Voluntary Termination of Life Insurance Policies in the U.S: Threshold Cointegration Approach

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Abstract

Life insurance policyholders usually are granted the option to terminate their policies before they mature. The action is called voluntary termination, or surrender. Since surrender options are exercised at the discretion of the policyholder, these actions usually cannot be fully anticipated by insurance companies in advance. Not able to access correctly may increase the company’s insolvency risk. There have been two different hypotheses in the behavior of life insurance policy surrenders: the Emergency Fund Hypothesis and the Interest Rate Hypothesis. During the financial crisis, interest rate dropped dramatically, while there is less change in the voluntary termination rates of life insurance in the U.S. This study extends the data period of previous literature to 2012 and finds out that both the interest rate and unemployment rate have long term impact on policyholders’ voluntary termination, implying that both the Emergency Fund Hypothesis and the Interest Rate Hypothesis may provide some explanation for life insurance policy voluntary termination. Furthermore, our TAR model found that the voluntary termination rate responds to a positive discrepancy, such that, when the actual change in the voluntary termination rate is higher than expected, we should observe adjustment toward the opposite direction in the future.

Keywords: life insurance, voluntary termination, cointegration, threshold autoregressive models

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1. Introduction

Life insurance companies have been facing challenges in different aspects. Integrations with the financial market triggered innovation of new life insurance product, forcing actuaries to improve their actuarial techniques to help ensure the sound operation of their companies.

Life insurance policyholders usually are granted the option to terminate their policies before they mature. The action is called voluntary termination, or surrender. Since surrender options are exercised at the discretion of the policyholder, these actions usually cannot be fully anticipated by life insurers in advance. In general, the option to surrender a life insurance exposes insurers to macroeconomic activity that may result in disintermediation and possible financial distress (Russell et.al. 2013). Early surrenders make insurers unable to fully recover their initial acquisition expenditure. Unexpected policy surrenders could result in a situation where the insurers must liquidate high-yielding investments to satisfy policyholder requests for cash values and thus negatively affect insurers’ profit (Jiang, 2010; Feir & Liebenberg, 2013; Russell et.al. 2013). A long term impact to insurers is that policy surrenders might involve mortality or morbidity adverse selection. Policyholders who have adverse health or other insurability problems tend not to surrender their policies, causing the insurers to experience more claims than expected if the surrender rate is high (Black & Skipper, 2000; Kuo, Tsai & Chen, 2003). Hence, surrenders may have great impact on the cash flows of a life insurer and should be considered in the valuation of company’s pricing and reserving. Not able to access correctly may increase the company’s insolvency risk.

There have been different hypotheses in the behavior of life insurance policy voluntary terminations. The Emergency Fund Hypothesis is that policyholders utilize cash values as emergency funds in times of personal financial crisis (Linton, 1932; Outreville, 1990; Kuo, Tsai & Chen, 2003; Russell et.al. 2013). In such case insurers need to be prepared for systematic increase in surrender during recessions (Russell et.al. 2013). The Interest Rate Hypothesis states that lapses and loans are primarily related to interest rates fluctuations (Kuo, Tsai & Chen, 2003; Feir & Liebenberg, 2013; Russell et.al. 2013). Policyholders may be willing to remove
funds from a life insurance policy in order to take advantage of higher markets rates (Feir & Liebenberg, 2013).

Outreville (1990) conducted a test on the Emergency Fund Hypothesis with regards to the lapse rates of whole life insurance policies. In this paper, the Emergency Fund Hypothesis is tested with regards to the lapse rates of whole-life insurance contracts. With data from both U.S. and Canada over the period 1955-1979, results showed a negative coefficient for the transitory income variable, thus providing evidence in favor of the Emergency Fund Hypothesis. Furthermore, results from both U.S. and Canada are found to be consistent. The author also finds that ordinary life insurance that lapse within 13 months of issue is not related to interest rate fluctuations but rather to changes in the expected personal income.

However, Outreville (1990) also mentions that, due to changing nature of the life insurance market in the 1980s with products such as Universal Life, it is difficult to justify using data posterior to 1979 to test for the Emergency Fund Hypothesis.\(^1\)

Kuo, Tsai & Chen (2003) examined the two lapse rate hypotheses: the Emergency Fund Hypothesis and the Interest Rate Hypothesis by using the cointegration vector autoregression model. With this technique, they are able to separate the potential long-term relationship among the lapse rate, interest rate, and unemployment rate from their short-term adjustment mechanism, which is different from the OLS method used by Outreville (1990).

