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Using Unit-Roots to Estimate Underwriting Cycles: The Case in the U.S. Insurance Market

James C. Hao
Tamkang University, Tamsui, Taiwan

Underwriting cycles, with their swings in underwriting margins, have existed in insurance markets for nearly a century. Such fluctuations may be attributed to phenomena under following hypotheses: financial pricing hypothesis, capacity constraint hypothesis, financial quality hypothesis, and option pricing approach. Earlier studies have ignored the time series characteristics of underwriting margins, focusing on short-term determination, and have utilized a conventional regression which still needs more comprehensive research. Fewer studies have employed time series methods, but they are limited with the stationary property of variables. Consistent with prior empirical studies and despite whether considerable variables have unit roots, an ARDL bound test for underwriting margins during the sample period demonstrates that the option pricing approach may be the most suitable model which provides evidence of the existence of market discipline for insurance pricing. The results have significant implications for insurance researchers and regulators.

Keywords: underwriting cycle, unit roots, ARDL

Introduction

Underwriting margins in property-liability insurance markets shift back and forth dynamically between hard and soft markets. Why such a wide and puzzling phenomenon takes place and whether the cycle continues to portray insurance markets are questions that still need comprehensive explanations. The underwriting cycle in property-liability insurance refers to changes in profitability for the whole industry, for a segment of the industry, for all lines combined in a business, or for a combination of lines into a major group such as Commercial Multiple Peril insurance, Workers Compensation insurance or Miscellaneous Liability insurance. For years, insurers have recognized that the business has its good times and its bad times. In soft market periods, insurance underwriting margins are lower and coverage is readily available to buyers, while underwriting margins are high and insurance coverage is more difficult to obtain during hard market periods. Underwriting cycles are a means of maintaining long-term profits, and not a random occurrence that could remove them. If such fluctuations could be modeling and predicted well, insurers could dampen their volatility of operations and insurers' costs of raising capital would be reduced. To optimize the operation results of insurance companies, insurance actuaries have to understand the forces that drive market prices and adapt adequate insurance rates that

James C. Hao, Associate Professor, Department of Insurance, Tamkang University.
Correspondence concerning this article should be addressed to James C. Hao, 151 In-Chun Road, Tamsui, Taiwan 251. E-mail: cjhao@mail.tku.edu.tw.

are most advantageous for the firm to the phase of the underwriting cycle.

Many studies provide evidence that historical underwriting margins are cyclical. The numbers of competing theories have been advanced to account for the underwriting cycle in property-liability insurance industry (e.g., Harrington & Niehaus, 2000 for an overview). Under the financial pricing hypothesis (i.e., Rational Explanations and Institutional Intervention), insurers have rational expectations for discounted claims costs and there are no discernable cycles in prices and profits should vary inversely with interest rates. The presence of underwriting cycles is instead caused by a filtration of rational expectations through special insurance market features such as patterns of claim payments, ratemaking procedures, natural catastrophes, regulatory characteristics and accounting lags. This implies that underwriting margins follow an autoregressive process which leads to underwriting cycle. Cummins and Outreville (1987) utilized an AR(2) model with a deterministic trend to the data and concluded that such hypothesis is enough to create an underwriting cycle. Several following studies (e.g., Doherty & Kang, 1988; Lamm-Tennant & Weiss, 1997) also provided consistent results. Implicitly, such models assume insurers are risk neutral and insurance markets are perfect, and thus insurers can adjust their capital quickly enough to produce a negligible level of insolvency risk. Accordingly, the underwriting margin being a decreasing function only depends on the interest rate in both the short run and the long run.

