggest that insurance premiums reflect the present value of expected losses and expenses in a rational expectations framework.[5] Thus, it can be hypothesized that current premiums are informationally efficient predictors of future losses.

HYP.3: Inverse relationship between current premiums and past surplus changes.

This hypothesis is based on the capacity constraint theory which was first advanced by Winter (1988 and 1989). Winter's argument, based on the assumption that external equity is more expensive to raise than internal equity (Myers and Majluf, 1984), suggests that the insurer will not immediately adjust surplus when the surplus is reduced by adverse outside shocks, such as catastrophes. Since the quantity of insurance potentially available is constrained by an insurer's equity or capacity, supply is reduced after adverse shocks. Thus, prices tend to be forced up when insurance capacity or equity is reduced. Similarly, when there is excess capacity, the potential supply of insurance is greater than market demand, and prices are driven down in competitive markets.

HYP.4: Inverse relationship between interest rates and premiums.

Financial models or an analysis in a rational expectations framework suggest that insurance premiums reflect the present value of expected losses and expenses (see Myers and Cohn, 1987, and Cummins, 1991). Thus, the higher the discount rate, the lower premiums will tend to be, other things being equal. This prediction is also consistent with a hypothesis suggested by Smith (1989) and Doherty and Kang (1988). Doherty and Kang in particular suggested that fluctuations in the interest rates cause insurance pricing cycles. The underlying

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[5]It should be noted that predictions in a rational expectations framework differ from rational expectations with an institutional lag hypothesis. A hypothesis of rational expectations with institutional lag hypothesis considers data collection lags and other institutional factors while these lags and institutional factors are ignored or assumed away in a simple rational expectations framework. For a detailed review of insurance pricing models, see Cummins (1991).

intuition is that higher interest rates generate greater investment income which brings about lower premiums, and vice versa.

HYP.5: Positive Relationship between uncertainty and premiums.

Lai and Witt (1990) recently developed a pricing model under uncertainty. The model suggests that premiums are a function of variance in both losses and interest rates, in addition to the expected value of losses and interest rates. The impact of increases in uncertainty about losses and interest rates on insurance premiums (as measured by their variance) would be expected to be positive, because managers of insurers are assumed to be risk adverse (for stock insurers one can assume there are agency problems due to the large investment in human capital specific to a stock firm by managers)[6]. In other words, Lai and Witt (1990 and 1992) suggest that uncertainty is one of the factors that caused the commercial liability insurance crisis. Their analysis can be extended to help explain the underwriting cycle. Specifically, when insurers' expectations about future uncertainty of losses and interest rates are high (low) then premiums will tend to be high (low), other things being equal.

Data and Methodology

Forty-four years of annual data spanning the period 1946 through 1989 are used in the time-series estimation. All data were derived from various issues of *Best's Aggregates and Averages* which are published by the A. M. Best Company.[7]

All of the variables in this study measure yearly changes in value and are transformed into first differences as follows:

$$y_t = Y_t - Y_{t-1}$$

where Y_t is the natural logarithm of the variable of interest (except for interest rates) at time t, and y_t is the first difference of the variable of interest. In the first model specified below, a two-variable VAR system (premiums and losses) is employed. A six-variable model is then specified.[8]

[6]For an alternative rationale, see Greenwald and Stiglitz (1990).
[7]The authors would like to thank Niehaus and Terry for sharing their data with us.

Two-Variable Vector Autoregressive Model.

Premium and losses are measured by premiums written during year t, PR_t, and losses paid during year t, LP_t, respectively. Premiums rather than loss ratios or combined ratios are used in this study for analytical purposes because premiums appear to be a major driving force behind the underwriting cycle. Premiums incorporate information about expected losses, discount rates, surplus, and uncertainty factors that are related to the hypotheses to be tested in this paper.[9] Paid losses are obtained by subtracting the change in the loss reserves from losses incurred. The VAR model for premiums and losses with three lags in each variable is specified as follows:[10]

$$PR_t = \alpha_{10} + \sum_{j=1}^{3}\alpha_{1j}PR_{t-j} + \sum_{j=1}^{3}\beta_{1j}LP_{t-j} + \varepsilon_{1t} \qquad (1)$$

$$LP_t = \alpha_{20} + \sum_{j=1}^{3}\alpha_{2j}PR_{t-j} + \sum_{j=1}^{3}\beta_{2j}LP_{t-j} + \varepsilon_{2t}$$

For illustration purposes, the **impulse response function** of any variable such as premiums can be expressed as:

$$PR_{1t} = \varepsilon_{1t} + \alpha_{11}\varepsilon_{1,t-1} + (\alpha^2_{12} + \alpha_{12}\alpha_{21})\,\varepsilon_{1,t-2}$$

$$+ \ldots + \alpha_{12}\varepsilon_{2,t-1} + \alpha_{12}(\alpha_{11} + \alpha_{22})\varepsilon_{2,\,t-2} \qquad (2)$$

In other words, PR_{1t} is a function of the current and lagged values of error terms. Specifically, equation (2) shows the current and lagged effects of changes (shocks) in $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$. Therefore, a one-time shock in losses at time t has no effect on premiums until time t+1.[11]

The Six-Variable Model.