Kuo, Tsai & Chen (2003), using data from 1951 to 1998, showed that the unemployment rate is statistically significant in explaining the short-term lapse rate dynamics whereas the explanatory power of interest rate is relatively weak in the short run. However, after performing impulse-response analysis based on the estimated error-correction model, their results show that the lapse rate responds insignificantly to the shocks from the unemployment rate but significantly to the shocks from the interest rate. Thus, the authors conclude that the Interest Rate

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\(^1\) Outreville (1990) found that policy lapses or surrenders may occur simply because the policyholder has identified a more attractive policy with better terms or rates. Some literatures refer the results as the Policy Replacement Hypothesis (Feir & Liebenberg, 2013; Russell et.al. 2013).
Hypothesis is more consistent with the evidence than the Emergency Fund Hypothesis. Jiang (2010) employed one error-correction model to avoid the problem of producing noise within traditional multiple cointegration vectors and show that both the Emergency Fund Hypothesis and interest hypothesis are sustained in the short run as well as in the long run. Results from Russell et. al. (2013) also support both the Emergency Fund Hypothesis and the Interest Rate Hypothesis. Feir & Liebenberg (2013) use a detailed household-level survey dataset, instead of employing macroeconomic data, to reexamine the hypotheses and identify household characteristics and life-cycle events that affect life insurance lapse or surrender behavior, and report results also supporting both the Emergency Fund Hypothesis and the Interest Rate Hypothesis. With a large dataset of U.S. term policies, Belaygorod et. al. (2014) set up models using Bayesian Multiple-Block Gibbs sampling and claim to find strong evidence in favor of the Emergency Fund Hypothesis.

In this study, data period will be extended to 2012. Previous studies (for example, Kuo, Tsai & Chen (2003)) have already shown that surrender rates, as well as interest rates and unemployment rates, are all I(1) processes. It should be noted that recent literatures in time series have shown that many economic variables display asymmetric adjustment paths. After the financial crisis, short term interest rate dropped dramatically, whereas the voluntary termination rate remained at a certain level. Therefore, it should be interesting to find out whether this nonlinear adjustment can also be applicable in the surrender rate model. On the nonlinear basis, this study employs the threshold cointegration technique which was advanced by Enders and Granger (1998) and Enders and Siklos (2001).

The remainder of this paper is organized as follows. In Section 2, we explain the methodology of the threshold cointegration technique. Section 3 describes the data, the nonlinear voluntary termination model and the empirical results. Section 4 concludes.

2. Methodology

Threshold autoregressive (TAR) and momentum threshold autoregressive (MTAR) models were formerly developed by Tong (1983) to address the asymmetry
problem within time series. Enders and Granger (1998) and Enders and Siklos (2001) advanced the threshold cointegration technique and error correction models so that the original cointegration models can be extended to deal with the problem of low power unit roots and cointegration tests in the presence of asymmetric adjustment. The model is a two-stage procedure.

In the first stage, the cointegration equations are estimated as follows:

\[ Y_{1t} = \alpha + \beta Y_{2t} + \mu_t, \]

where \( Y_{1t} \) and \( Y_{2t} \) are both I(1) series, \( \alpha \) and \( \beta \) are estimated parameters and \( \mu_t \) is the disturbance term that may be serially correlated.

The second stage focuses on the OLS estimates of \( \rho_1 \) and \( \rho_2 \) in the following regression:

\[ \Delta \mu_t = I_t \rho_1 \mu_{t-1} + (1-I_t) \rho_2 \mu_{t-1} + \sum \Delta \mu_{t-i} + e_t, \]

where \( e_t \) is a white noise disturbance and the residuals \( \mu_t \) in (1) are extracted to (2) to be further estimated. \( I_t \) is the Heaviside indicator function such that

\[ I_t = \begin{cases} 1, & \text{if } \mu_{t-1} \geq \tau \\ 0, & \text{if } \mu_{t-1} < \tau \end{cases}, \]

where \( \tau \) is the threshold value.

A sufficient condition for the stationarity of \( u_t \) is \(-2 < (\rho_1, \rho_2) < 0\). If \( \rho_1 = \rho_2 \), then the adjustment is symmetric, which is a special case of (1) and (2). Eq. (1) can also contain lagged values of \( \Delta \mu_t \).

