

A Simple Model to Predict Loss Ratios in the Domestic Stock Property–Liability Insurance Industry

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We evaluate the relative contributions of exogenous macroeconomic variables and industry-specific variables for predicting the aggregated property-casualty insurance loss ratio using multiple linear regression models. Our work was motivated by Grace and Hotchkiss (1995), who used only economic exogenous variables in a similar analysis. We find that the macroeconomic variables that we consider contributed little to the explanation and prediction of the property-casualty insurance loss ratio, and that a simple model with just two industry variables predicted a transformed version of loss ratio very well.

Introduction and Literature Review

The relationships among various industry-related variables have been the subject of continuing research interest in property-casualty insurance. The issues at hand are not specific to the property-casualty insurance industry. They do arise in similar kinds of studies in any business sector. The specific question we examine is the relative value of a set of macroeconomic predictor variables and a set of industry-specific predictor variables for predicting an industry variable of interest. In a study from the property-casualty insurance industry, Niehaus and Terry (1993) used loss payments and surplus as predictor variables and premium volume as a dependent variable. They also included the interest rate on treasury bills as a predictor variable, but it was non-significant. Venezian (1985) found that premiums are only a weak predictor of losses because premiums are set in accordance to past losses. Cummins and Danzon (1997) also showed that premiums are a weak predictor of losses

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because of the effect of past surplus upon premiums. Cummins (1990) showed that current premiums are explained by expected future losses and not by past loss experience. Haley (1993) showed that the underwriting margin does correlate with the treasury bill interest rate. Grace and Hotchkiss (1995) predicted the combined loss and expense ratio using only economic predictor variables. The independent variables considered were the real Gross Domestic Product, the interest rate on 90 day treasury bills, and the Consumer Price Index.

The combined ratio of property-casualty insurance is the sum of the loss ratio and the expense ratio. The loss ratio (LR) is the annual aggregate of losses plus loss adjustment expenses divided by aggregate net premiums earned. Net premium earned is an accrual of earnings due in a given year, given that the policy lifetime runs for several years. The expense ratio is the aggregate of operating expenses divided by annual net premiums written. We believe that the combined ratio is a poor choice for an industry profitability measure because one of its components, the expense ratio, has become nearly constant over time, at about 20 percent. Therefore, it was excluded from the profitability consideration and the dependent variable was just the loss ratio portion of the combined ratio. The Grace and Hotchkiss study, which motivated our work, used the combined loss plus expense ratio as the dependent variable. Price was used as the dependent variable by Cummins and Outreville (1987). Price is the reciprocal of the loss ratio. That is, price is the premium obtained per dollar of losses. This was extended by Cummins and Danzon (1997), who slightly modified the definition of price to use present value of future losses instead of losses. The loss ratio or a variant thus appears to be a consistent choice as a dependent variable.

The loss ratio recently generally has been growing. This trend is a matter of great concern to underwriters, as it portrays steady erosion of operating profits in the industry. Premium growth has not been sufficient to match loss payments, which is one reason why the loss ratio is of such great interest. Both the magnitude and the variability in the loss ratio have changed over time. The implication of this observation is that annual underwriting profit or loss has been inconsistent. Note from Table 1 that underwriting profit or loss has almost always been recorded as a loss over the last 30+ years. The industry is facing loss payments and operating expenses that exceed premium collections. The expense ratio has settled into being nearly constant at about 20 percent, while the loss ratio has become both larger and more variable, being at least 80 percent recently. It seems clear that the loss ratio is critical to capital retention. The contraction in capital does carry long-term implications for the financial strength of the property-casualty industry, and, hence, the nature of the loss ratio is important to the industry and to consumers.

Property-casualty underwriters historically have relied upon net investment income to offset operating losses, but investment experience of recent years has not sustained that relief. Because investment returns have become problematic, attention

must be directed toward operating conditions. The loss ratio is studied here to reach an understanding of the significant relations between it and other operational variables as well as between it and exogenous economic variables. Doing so will provide insurers with information that will be helpful in dealing with continued operating losses. If the loss ratio is strongly dependent upon economic conditions, then insurers can react only to the environment, but if it is related primarily to internal operating variables, then insurers have the possibility of working proactively to improve conditions.