In the second model, lagged values of four variables (surplus, interest rates, loss variance, and interest rate variances) are utilized along with variables for the conditional variance of losses

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[8]Sims (1972, 1980a, and 1980b) first suggested the VAR approach. For a general discussion about innovation accounting which provides a basis for the VAR analysis, see Lee (1992).

[9]See Lamm-Tennant and Weiss (1992) for a similar supporting rationale.

[10]In the two models in this study, all variables are examined with two and three lags. Since the results are very similar in all cases regardless of the number of lags chosen, only the results obtained. With three lags are reported in order to save space.

[11]For a supporting type of rationale, see Sims (1972, 1980a, and 1980b) or Maddala (1992).

paid and interest rates on treasury bonds. The form of the model used for the estimation is specified below:

$$PR_t = b_{1t} + \Sigma b_{2j} PR_{t-j} + \Sigma b_{3j} LP_{t-j} + \Sigma b_{4j} SU_{t-j} + \Sigma b_{5j} TB_{t-j} + \Sigma b_{6j} VLP_{t-j} + \Sigma b_{7j} VTB_{t-j} + \varepsilon_{1t} \quad (3)$$

where PR_t is premiums at time t and LP_t is losses paid at time t as in the two-variable system; SU_t is the aggregate policyholder surplus; TB_t is the five-year Treasure bond rate at time t; VLP_t is the conditional variance of losses paid at time t; and VTB_t is the conditional variance of interest rates on treasury bonds at time t.

To generate the conditional variance for losses-paid and interest rates in equation (3), a general GARCH model was used to examine the data [Bollerslev (1987); Hamao, Masulis and Ng (1990)]. Initial examination of the losses-paid and interest rates variables indicated that they were non-stationary. Taking first differences of the natural log of these variables achieved stationarity. Applying the transformed data in the model yields an ARCH(2) process for the conditional variance, as shown below:

$$y_t = a + \varepsilon_t$$

$$h(t) = b_0 + b_1\varepsilon^2_{t-1} + b_2\varepsilon^2_{t-2}$$

where y_t is the first difference of interest rates and the natural log of losses-paid; h is the conditional variance; ε is the error term; and a and b are the measurement parameters or coefficients.

Empirical Results and Interpretations

The results of the variance decomposition of the forecast error for the two-variable model are reported in Table 1. Premiums (PR) appear to be determined by prior premiums in a Granger-causally-prior sense because most of the forecast error variance (83.8%) is accounted for by its own variation or prior change (innovation). Losses paid also appear to explain a substantial percentage (16.2%) of the variation in premiums. Figure 1.2 shows that, in response to a one-time shock in LP (losses paid), PR (premiums) increase initially for the first four years and then decline below zero for the fifth and sixth years and then move above zero again. Two interesting observations should be noted. Although the initial response of PR to an increase in losses paid is positive as expected, the response becomes negative after four years. This result appears to capture the cyclical effect of a paid-loss shock on premiums. Furthermore, the response does not die out even after six years, implying that the effect of a shock in losses on premiums is relatively permanent. These two observations are quite different from the typical patterns of impulse response functions found in the finance literature (such as Lee, 1992) where stock returns are the main focus. Specifically, the impulse functions of stock returns do not show a cyclical trend and the shocks are not permanent. Thus, the economic behavior of insurance markets appears to differ substantially from stock markets.

Similar to the results for premiums, it appears that changes (innovations) in losses explain most of the forecast error in the variance of losses themselves (62.3%), as shown in Table 1. More importantly, however, premiums help explain a substantial percentage (37.7%) of the variance in future losses. These empirical results differ from what was found by Niehaus and Terry (1993). Based on their results, Niehaus and Terry tentatively concluded that future losses failed to "predict" current premiums due to an errors in variable problem. They used paid losses based on calendar-year rather than policy-year loss data which they thought may have created the problem.[12] However, using the VAR approach this study provides evidence that current premiums do predict future losses (or vice versa) by utilizing the same calendar-year paid-loss data. This result is logically consistent with a prediction that premiums reflect the present value of future losses based on financial pricing models for insurance in a rational expectations framework. The suggestion that current premiums can at least partially predict future losses seems intuitively reasonable, even though underwriting cycles exist, because insurers always try to set premiums based on expected future losses and expenses based on all available information when rates are established.