The well-known capacity constraint hypothesis (Winter, 1988, 1994; Gron, 1994a, 1994b; Doherty & Garven, 1995) argues that the underwriting cycle is attributable to market imperfections. Uncertainty and asymmetric information in the insurance market prevents insurers from quickly adjusting their capital to the long-term equilibrium condition. Such constrained supply in the insurance industry results in temporary capital shortages. Because of imperfections in the capital market, raising insurance prices becomes a commonly used method to adjust capital after the insurer experiences a negative shock or unexpected crisis. These features imply that insurance prices will depend on capacity or surplus inversely in the short run. However, insurance prices do not depend on surplus or capacity in the long run. Such a model presents a short-run price determination in which the underwriting margins are decreasing with capacity. The model at the same time adopts a present value notion of insurance prices implicitly, and hence the financial pricing hypothesis still holds in both the short run and long run (Doherty & Garven, 1995), and the testable implication is whether capacity negatively relates to the underwriting margins in the short run. In addition, the financial quality hypothesis (Harrington & Danzon, 1994; Cagle & Harrington, 1995) extends the capacity constraint hypothesis by taking into account the endogenous insolvency risk in insurance prices. This model assumes that the shock to surplus shifts both demand and supply and the effect of the supply shift is greater than the demand shift in the short run. Therefore, the short-run implications of the financial quality hypothesis are the same with the capacity constraint hypothesis. In the long run, underwriting margins should depend positively on the level of capacity since a higher level of capacity implies higher levels of financial quality and consumers presumably have a greater willingness to pay for higher quality policies.

Sommers (1996) provided an option pricing approach to insurance pricing whereby the policy holders have a short position in a put option on the asset of insurers. Such a put option is referred to as the insolvency put option. The lower the insurer's capacity is, the greater the insolvency risk will be as well as the value of the insolvency put. Like the value of risky corporate debt, the value of insurance policies should be negatively correlated with the level of insolvency risk. It follows that the underwriting margins increase with insurer's capacity both in the long run and short run and decrease with the interest rate, which is as the same as what the financial pricing hypothesis implies. Table 1 summaries different implications of the alternative hypothesis for underwriting margins by adopting the framework developed by Choi, Hardigree and Thistle (2002).

Table 1

Summary of Implications of Underwriting Margins for Alternative Hypothesis

Hypothesis	Interest rate		Capacity	
	Short run	Long run	Short run	Long run
Financial pricing hypothesis	-	-	.	.
Capacity constraint hypothesis	-	-	-	.
Financial quality hypothesis	-	-	-	+
Option pricing approach	-	`-	+	+

Notes. "-" means a negative impact on underwriting margin; "+" means a positive impact on underwriting margin; "." means no specific impact on underwriting margin.

Earlier empirical analyses over the last decade have focused on whether the insurers lagged surplus (i.e., capacity) is a determinant of underwriting margins. However, they conclude with somewhat inconsistent evidences and leave some ambiguous interpretations. Niehaus and Terry (1993) found that the regression coefficients of a lagged surplus on insurance prices have opposite signs for different sample periods. Gron (1994a) conducted a by-line analysis on the determinants of the underwriting margin as measured by one minus loss ratio. She applied lagged policyholders surplus to the current-period GNP as the proxy for capacity. The findings support the capacity constraint hypothesis for short-tail lines of insurance (auto-liability, auto-physical damage, and homeowners' coverage), but surprisingly, they don't support it not for long-tail coverage (Other Liability insurance) which are the most affected during a financial crisis. She merely suggested that this undesirable result is attributable to insurers' loss reserve management activities. Cummins and Danzon (1997) used policyholders' lagged surplus over the historical average surplus as the proxy for capacity, finding that underwriting margins positively correspond to the lagged capacity measure, a relationship unexplainable under the capacity constraint framework. Cummins and Danzon argued that this positive relationship could be explained by the shock effect on insurance demand. An increase in capital, which reduces insurers' insolvency risk, raises insurance prices, while it supports the financial quality hypothesis. Higgins and Thistle (2000) employed the logistic smooth transition regression to test for a regime shift and to estimate the speed of the transition between regimes. The results show that capacity is an important determinant of underwriting margins in the short run, however, the results are not consistent with the capacity constraint hypothesis or the financial quality hypothesis. They also found that the interest rate is not a significant determinant of underwriting margins, thus implying that there are no models supporting the existing hypothesis and this merits further investigation.

Most studies have utilized a conventional regression procedure in which changes in the interest rate and capacity proxies are used extensively in examining the relation between levels of underwriting margins in order to characterize the validity of the capacity constraint model. Such an empirical model is inherently dangerous and could lead to spurious regression due to misspecification (Venezian, 2002). For more robust and effective empirical methods in testing insurance pricing models, a growing body of literature analyzes the determinants of insurance prices employing the time series approach or econometric techniques on insurer underwriting margins.