Table 1—Raw Data Used in the Analyses.

LR is the loss ratio, GDP is gross domestic product (in billions of dollars), TBill5 is the five-year treasury bill interest rate, PHS is policy holder surplus (in thousands of dollars), NII is the net investment income (in thousands of dollars), UPL is underwriting profit or loss (in thousands of dollars), CPI is the Consumer Price Index, and Infl is the rate of inflation as measure by the annual change in the consumer price index

Year	LR	GDP	TBill5	PHS	NII	UPL	CPI	Infl
1969	70.3	982.2	6.93	12,698,940	1,238,191	-395,830	1.0000	0.06089
1970	69.7	1,035.6	7.37	14,014,350	1,438,519	-154,048	1.0549	0.05490
1971	66.7	1,125.4	5.98	17,308,206	1,784,761	679,155	1.0905	0.03371
1972	66.0	1,237.3	5.98	21,398,062	1,784,761	914,510	1.1279	0.03432
1973	68.6	1,382.6	6.86	20,056,434	2,491,217	225,638	1.2265	0.08739
1974	75.3	1,496.9	7.80	14,831,441	2,890,580	-1,760,721	1.3762	0.12208
1975	78.8	1,630.6	7.76	18,451,106	3,142,861	-2,880,201	1.4729	0.07026
1976	74.6	1,819.0	7.18	23,021,021	3,628,913	-1,405,967	1.5440	0.04828
1977	70.1	2,026.9	6.99	27,062,346	4,647,765	803,850	1.6482	0.06747
1978	69.0	2,291.4	8.31	32,509,869	5,723,821	1,335,093	1.7973	0.09046
1979	71.7	2,557.5	9.51	39,170,044	7,600,915	-365,407	2.0362	0.13294
1980	73.9	2,784.2	11.47	47,498,725	8,835,688	-1,956,217	2.2888	0.12408
1981	75.5	3,115.9	14.23	47,523,770	10,291,289	-3,680,595	2.4935	0.08940
1982	78.6	3,242.1	13.00	53,332,623	11,846,177	-6,474,540	2.5901	0.03878
1983	81.0	3,514.5	10.79	56,421,520	12,380,941	-9,089,703	2.6238	0.01301
1984	88.8	3,902.4	12.24	53,284,106	13,695,134	-15,669,516	2.7623	0.05278
1985	88.8	4,180.7	10.12	64,374,920	14,956,711	-17,878,863	2.8671	0.03794
1986	80.3	4,422.2	7.31	81,845,126	16,872,042	-10,445,905	2.8983	0.01088
1987	76.2	4,692.3	7.93	89,858,557	18,824,127	-5,450,408	3.0268	0.04434
1988	76.2	5,049.6	8.46	102,306,672	22,380,107	-5,838,143	3.1610	0.04431
1989	80.4	5,438.7	8.50	117,742,315	25,026,544	-12,289,252	3.3076	0.04638
1990	80.2	5,743.8	8.37	122,947,963	25,192,820	-12,621,856	3.5097	0.06111
1991	80.1	5,916.7	7.37	140,840,920	27,070,595	-12,842,635	3.6170	0.03057
1992	89.7	6,244.4	6.18	142,604,003	26,472,233	-27,760,875	3.7224	0.02915
1993	78.9	6,558.1	5.14	159,867,350	24,977,675	-12,270,383	3.8378	0.03100
1994	80.3	6,947.0	6.68	167,448,525	25,716,577	-14,179,809	3.9358	0.02552
1995	78.1	7,265.4	6.39	202,416,185	28,507,223	-11,090,687	4.0430	0.02726
1996	78.0	7,636.0	6.17	217,575,813	30,191,295	-11,233,369	4.1641	0.02993
1997	72.4	8,304.0	5.71	268,754,775	34,476,872	-2,183,894	4.2595	0.02292
1998	75.1	8,747.0	4.56	292,354,375	33,317,877	-8,317,093	4.3256	0.01552
1999	77.4	9,268.0	6.36	290,641,514	34,824,352	-12,935,792	4.4211	0.02207
2000	79.5	9,817.0	4.99	268,584,614	35,222,299	-17,093,658	4.5696	0.03358
2001	87.4	10,100.0	4.38	254,835,231	30,934,616	-33,535,560	4.6993	0.02840