[12]For an explanation why policy-year loss data are better for measurement purpose than paid losses on a calendar-year basis, see Niehaus and Terry (1993, pp 471-472).

The empirical observation above does not necessarily invalidate the results obtained by Niehaus and Terry because they used a lead-loss variable to predict current premiums while lagged premiums were used here to predict current losses. Specifically, Niehaus and Terry (1993) use premiums as the dependent variable and a lead-loss variable as independent variable; thus, their approach is basically an indirect test. The approach used here may be a better test because it tries directly to determine whether lagged premiums predict current losses.

As shown in Figure 1.4, the response of losses paid, LP, to a one-time shock in premiums, PR is either negligible (see the first year) or positive for the first 6 years, except for year 3. It appears initially that premiums and losses are positively related, as one would expect. However, after the first six years, the effect becomes negative for three years and then becomes positive again. The response of LP to shocks in PR was also found to be relatively permanent and cyclical.

In sum, the results from the decomposition of variance in the two-variable system suggest that losses explain substantial fractions of variations in premiums, as one might expect. Moreover, the results are consistent with an extrapolation hypothesis and rational-expectations/institutional-intervention hypothesis. Furthermore, premiums explain a substantial percentage of the variance in losses in the two-variable system. This empirical result is consistent with predictions offered by a rational expectations hypothesis with perfect capital markets or insurance pricing models, such as the one suggested by Myers and Cohn (1987).

Table 2 presents the decomposition of variance results of the forecast error for the six-variable system which includes two conditional variance terms. With other variables in the system, the explanatory power of paid losses becomes weaker. The response of PR to shock in, LP as shown in Figure 2.2, is similar to the two-variable system except the response of PR is negligible during the first year. This interesting result deserves some attention. At first glance, the response of premiums in the first year may seem to be inconsistent with almost all of the existing hypotheses and theories (such as the insurance pricing model by Kraus and Ross, 1982) which predict premiums and losses are positively correlated. However, the response can be explained by the hypothesis of rational expectations with an institutional lag, as advanced by Cummins and Outreville (1987). A shock in losses in year zero may not cause premiums to increase in year 1 because of a regulatory lag, a data collection lag, or other institutional-lag factors. The response of PR does become positive in years 2, 3, 4, and 5. This positive response is consistent with insurance pricing models and other theories when lags in responses are recognized.

Changes in surplus (SU) seems to explain a substantial percentage (14%) of the variance in premiums as shown in Table 2. This result is consistent with a capacity-constraint or imperfections in the capital market hypothesis that suggests surplus influences or explains premiums. Figure 2.3 shows that the first and second year response of premiums to a positive shock in surplus are zero and positive. The response becomes negative in years 3, 4, and 5, and then positive again. The response of premiums in the first two years does not seem to be consistent with a capacity-constraint hypothesis because Winter predicted that premiums and surplus would be negatively correlated. However, the initial two-year response of PR to a one-time shock in SU can possibly be explained with a Cummins-Outreville type of hypothesis of rational expectations with an institutional lag. A shock increasing surplus in year 0 may not cause premiums to decrease during the following two years because of lags or other institutional factors. Premiums, however, do decrease in years 3, 4, and 5, which is consistent with a capacity-constraint hypothesis with a lag. This result seems to reflect a lag effect suggested by Cummins and Outreville (1987). In other words, the response of premiums to shock in SU cannot be explained by the capacity hypothesis alone, as suggested by Winter (1988).

A combination of the capacity-constraint hypothesis and a hypothesis of rational expectations with an institutional lag, however, can reasonably explain the response of premiums to a shock in surplus. By comparing the lagged effect of the premium response to shocks in paid losses (Figure 2.2) and surplus (Figure 2.3), it can be observed that it takes at least a year for premiums to react to either a shock in surplus or a shock in losses. This result seems reasonable because the adjustment process for insurers to change premiums after a shock in losses or surplus should not differ substantially. It might be noted that a reduction in surplus or capacity could result from a reduction in assets from adverse investment results, as well as from adverse underwriting experience.