Fung, Lai, Patterson, Gary and Witt (1998) firstly employed a variance decomposition technique under a vector auto-regression model (VAR) to show that the responses of premiums to a surplus in the first two years appear to be inconsistent with the capacity constraint hypothesis. They argued that this result may be attributed to institutional factors and gave a reasonable interpretation of the combined effects of capacity constraint and rational expectation with institutional lags hypothesis. However, the VAR methodology is a "pure" econometric tool and has been criticized on several counts. For example, Kim (1998) asserted that it would lead to a serious misspecification error in the model as it omits long-run equilibrium relations.

Based on pre-tests for a unit root, some studies have instead used co-integration analysis to analyze the long-run relationship between underwriting margins and the insurance capacity proxy in order to test theories of the determinants of underwriting cycles. They argue that underwriting margins and other variables are not stationary (e.g., Haley, 1993; Grace & Hotchkiss, 1995; Choi & Thistle, 2000), implying that the earlier conventional regression approach is not appropriate to analyze determinants of underwriting margins. Haley (1993) pointed out that underwriting margins and short-term interest are cointegrated with a negative long-run relationship. Grace and Hotchkiss (1995) tested not only short-term interest rates, but included general economic variables to show that, while there is in fact a long-run relationship, general economic fluctuations have little short-run impact on underwriting margins. They suggested that the cycle is endogenous to the industry. Choi and Thistle (2000) examined the cause of insurance cycles by using the one minus combined ratio as the proxy for the underwriting margin and policyholders' surplus to assets as a capacity proxy. They found that capacity is not a determinant of profits neither in the short nor the long run. Choi, Hardigree and Thistle (2002) reported that insurance price is I(0), but the interest rate and surplus series are I(1). It implies that insurance prices cannot be cointegrated with either the interest rate or a surplus. Harrington and Yu (2003) applied GLS ADF tests under different assumptions in AR(2) data-generating process (DGP) to prove that underwriting margins are stationary, meaning that there is no need to utilize co-integration analysis on underwriting margins, and conventional regression methods can be used appropriately to analyze underwriting margins after controlling for deterministic influences and transforming any non-stationary regressors. Their results may present some problems. First, they assumed that the underlying DGP follows an AR(2) process which may not be an appropriate DGP in underwriting margins (Leng & Venezian, 2003). Second, given that problems arising from non-stationarity and auto-correlation at the levels of regressors could possibly be avoided by the use of difference transforming, however, any transforming or taking a difference on the variables may ignore or destroy the systematical characteristics of multiple time series. For example, if one of the variables is fractionally integrated, simply differencing may result in correlated error terms, thus unclear answers.

A critical issue in time series regression analyses is whether underwriting margins and relevant explanatory variables are stationary. A least squares regression provides meaningful inferences only when the regress and regressors are either stationary or cointegrated. As mentioned above, previous studies seem to leave the characteristic of underwriting margins ambiguous as well as that for the capacity proxy. It may imply that efforts have to put into the development of a more robust empirical model since some of the variables in questions are stationary while others are non-stationary. In this study, the ARDL approach, in order to solve the above problems, is used to assess the long-run and short-run effects of such empirical models all together, removing the problems associated with omitted variables and auto-correlation. Given the uncertainty concerning the time series properties of the variables in question, we view this methodology as the most appropriate in this context.

The remainder of this paper is organized as follows. The following section briefly describes the data's assessment and presents the ARDL methodology. The subsequent section presents the results of our analysis. The last section summarizes and concludes the study.