The work done here was undertaken because there does not appear to be an existing analysis of the relative importance of the industry and economic predictor variables. An aggregate loss ratio model of property-casualty insurance is established using both internal industry variables and economic variables. The results provide a way of establishing which set of variables is the stronger predictor of the loss ratio.

The Loss Ratio Model

In order to simplify exposition, the following symbols are used:

- GDP = Gross domestic product (in \$billions).
- CPI = Consumer Price Index (compared to 1969).
- Infl = Annual percentage change in consumer price index (rate of inflation).
- TBill5 = Interest rate on five-year treasury bills.
- PHS = Policy holder surplus (in \$thousands).
- NII = Net investment income (in \$thousands).
- UPL = Underwriting profit or loss (in \$thousands).
- RGDP = Real gross domestic product (= GDP/CPI).
- RPHS = Real policy holder surplus (= PHS/CPI).
- RNII = Real net investment income (= NII/CPI).
- RUPL = Real underwriting profit or loss (= UPL/CPI).
- LRUPL = $-1 \times \log(1,000,000 - \text{real underwriting profit or loss})$.
- DLR = First difference of the log of the loss ratio.
- DLRGDP = First difference of log of real gross domestic product.
- DLTBILL5 = First difference of log of interest rate on five-year treasury bills.
- DLInfl = First difference of log of annual change in Consumer Price Index.
- DLRPHS = First difference of log of real policy holder surplus.
- DLRNII = First difference of log of real net investment income.
- DLRUPL = First difference of log of real underwriting profit or loss.

The data used in our analyses were obtained from the *Survey of Current Business* (various years) and Best's *Aggregates and Averages* and are the aggregate values for the entire property-casualty insurance industry. The external variables we used were gross domestic product (GDP) in billions of dollars, the rate of inflation (Infl) expressed as the percentage annual change in the Consumer Price Index (CPI), and the interest rate on five-year treasury bills (TBill5). This interest rate was selected because the issuance period captures the loss tail of most property-casualty claims. These variables are related to those used by Grace and Hotchkiss. The main difference is that the interest rate used here is better able to capture the long-tail loss in property-casualty insurance. Grace and Hotchkiss used the Consumer Price Index in their work in order to represent the effect of inflation. The industry variables used were net investment income (NII), policyholder surplus (PHS) and underwriting profit and loss (UPL). All three industry variables are in thousands of dollars. Policyholder surplus is the industry term for paid-in capital plus surplus plus free capital

reserves. Among these variables, net investment income is included because of the possible demonstration that the relatively secure and consistent investment gains would be more influential upon the loss ratio than the more erratic underwriting profit or loss.

Haley (1993) used data from 1930 to 1989 from the same sources that we have used. The inclusion of this entire time series was later criticized by Grace and Hotchkiss, who showed that the relationships between the variables were not the same in the early time period from 1930 to 1968 as they were in the later years from 1969. Grace and Hotchkiss argued that the different behaviors are due to differences in the regulatory climates in the two time periods. The analyses reported here were performed on the 28 years of data from 1969–1996. Data for 1997–2001 were also available and were used for validation purposes. The full data set, for 1969 to 2001, is given in Table 1. One can see from the raw data that the variables GDP, PHS, NII, and CPI all have been increasing steadily over time. These series are, therefore, non-stationary and highly correlated. From Table 2 we see that the correlations among the four variables listed above and Year are all greater than 0.90, and many of them exceed 0.95. In contrast, UPL has shown accelerating and somewhat erratic losses (Table 1) and has a strong negative correlation of -0.729 with Year (Table 2), and similar correlations with other variables that increase with Year. Inflation (Infl) is well-known to have increased to a peak of over 12 percent in 1979 and 1980. It has fallen subsequently to lower levels, and was consistently between 2 percent and 3 percent from 1991 to 2001. treasury bill interest rates (TBILL5) follow a similar pattern, with a peak of over 14 percent in 1981 and a spell of 6 years from 1980 to 1985 in excess of 10 percent, dropping to less than 5 percent in 2000 and 2001. The correlation between Infl and TBILL5 is 0.421, even though they exhibit this similar nonstationarity. Finally, as noted earlier, the loss ratio has slowly increased over time, from about 70 percent in 1969 to 80 percent at the end of the 1990's. The nonstationarity of, and the strong associations among the variables, dictated many of the decisions that were made in the statistical analyses of these data.