Enders and Granger (1998) and Enders and Siklos (2001) both point out that, under the null hypothesis of no convergence, the F-statistic for the null hypothesis, \( \rho_1 = \rho_2 = 0 \), has a nonstandard distribution. The critical values for this non-standard F-statistic are tabulated in their paper. Enders and Granger (1998) also show that if the sequence is stationary, the least squares estimates of \( \rho_1 \) and \( \rho_2 \) have an asymptotic multivariate normal distribution. The threshold error-correction model is then expressed as follows:

\[ \Delta Y_t = \alpha + \gamma_1 u_{t-1}^+ + \gamma_2 u_{t-1}^- + \sum \delta_i Y_{t-i} + \sum \theta_i \Delta Y_{t-i} + v_t. \]
The above model is referred to as the Threshold Autoregression Model (TAR), where the test for threshold behavior of the equilibrium error is termed threshold cointegration test. Assuming that the system is convergent, $\mu_t = \tau$ can be considered as the long-run equilibrium value of the sequence. If $\mu_t$ is above its long-run equilibrium, the adjustment is $\rho_1 \mu_t$. If $\mu_t$ is below its long-run equilibrium, the adjustment becomes $\rho_2 \mu_t$. The equilibrium error therefore behaves like a threshold autoregression. The null hypothesis of $\rho_1 = \rho_2 = 0$ tests for the cointegration relationship and the rejection of this null implies the existence of cointegration between variables. With the finding of $\rho_1 = \rho_2 = 0$, it is valuable to further test for symmetric adjustment (i.e., $\rho_1 = \rho_2$) by using a standard F-test. When adjustment is symmetric so that $\rho_1 = \rho_2$, (2) converges to the prevalent augmented Dickey-Fuller Test. Rejecting both the null hypotheses of $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ implies the existence of threshold cointegration and the asymmetric adjustment.

Instead of estimating (3) with the Heaviside indicator depending on the level of $\mu_{t-1}$, the decay could also be allowed to depend on the previous period’s change in $\mu_{t-1}$, which is $\Delta \mu_{t-1}$. The Heaviside indicator could then be specified as

$$I_t = \begin{cases} 1, & \text{if } \Delta \mu_{t-1} \geq \tau \\ 0, & \text{if } \Delta \mu_{t-1} < \tau \end{cases}$$

where $\tau$ is the threshold value.

According to Enders and Granger (1998), this model is especially valuable when adjustment is asymmetric such that the series exhibits more ‘momentum’ in one direction than the other. This model is termed Momentum-Threshold Autoregression Model (MTAR).

The TAR model can capture ‘deep’ cycle process if, for example, positive deviations are more prolonged than negative deviations. The MTAR model allows the autoregressive decay to depend on $\Delta \mu_{t-1}$. Hence, the MTAR representation can capture ‘sharp’ movements in a sequence.

In the most general case, the value of $\tau$ is unknown and needs to be estimated along with the value of $\rho_1$ and $\rho_2$. A consistent estimate of the threshold $\tau$ can be obtained by using Chan’s (1993) method of searching over
possibility threshold values to minimize the residual sum of squares from the fitted model. Enders and Siklos (2001) apply Chan’s methodology to a Monte Carlo study to obtain the F-statistic for the null hypothesis of $\rho_1 = \rho_2 = 0$ when the threshold $\tau$ is estimated using Chan’s procedure. The critical values of this non-standard F-statistic for testing the null hypothesis of $\rho_1 = \rho_2 = 0$ are also tabulated in their paper.

As there is generally no presumption as to whether to use TAR or MTAR model, the recommendation is to select the adjustment mechanism by a model selection criterion such as the AIC or SBC.

3. Empirical Results

3.1. Data

Voluntary termination rates were acquired from the Life Insurers Fact Book, an annual statistical report of the American Council of Life Insurers (ACLI). ACLI is a trade association with life insurance member companies operating in the United States and abroad. The Life Insurers Fact Book, the annual statistical report of the ACLI, provides information on trends and statistics about the life insurance industry. The data in the Fact Book are derived from the annual statements filed by life insurance companies with the National Association of Insurance Commissioners, ACLI’s surveys, and/or external sources such as government agencies and trade associations. The sample contains the annual voluntary termination rates for all ordinary life insurance policies in force from 1965 to 2012. The voluntary termination rate is a combined termination rate, including the lapse rate and the surrender rate. The lapse rate reports the percentage of policies terminated at the end of the grace period because of non-payment of premiums. The surrender rate represents the percentage of policies terminated by the application of policyholders.