Data and Methodology

Data

The objective of this paper is to construct an empirical model exploring the dynamic behavior of underwriting margins as well as to examine previous empirical findings. Underwriting margins usually refer to insurers underwriting returns, which are the profit margins without including investment returns. Several proxies are employed in earlier studies in the literatures. This paper utilizes the one minus loss ratio which is utilized to avoid the problem controlling for acquisition expenses (Gron, 1994a). The loss ratio is the ratio of losses and loss adjustment expenses incurred to net premiums earned in a calendar year. In Figure 1, the author applies annual U.S. insurance industry-wide data for all lines combined during the period of 1951-2001 from Best's Aggregates and Averages published by A.M. Best Company. Specifically, the loss ratios for Other Liability insurance (also called Miscellaneous Liability Insurance) are more volatile than those of all lines combined. Because liability insurance includes long-tailed insurance lines, the underwriting profits are more affected by insurers' financial conditions, interest rates, and other factors affecting general economic conditions. Therefore, such insurance lines which appear to be most pronounced during liability crisis needs more comprehensive considerations. This paper particularly collects the loss ratio of other liability insurance during the period 1951-2001 from Best's aggregates and averages. The results here may help facilitate a comparison with the results from Gron's (1994a) study.

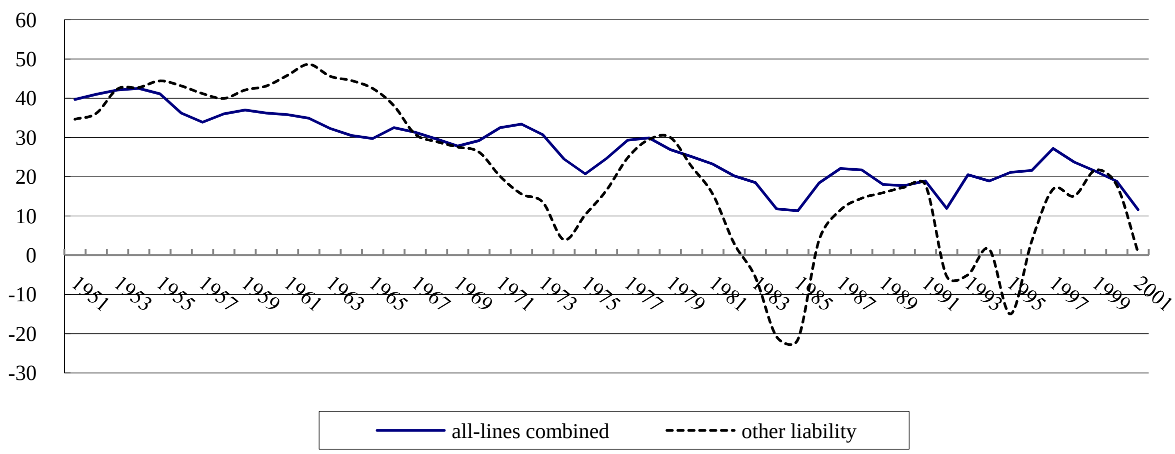

Figure 1. Underwriting margins (%): All-line combined vs. other liability.

Capacity generally refers to the degree of aggregate industry to supply insurance without increasing the level of insolvency risk. It is related to the volume of policies that can be supported by the industry's capital base. This paper employs the ratio of industry-wide policyholders lagged surplus to the historical five-year average of policyholders surplus, because such a ratio captures insurers existing capacity to their long-run equilibrium (Winter, 1994). Such a capacity measure is also employed in Gorn (1994b). The policyholders lagged surplus which reflects insurers' capacity at the beginning of a new period is reported at the end of the previous year from Best's aggregates and averages. Finally, three-month treasury bill rates are collected from the Federal Reserve Bulletin and used as the proxy for the short-term interest rate.

Methodology

To examine the long-run relationship between ocean marine insurance underwriting margins and its determinants, the author employs the newly developed autoregressive distributed lag (ARDL) co-integration framework (Pesaran, Shin, & Smith, 2001). This method avoids the classification of variables as I(1) and I(0) by developing bands of critical values which identify the variables as being stationary or non-stationary processes. Unlike other co-integration techniques (e.g., Johansen's procedure) which require certain pre-testing for unit roots and the underlying variables to be integrated are of order one, the ARDL model provides an alternative test for examining a long-run relationship regardless of whether the underlying variables are purely I(0) or I(1), or even fractionally integrated. Therefore, previous unit root testing of the variables (e.g., Haley, 1995; Harrington & Yu, 2003) is unnecessary. Moreover, the traditional co-integration method may also suffer from problems of endogeneity while the ARDL method can distinguish the dependent and explanatory variables. Thus, estimates obtained from the ARDL method of co-integration analysis are unbiased and efficient, since they avoid the problems that may arise in the presence of serial correlation and endogeneity. Note also that the ARDL procedure allows for uneven lag orders, while Johansen's VECM (1988) does not.