Table 2—Correlations Among Raw Variables and Year

LR is the loss ratio, GDP is gross domestic product, TBILL5 is the five-year treasury bill interest rate, PHS is policy holder surplus, NII is the net investment income, UPL is underwriting profit or loss, CPI is the Consumer Price Index, and Infl is the rate of inflation

	YEAR	LR	PHS	NII	UPL	GDP	TBILL5	CPI	Infl
YEAR	1.000	0.576	0.939	0.983	-0.729	0.986	-0.331	0.997	-0.549
LR	0.576	1.000	0.356	0.522	-0.881	0.516	-0.422	0.597	-0.360
PHS	0.939	0.356	1.000	0.948	-0.591	0.974	-0.514	0.928	-0.559
NII	0.983	0.522	0.948	1.000	-0.686	0.978	-0.370	0.984	-0.578
UPL	-0.729	-0.881	-0.591	-0.686	1.000	-0.720	0.192	-0.740	0.489
GDP	0.986	0.516	0.974	0.978	-0.720	1.000	-0.422	0.981	-0.563
TBILL5	-0.331	-0.422	-0.514	-0.370	0.192	-0.422	1.000	-0.289	0.421
CPI	0.997	0.597	0.928	0.984	-0.740	0.981	-0.289	1.000	-0.551
Infl	-0.549	-0.360	-0.559	-0.578	0.489	-0.563	0.421	-0.551	1.000

An initial regression of LR on GDP, TBill5, PHS, NII, UPL, and Infl yielded an appealing value of the coefficient of determination ($R^2 = 0.9283$), but numerical and graphical diagnostics revealed several major problems with the regression. A significant Durbin-Watson statistic indicated that the residuals from the regression were not independent, and scatter plots of the residuals showed heteroscedasticity. Condition indices and other diagnostics showed clear evidence of extreme multicollinearity among the predictor variables due to the dependence of several of the variables on time. As Seber (1977) and Frees (1995) note, regression coefficients can have the wrong sign and otherwise be misleading when multicollinearity is present. Plots of the time series for LR, GDP, TBill5, PHS, NII, UPL, CPI, and Infl all showed clear nonstationarity in the mean and variance, and augmented Dickey Fuller unit root tests (Dickey and Fuller, 1979) confirmed the lack of stationarity.

Our first step in dealing with nonstationarity and the multicollinearity in the variables was to obtain real values of GDP, NII, PHS, and UPL (respectively, RGDP, RNII, RPHS, and RUPL) by dividing the stated, or nominal, values by the CPI relative to 1969. Real values are preferred over raw values because they help to offset inflation effects, making annual values more comparable. The concern in doing this is that the CPI variable becomes embedded in several of the predictor variables, possibly giving rise to additional multicollinearity. The real values of GDP, NII, PHS, and UPL still exhibited nonstationarity in both their means and variances. A natural logarithmic transform of the variables eliminated the nonstationarity in the variance (heteroscedasticity). The variable UPL takes on both positive and negative values within the 1969–1996 time period under consideration, so the transformation applied to this variable was