For the relationship between interest rates (TB) and premiums (PR), it can be seen that interest rates are able to explain 11.4% of variations in premiums, as shown in Table 2. These results are consistent with the interest-rate-fluctuation hypothesis. The initial response of premiums to a positive shock in interest rates (TB) is similar to a shock in surplus (SU) as shown in Figure 2.4. The negative effect on premiums from an increase in interest rates predicted by Smith (1989), Doherty and Kang (1989), Lai and Witt (1990 and 1992), and others does not become apparent until the third year. Again, rational expectations with an institutional lag can explain this type of response. Moreover, the fact that insurers tend to invest and hold assets may help to explain the result because insurers do not have to realize gains or losses on financial assets immediately after a change in interest rates. Thus, insurance rates do not have to be adjusted immediately. Finally, it should be noted that the response becomes positive again in the sixth through the tenth year which reflects the cyclical nature of the effect of an interest rate shock on premiums.

In the presence of other variables, Table 2 shows that the conditional variance of two variables on a combined basis (the variance of losses and variance of interest rates) are able to explain a substantial percentage (10%) of the forecast error in the variance of premiums. This finding is consistent with the hypothesis by Lai and Witt (1990 and 1992) that uncertainty about future plays an important role in determining insurance premiums. The impulse response function in Figure 2.5 show that a one-time shock in the variance of losses is associated with a delayed increase in premiums during the second through the fifth year, except for the third year. A cyclical trend can again be observed. Why premiums initially increase during the second year and then decrease during the third and then increase during the next two years is not entirely clear. Perhaps the market is searching for an equilibrium on a continuous basis with some overreaction.

It may also be more difficult to obtain regulatory approval of rate changes based on risk arguments alone.

In summary, the results from the decomposition of variance in Table 2 are basically consistent with the extrapolation hypothesis and the rational-expectations/institutional-intervention hypothesis, the capacity-constraint hypothesis, the interest-rate-fluctuation hypothesis, and a change-in-expectations hypothesis. The conclusions derived from the results of impulse response functions suggest that all of the shocks tend to be relatively permanent and cyclical in nature. Furthermore, almost all of the premium responses to shocks in other variables display a lagged effect. These results provide support for an underwriting cycles hypothesis based on rational expectations with an institutional lag, as suggested by Cummins and Outreville (1987).

Summary and Conclusions

This research explored two major insurance-market issues. First, it investigated the dynamic interactions between premiums and losses using vector autoregressive (VAR) models. Second, it showed how premiums respond to shocks to losses, surplus, interest rates, the variance in losses, and the variance in interest rates.

New empirical results based on a decomposition of variance methodology suggest that changes in losses, surplus, interest rates, and uncertainty do explain substantial percentages of variations in premiums. Our results are substantially consistent with an extrapolation hypothesis and a hypothesis of rational expectations with an institutional lag, a capacity-constraint hypothesis, an interest-rate-fluctuation hypothesis, and a change-in-expectations hypothesis. Interestingly, current premiums were found to explain a substantial percentage of the variation in future losses in a two-variable system. This result is consistent with the predictions offered by rational expectations with institutional lags and some financial pricing models for insurance coverages.

New evidence on the response of premiums to shocks in various financial variables is also provided by this study. Three conclusions can be drawn from the results based on impulse response functions. First, all one-time shocks to variables tend to be relatively permanent.

Second, the response of premiums to shocks in the variables examined were all cyclical in nature. These two results are important because they reflect and help to explain the existence of an insurance underwriting cycle. Third, all of the premium responses to shocks in variables other than premiums themselves displayed a lagged effect.

In summary, the pattern generated by impulse response functions for premiums seem to support Cummins and Outreville's hypothesis of rational expectations with an institutional lag, a result which differs somewhat from the observations of Niehaus and Terry (1993).

TABLE 1

Percentage of 10-Year Forecast Error Variance Explained by Prior Changes or Innovations in Each Variable Based on a Two-Variable System[a]

Variable Explained	By Innovation or Changes in[b]	
	PR	LP
PR	83.8%	16.2%
LP	37.7%	62.3%

[a]The sample period is from 1946 to 1989.

[b]PR is premiums written, and LP is losses paid.

TABLE 2

Percentage of 10-Year Forecast Error Variance of Premiums Explained by Prior Changes or Innovations in Each Variable[a]

Variables Explained	By Innovations or Changes in[b]					
	PR	LP	SU	TB	VLP	VTB
PR	57.0%	7.6%	14.0%	11.4%	5.6%	4.4%

[a]The sample period is from 1946 to 1989.

[b]PR is premiums written; LP is losses paid; SU is aggregate policyholder surplus; TB is the five year Treasure note rate; VLP is the conditional variance of losses paid; and VTB is the conditional variance of five-year Treasure note rate at time t.

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