This approach involves two stages. In the first stage, testing the null hypothesis of the non-existence of the long-run relationship is given by:

$$\Delta UM_t = \alpha + \beta_0 t + \sum_{i=1}^{n} \beta_i \Delta UM_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta r_{t-i} + \sum_{i=0}^{n} \delta_i \Delta K_{t-i} + \theta_1 UM_{t-1} + \theta_2 r_{t-1} + \theta_3 K_{t-1} + \varepsilon_t \tag{1}$$

$$H_0 : \theta_1 = \theta_2 = \theta_3 = 0$$
$$H_1 : \theta_1 \neq \theta_2 \neq \theta_3 \neq 0 \tag{2}$$

Here, *UM*, *r* and *K* denote respectively the underwriting margins, short-term interest rate, and capacity proxy, and the *n* represents the maximum lags on the first differenced variables. Accordingly, the relevant statistic to test (2) is the *F*-test or the Wald-test. Such test is used to examine the existence of a stable and long-run relationship. Note that the asymptotic distributions of the *F*-statistic are non-standard irrespective of whether the variables are I(0) or I(1), because the asymptotic distribution of these two tests is non-standard. Pesaran et al. (2001) provided two sets of asymptotic critical values. One set assumes all variables are I(0) and the other assumes that all variables are I(1). If the computed *F*-statistic falls above the upper limit of the bound critical value, then the null hypothesis is rejected which means the variables are cointegrated. Conversely, if the computed *F*-statistic falls below the lower bound critical value, then the variables are not cointegrated and the null hypothesis cannot be rejected. Finally, the case within the band would be considered inconclusive. Once co-integration is determined, the augmented ARDL (*m*, *p*, *q*) model is estimated by the following:

$$a(L,m)UM_t = a_0 + b_0 t + \sum_{i=0}^{p} c_i r_{t-i} + \sum_{i=0}^{q} d_i K_{t-i} + u_t \tag{3}$$

Where $a(L,m) = 1 - a_1 L^1 - \cdots - a_m L^m$, and L is a lag operator such that $L^j UM_t = UM_{t-j}$.

The maximum of the lags (n) in equation (1) must be retained in order to determine the numbers of lags (*m*, *p*, *q*) in equation (3) as selected by the Akaike Information Criterion (AIC) or Schwartz Bayesian Criterion

(SBC), which establishes the optimal structure for the ARDL specification. Notice that if the underwriting margin follows a second-order autoregressive model (i.e., m = 2), then the condition of the cyclical phenomenon is the following in-equality:

$$a_1^2 + 4a_2 < 0 \tag{4}$$

Having found the associate ARDL model, the second stage involves estimating the long-run coefficients of underwriting margins and the associated ARDL error correction models. Incorporating the long run and short-run terms into the model allows for a more efficient estimate of the short-run coefficients. The conditional long-run model for underwriting margins can be obtained from the reduced form solution of equation (3) as follows:

$$UM_t = \lambda a + \lambda b_0 t + \lambda \sum_{i=0}^{p} c_i r_t + \lambda \sum_{i=0}^{q} d_i K_t + \lambda u_t \tag{5}$$

where $\lambda = \dfrac{1}{a(L,m)}$.