$$\text{LRUPL} = -1 \times \log(1,000,000 - \text{RUPL}),$$

where RUPL is the real version of UPL. This transformation preserves the direction of UPL. To eliminate the time dependence (nonstationarity in the mean) first differences of the logged variables were calculated. Thus, for example, DLRPHS is the first difference of the logged, real values of the variable PHS. Similarly, we created the variables DLLR, DLRGDP, DLTBill5, DLRPHS, DLRNII, DLRUPL, and DLInfl. The correlations among the transformed predictor variables (all the variables listed above except DLLR) and between the predictor variables and Year are now all much less than for the raw variables, with the highest value being less than 0.6 in magnitude (Table 3). The augmented Dickey-Fuller unit root tests for the transformed (logged, differenced, real) variables were all highly significant, indicating at least approximate first-order stationarity of the variables.

The statistical methodology described so far is similar to elements of the analyses of Grace and Hotchkiss. In particular, they tested for stationarity using the augmented Dickey-Fuller unit root test and also differenced their time series to eliminate time dependencies. The next step in our analyses was to regress DLLR on

DLRGDP, DLTBill5, DLRPHS, DLRNII, DLRUPL, and DLI_{infl}. There was no evidence of autocorrelation or heteroscedasticity in the residuals from this model, and most of the multicollinearity had been eliminated. The multicollinearity that remained was due to the logged and differenced inflation rate, DLI_{infl}. This variable is a function of the consumer price index, which is also a divisor of four of the five other predictor variables. Removing DLI_{infl} from the regression model eliminated *all* the remaining multicollinearity and incurred a negligible reduction in R^2 . The resulting fitted model is given below.

$$\begin{aligned} \text{Predicted DLLR} = & 0.00363 + 0.39781 \times \text{DLRGDP} + 0.04509 \times \text{DLTBILL5} \\ & - 0.07309 \times \text{DLRPHS} - 0.11596 \times \text{DLRNII} - 0.05790 \times \text{DLRUPL} \end{aligned} \quad (I)$$

Standard errors for the coefficients may be found in Table 4, along with other diagnostics for the model. The R^2 value for this model was 0.6405, which compares favorably with Grace and Hotchkiss, who reported R^2 values between 0.19 and 0.30, and also with Cummins and Danzon (1997), who used Price as a response variable and reported R^2 values between 0.249 and 0.349.

The relative contributions of the industry predictor variables and the economic predictor variables are of primary interest in this paper. One way to address this question is to perform partial F -tests that the coefficients of the economic variables DLRGDP and DLTBill5 in model (I) are simultaneously zero, and also that the coefficients of the industry variables DLRNII, DLRPHS and DLRUPL are all zero. The test statistic for the economic variables was not significant ($F_{2,22} = 0.96$, P-value = 0.3983), while the statistic for the industry variables was highly statistically significant ($F_{3,22} = 9.39$, P-value = 0.0003). This suggests that the economic variables are at best weakly associated with the response variable DLLR.

Table 3—Correlations Among Transformed Variables

DLLR is the first difference of the log of the loss ratio, DLRPHS is the the first difference of the log of the real policy holder surplus values, DLRNII is the first difference of the log of the real net investment income, DLRUPL = $-\log(1,000,000 - \text{Real underwriting profit or loss})$, DLRGDP is first difference of the log of the real gross domestic product, DLTBill5 is first difference of the log of the five-year treasury bill interest rate, and DLI_{infl} is the first difference of the log of the rate of inflation

	YEAR	DLLR	DLRPHS	DLRNII	DLRUPL	DLRGDP	DLTBILL5	DLINFL
YEAR	1.000	0.029	0.082	-0.538	-0.049	0.037	-0.264	-0.009
DLLR	0.029	1.000	-0.599	-0.263	-0.770	-0.336	0.276	0.177
DLRPHS	0.082	-0.599	1.000	0.165	0.565	0.433	-0.412	-0.443
DLRNII	-0.538	-0.263	0.165	1.000	0.088	0.167	0.217	0.090
DLRUPL	-0.049	-0.770	0.565	0.088	1.000	0.486	-0.270	-0.164
DLRGDP	0.037	-0.336	0.433	0.167	0.486	1.000	-0.261	-0.145
DLTBILL5	-0.264	0.276	-0.412	0.217	-0.270	-0.261	1.000	0.499
DLINFL	-0.009	0.177	-0.443	0.090	-0.164	-0.145	0.499	1.000