The error correction (EC) representation of the ARDL model which involves the ECM term can be estimated by rearranging the original equation by OLS. Under the ARDL approach, the existence of a unique valid long-run relationship among variables, and hence a sole error-correction term, is the basis for estimation and inference. A short-run or difference-based relationship cannot be supported unless a unique and stable equilibrium relationship holds in significant statistical sense. According to Pesaran et al. (2001), an ECM estimation is significant according to a non-standard t-statistic table of critical values, which are much higher than the standard ones. More importantly, if the coefficients of the ECM term carry the expected negative sign and are highly significant, then the cyclical phenomenon will be specified and will facilitate our empirical finding of co-integration as provided herein. The error-correction mechanism is described below:

$$\Delta UM_t = \hat{b}_0 - \sum_{j=2}^{m} \hat{a}_j \Delta UM_{t-j} + \hat{c}_0 \Delta r_t - \sum_{i=2}^{p} \hat{c}_i \Delta r_{t-i} + \hat{d}_0 \Delta K_t - \sum_{i=2}^{q} \hat{d}_i \Delta K_{t-i} - a(L,m) ECM_{t-1} + \varepsilon_t \tag{6}$$

where $ECM_{t-1} = UM_{t-1} - \lambda \hat{a} - \lambda \hat{b}_0 (t-1) - \lambda \sum_{i=0}^{p} \hat{c}_i r_{t-1} - \lambda \sum_{i=0}^{q} \hat{d}_i K_{t-1}$.

Note that $\hat{a}_j, \hat{b}_0, \hat{c}_i$, and $\hat{d}_i$ are the coefficients estimated from equation (3), and $a(L,m)$ measures the speed of adjustment to the long-run equilibrium.

Empirical Results

In testing the null of non-co-integration in equation (1), the critical issue is choosing the maximum lag (n). Bahmani-Oskooee and Bohl (2000) showed that the results of this first stage are usually sensitive to the order of VAR. Obviously, earlier studies in the literatures (i.e., Fung et al.,1998) ignored such potential serious problems. In this study, the authors impose an order of lag from 1 to 3 on the first difference of each variable and compute the F-statistic for the joint significance testing (2) of a non-standard F distribution (Pesaran et al., 2001). The results are reported in Table 2 as the following.

The null hypothesis of the non-existence of the long-run relationship is rejected for all lines combined and for other liability underwriting margins when the order of lag is larger than one. The results provide evidence for the existence of a long-run underwriting margins equation, particularly when a higher order of lag is selected for formulating the model. Therefore, merely considering the short-term determination is not enough to explain the dynamics of underwriting margins. In the second stage, the maximum order of lag (n = 2) is selected in this study. Retaining the maximum lag, at the same time the Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) are used to estimate equation (3). Both all-lines combined and other liability underwriting margins formulate an ARDL model, respectively, and the estimates are reported in Table 3.

Table 2
F-Statistics for Testing the Existence of Co-integration

Order of lag	*F*-statistics	
	All-lines combined	Other liability
1	4.4972	5.2478
2	11.3577*	8.5673*
3	8.6489*	9.7551*

Notes. The relevant critical value bounds are given in p. 301, Table CI(v).case V (with an unrestricted intercept and unrestricted trend; $k = 2$), Pesaran et al. (2001). They are 4.86-5.85 at the 95% significance level, and * denotes that the *F*-statistic falls above the 95% upper bound.

Table 3
Estimates of ARDL Model for Underwriting Margins

Coefficient	All-lines combined		Other liability	
	AIC-ARDL(1,0,2)	SBC-ARDL(1,0,0)	AIC-ARDL(2,0,0)	SBC-ARDL(1,0,0)
Constant	19.2147 [0.001]**	13.1912 [0.006]**	5.6382 [0.564]	-1.9226 [0.830]
t	-0.16821 [0.012]**	-0.20374 [0.002]**	-0.32633 [0.011]**	-0.26512 [0.032]**
UM_{t-1}	0.58083 [0.000]**	0.51524 [0.000]**	0.892320 [0.000]**	0.67743 [0.000]**
UM_{t-2}			-0.26408 [0.086]*	
r_t	-0.41633 [0.044]**	-0.57238 [0.004]**	-1.0359 [0.032]**	-1.2196 [0.012]**
$capacity_t$	6.0128 [0.097]*	6.6466 [0.046]**	13.5026 [0.093]*	18.3467 [0.019]**
$capacity_{t-1}$	-2.7490 [0.495]			
$capacity_{t-2}$	-4.6322 [0.180]			
Adj. R^2	0.87749	0.87054	0.84576	0.83838
F-stat.	58.3021 [0.000]**	81.6908 [0.000]**	53.6424 [0.000]**	63.2484 [0.000]**
DW-statistic	1.9235	1.6538	2.0099	1.5964
LM Serial correlation *F* test	0.019499 [0.890]	1.6538 [0.205]	0.091823 [0.763]	2.6190 [0.113]
RESET *F* test	0.63514 [0.430]	`2.2737 [0.139]	0.39000 [0.536]	0.00684990 [0.934]

Notes. Observations 1951-2001; [ ] denotes probability values; * significant at the 90% significance level; ** significant at the 95% significance level.