A more direct, but non-inferential, comparison of the relative contribution of the industry and the economic variables is accomplished by comparing the fit of a model

containing just the economic variables to the fit of a model containing just the industry variables, using the coefficient of determination, R^2 . For the regression model with just DLTBill5 and DLRGDP, $R^2 = 0.1802$, while the model with just DLRPHS, DLRNII, and DLRUPL has $R^2 = 0.6092$. Thus, the industry variables explain a lot more variability than do the economic variables. The proportion of variability in DLLR explained by the three industry variables ($R^2 = 0.6092$) is only marginally less than the proportion of variability explained by all five variables ($R^2 = 0.6405$).

Table 4—Estimated Coefficients, Standard Errors (SE), R^2 , Adjusted R^2 , Durbin-Watson Statistics, and Maximum Condition Indices for Regression Models (I) and (II).

DLLR is the first difference of the log of the loss ratio, DLRPHS is the first difference of the log of the real policy holder surplus values, DLRNII is the first difference of the log of the real net investment income, DLRUPL = $-\log(1,000,000 - \text{Real underwriting profit or loss})$, DLRGDP is first difference of the log of the real gross domestic product, and DLTBill5 is first difference of the log of the five-year treasury bill interest rate

Variable/Statistic	Model (I)	Model (II)
INTERCEPT (SE)	0.00363 (0.01123)	0.00622 (0.00744)
DLRPHS (SE)	-0.07309 (0.06916)	-0.08887 (0.06089)
DLRNII (SE)	-0.11596 (0.09612)	
DLRUPL (SE)	-0.05790 (0.01350)	-0.05169 (0.01254)
DLRGDP (SE)	0.39781 (0.31891)	
DLTBILL5 (SE)	0.04509 (0.05665)	
R^2	0.6405	0.5958
Adjusted R^2	0.5588	0.5634
Durbin-Watson	2.403	2.488
Maximum Condition Index	3.408	2.018

Several of the variables in model (I) have non-significant coefficients. Further, the adjusted R^2 value for the model with just the industry variables was slightly higher than the value of the adjusted R^2 for model (I). These observations led us to consider the possibility that a simple model involving industry variables could satisfactorily describe the data. We perform all possible subsets regression (Seber, 1977) using the five predictor variables, DLRGDP, DLTBill5, DLRPHS, DLRNII, and DLRUPL. The adjusted R^2 , Mallows' C_p , and AIC criteria all selected the two-variable model with just DLRPHS and DLRUPL. The resulting fitted model is given below.

$$\text{Predicted DLLR} = 0.00622 - 0.08887 \times \text{DLRPHS} - 0.05169 \times \text{DLRUPL} \quad (\text{II})$$

For model (II), $R^2 = 0.5958$, so little predictive power and quality of fit is lost by eliminating DLRGDP, DLTBill5, and DLRNII from model (I), and the R^2 value for this simple model is still competitive with R^2 values reported by other authors (Grace and Hotchkiss, Cummins and Danzon, 1997) working on related problems. Standard regression diagnostics show no evidence of heteroscedasticity, autocorrelation among the residuals, or collinearity between the two variables remaining in the model. Figure 1 provides a visual interpretation of model (II). The black dots are the observed values of DLLR from 1969—1996, the time span of the data that was used to fit model (II). Predicted values were generated using model (II) for these years, as well as for the five subsequent years, 1997—2001, and are represented by the solid line in the middle of Figure 1. The empty circles on Figure 1 are the observed values of DLLR for the years 1997—2001. It is important to note that the values of DLLR for 1997—2001 were not used in the estimation of the regression coefficients in model (II), yet model (II) predicts fairly well for these years. The dashed curves on Figure 1 are 90 percent prediction bands for the new observations and one can see that all five of the DLLR values for the years 1997—2001 fall within the bands, and $26/28 = 92.8$ percent of the observations from 1969—1996 fell within the prediction bands.