Such a modeling framework, like above, provides as expected good efficient estimates of parameters, and all the diagnostic testing are statistically insignificantly, implying no evidence of misspecification. The adjusted R^2 are respectively 0.88, 0.87, 0.85 and 0.84 for the four models, and the computed *F*-statistics clearly reject the null hypothesis that all regressors have zero coefficients for all cases, suggesting that such ARDL models fit the data reasonably well. Estimating the dynamic relationships between underwriting margins and other variables requires an estimation method designed to deal with the particular problems raised by the inclusion of lagged dependent variables. After controlling the variables of interest rate and capacity proxy, the underwriting margins for all-lines combined seem to follow the AR(1) process at the 95% significant level. This result demonstrates that the first lagged underwriting margin has crucial explanatory power on the current period's underwriting margin while the coefficient on the second lagged underwriting margin is negligible. Under the financial pricing hypothesis advocated by Cummins and Outreville (1987), the effect of information lags can produce an AR(1) model and the combined effects of reporting lags and information lags can generate an underwriting cycle. Thus the AR(2) process with a deterministic trend yields a good data-generating process. Many of the following research studies adopted the same assumption (i.e., Niehaus & Terry, 1993; Lamm-Tennant & Weiss, 1997; Fung et al., 1998; Harrington & Yu, 2003). However, Leng and Venezian (2003) argued that such a model involves serious errors in specification and is not valid for modeling underwriting margins. In contrast, the result under carefully data assessment provides a more reliable explanation with statistically recognition.

For other liability insurance, the AIC-type ARDL model shows that the coefficient on the second lagged underwriting margin is significantly negative at the 90% significant level, but the BIC-type ARDL model supports the AR(1) process which is the same as all-lines combined. Such inconsistency may needs following ECM reference—which reinforces these findings of underwriting cycle dynamics—to determine an optimal structure of the ARDL model for other liability insurance. For the interest rate variable, all models confirm the negative relationships between the underwriting margins and current interest rate. Such findings are consistent with earlier studies. By contrast, it is worthy noting that the coefficient of the capacity proxy is substantially positive which goes against the implication of the popularly receivable capacity constraint hypothesis. For all-lines combined, the second and the third lagged capacity proxies are introduced into the AIC-type ARDL model, but are not significantly. Fung et al. (1998) found that there is evidence which goes against capacity constraint hypothesis in the first two years. One may need to further explore the specification of underwriting margins for the long-term equilibrium and short-term dynamics separately. The static long-run model and the error correction representation of the corresponding ARDL model are reported in Table 4 and Table 5, respectively.

The error correction coefficient reveals a highly significant negative sign in the SBC-type model for all-lines combined and in the AIC-type for other liability. Therefore, the optimal structure of the model for other liability insurance is AR(2) which is different from AR(1) for all-lines combined. This may be due to the characteristic of the long claims tail for other liability insurance that increases the risk of large errors in forecasting claim costs. The "tail" shows the time between the accident event and actual payment. As mentioned above, the second-order autoregressive process is consequential to reporting the lags, which usually emerge in long tail lines, thus confirming the findings. Furthermore, for the long-run model exhibited in Table 4, the coefficients on the constant are not significant for other liability insurance, which reveals a more volatile pattern of other liability insurance.