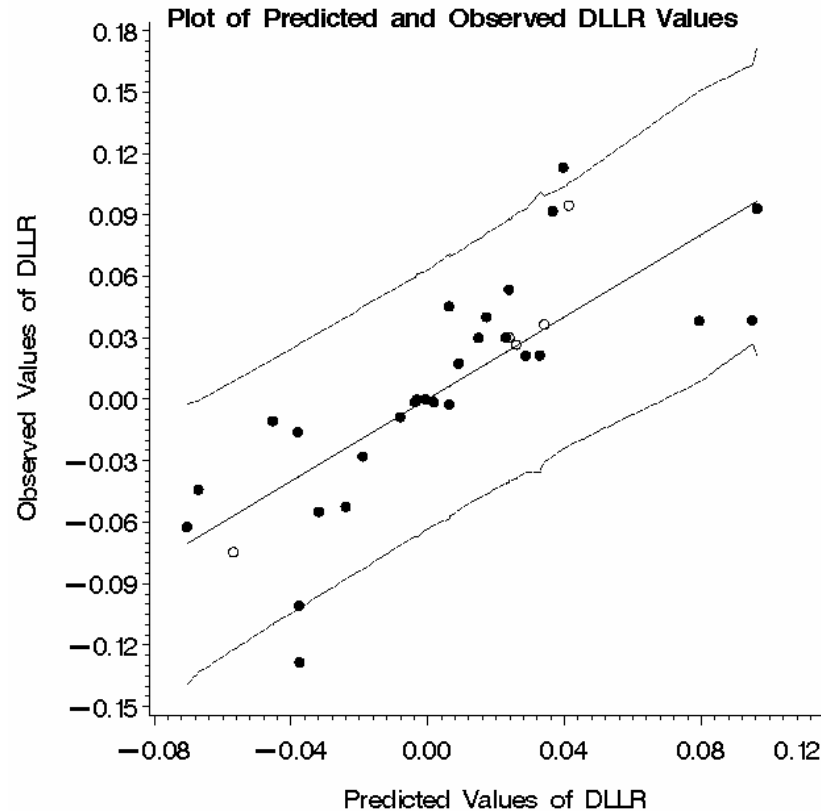
That the variable DLRNII is not included in model (II) is important because it indicates that the outcome of investment experience does not have a substantial influence on the loss ratio. This most likely suggests that investment activity is kept separate from underwriting, so that investment returns do not affect premium volume or losses. The coefficient of DLRPHS is negative, suggesting that an increase in LR is associated with a decrease in policyholder surplus (PHS). This is in agreement with the negative association between DLLR and DLRUPL. If there is an increased loss ratio in a year there is an expectation that underwriting profit or loss will decrease, leading to a reduction in policyholder surplus.

Conclusion

The work by Grace and Hotchkiss gave rise to the question of the suitability or necessity of including external economic variables in property-casualty financial performance prediction models. Earlier papers typically used industry-related variables to predict several variables of interest. In contrast, Grace and Hotchkiss used only external economic variables as predictors. In the work reported here we consider both kinds of predictor variables to predict the aggregate loss ratio of the domestic stock property-casualty insurance industry. Our general finding is that the economic variables contribute little to the explanation or prediction of the loss ratio. Through a number of steps we developed a simple regression model with just two industry predictor variables that predicted the (transformed) loss ratio almost as well as a model that included three industry predictor variables and two economic vari-

ables. Our results show that external macroeconomic variables were of little value in the prediction of the loss ratio.

Figure 1—Scatter Plot of Observed Values of the First Differences of the Logs of the Loss Ratio Values (DLLR) for 1969 to 1996 (Solid Dots) and 1997–2001 (Open Circles) Overlaid with Predicted Vales of DLLR and 90 percent Prediction Bands for New Observations



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