The interest rate reveals a negative direction to underwriting margins in both the long run and short run as the author expected. Interestingly, for the capacity proxy, the models show an apparently positive long-run relationship between underwriting margins and capacity proxy, which denies the capacity constraint hypothesis due to its short-term determinant nature. In the short run, the models indicate that underwriting margins and capacity proxy are still positively related, again in contrast to the prediction of basic capacity constraint model as well as the financial pricing hypothesis. Such a puzzle for the capacity constraint model historically appears in several earlier studies in the literature which suffered to explain the financial crisis in the U.S. insurance industry during the 1980s, especially for other liability insurance (i.e., Winter, 1994; Gron, 1994a). By contrast, the study's findings of are consistent with the option pricing approach, which implies a positive relationship between underwriting margins and capacity proxy in both the short run and long run. More recently, through theoretical developing, Lai et al. (2000) introduced the loss expectations on the demand side of the market into their endogenous economic model, meaning that the premium increases are negatively related to insurance leverage (i.e., premium-to-surplus ratio), while giving the same conclusion as the option pricing approach that the author suggested.

Table 4
Estimated Long-Run Effects of the ARDL Model (Dependent Variable: Underwriting Margins)

Coefficient	All-lines combined		Other liability	
	AIC-ARDL(1,0,2)	SBC-ARDL(1,0,0)	AIC-ARDL(2,0,0)	SBC-ARDL(1,0,0)
constant	45.8399 [3.3342]**	27.2120 [4.0164]**	15.1663 [6.1211]	-5.9603 [-0.21178.]
t	-0.40129 [-5.1858]**	-0.42030 [-6.2436]**	-0.87780 [-3.9876]**	-0.82191 [-3.1710.]**
r_t	-0.99324 [-2.2472]**	-1.1808 [-2.9742]**	-2.7866 [-2.0355]**	-3.7810 [-2.3235]**
$capacity_t$	-3.2645 [-2.6657]	13.7113 [2.3304]**	36.3209 [1.6361]*	56.8769 [2.2510]**

Notes. Observations are for 1951-2001; [ ] denotes standard error. * is significant at the 90% significance level; ** is significant at the 95% significance level.

Table 5
Error Correction Representation of the ARDL Model (Dependent Variable: First Difference of Underwriting Margins)

Coefficient	All-lines combined		Other liability	
	AIC-ARDL(1,0,2)	SBC-ARDL(1,0,0)	AIC-ARDL(2,0,0)	SBC-ARDL(1,0,0)
constant	-0.16821 [-2.6247]**	-0.20374 [-3.2384]**	-0.32633 [-2.6747]**	-0.26512 [-2.2144]**
ECM_{t-1}	-0.41917 [-3.4994]	-0.48476 [-4.1549]**	-0.37176 [-3.9515]**	-0.32257 [-3.4976]
ΔUM_{t-1}			0.26408 [1.7635]*	
Δr_t	-0.41633 [-2.0808]**	-0.57238 [-3.0266]**	-1.0359 [-2.2163]**	-1.2196 [-2.6147]**
$\Delta capacity_t$	6.0128 [1.6982]*	6.6466 [2.0516]**	13.5026 [1.7106]*	18.3467 [2.4379]**
$\Delta capacity_{t-1}$	4.6322 [1.3629]			

Notes. Observations are for 1951-2001; [ ] denotes standard error. The relevant critical value bounds for the ECM term reference are given in p. 304, Table CII(v). case V (with an unrestricted intercept and unrestricted trend; *k* = 2), Pesaran et al. (2001). They are (-3.41,-3.95) at the 95% significance level (-3.13, -3.63) at the 90% significance level. * is significant at the 90% significance level; ** is significant at the 95% significance level.

Conclusion Remarks

The major contribution of this study employing the ARDL framework is to investigate the presence and causes of the underwriting cycle in the U.S. property-liability insurance market and to criticize the previous ambiguous findings by which these models utilize a conventional regression or traditional cointergression that inherent leads to misspecification. This study reveals two interesting findings. First, the second-order autoregressive model may not be appropriate for different groups of insurance, and therefore earlier studies employing such a data-generating process may not provide reliable solutions. The result is that the AR(2) process for other liability supports the existence of its unique long-tail-claim characteristic which aggravates the effects of reporting lags. However, the result for the AR(1) process is that all-lines combined merely reflects the effect of information lags. In addition, the interest rates appear to be negatively correlated to underwriting margins in both the long run and short run. This result may be consistent with the option pricing approach.

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