Annualized 90-day T-bill rates can be retrieved from the US Federal Reserve

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2 ACLI members offer life insurance, annuities, retirement plans, long-term care and disability income insurance, and reinsurance, representing more than 90 percent of industry assets and premiums.

3 We obtained data before 1997 from the 2000 Life Insurers Fact Book and data thereafter from the 2013 Life Insurers Fact Book.
Database and the historical unemployment rates were collected from the Labor Bureau.

Figure 1 shows the time series of voluntary termination rates, interest rates and unemployment rates.

![Figure 1](image)

**Figure 1.** The time series of voluntary termination rates, interest rates and unemployment rates

### 3.2. Unit Root Tests

ADF test is used to examine whether the variables are non-stationary time series and are I(1) processes rather than processes with higher-order integration. Since the ADF test depends critically on the assumption about the underlying process and the estimated regression, we estimate the following regressions:

\[
\begin{align*}
    s_t &= \alpha_1 + \beta t + \theta_{1,0} s_{t-1} + \theta_{1,1} \Delta s_{t-1} + \theta_{1,2} \Delta s_{t-2} + \ldots + \theta_{1,r-1} \Delta s_{t-r+1} + \varepsilon_{1,t} \\
    r_t &= \alpha_2 + \beta t + \theta_{2,0} r_{t-1} + \theta_{2,1} \Delta r_{t-1} + \theta_{2,2} \Delta r_{t-2} + \ldots + \theta_{2,r-1} \Delta r_{t-r+1} + \varepsilon_{2,t} \\
    u_t &= \alpha_3 + \beta t + \theta_{3,0} u_{t-1} + \theta_{3,1} \Delta u_{t-1} + \theta_{3,2} \Delta u_{t-2} + \ldots + \theta_{3,r-1} \Delta u_{t-r+1} + \varepsilon_{3,t}
\end{align*}
\]

and test the following null hypothesis \( H_0 : \beta_i = 0 \) and \( \theta_{i,j} = 1 \), where \( i = 1, 2, 3 \) and \( j = 0, 1, 2 \).

Table 1 reports the results of the unit root test on the voluntary termination rate,
90-day T-bill rate, the unemployment rate, and their first-order differences. All of the ADF statistics suggest that the null hypothesis of a unit root cannot be rejected. In addition, the corresponding statistics for their first-order differences suggest rejecting the null hypothesis. Therefore, we conclude that all the data series are integrated of order one, i.e. I(1) series.

### Table 1  ADF Unit Root Tests

<table>
<thead>
<tr>
<th></th>
<th>Voluntary Termination Rate</th>
<th>90-day T-Bill Rate</th>
<th>Unemployment Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>-1.279(0)</td>
<td>-2.371(0)</td>
<td>0.131(2)</td>
</tr>
<tr>
<td>1st Difference</td>
<td>-5.742(1)**</td>
<td>-5.037(0)**</td>
<td>-4.972(2)**</td>
</tr>
</tbody>
</table>

Notes:

1. The numbers in the parentheses are the appropriate lag lengths selected by MAIC (Modified Akaike Information Criterion)
2. ** p<.01

### 3.3. Johansen Cointegration Tests

For comparison, a Johansen Cointegration test which is similar to the test in Kuo, Tsai & Chen(2003) is conducted first. Table 2 reports the results of the maximum eigenvalue test and the trace test.

Different from Kuo, Tsai & Chen (2003), both the trace test and the maximum eigenvalue test show that VAR(1) is significant at the 0.01 level. Based on the AIC and the likelihood ratio test, we still follow Kuo, Tsai & Chen (2003) and choose VAR(2) as the optimal model and estimate the error-correction model with two cointegration vectors as follows:

### Table 2. The Maximum Eigenvalue Test and the Trace Test of Johansen

#### A. The Maximum Eigenvalue Test

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Eigenvalue</th>
<th>Max-Eigen statistic</th>
<th>0.05 Critical Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.429</td>
<td>26.340</td>
<td>21.132</td>
<td>.00:</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.135</td>
<td>6.830</td>
<td>14.265</td>
<td>.51:</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.066</td>
<td>3.213</td>
<td>3.841</td>
<td>.07:</td>
</tr>
</tbody>
</table>

#### B. The Trace Test
To examine the responses of voluntary termination rates from interest rates and unemployment rates, we carry out an impulse response analysis of (5). Figure 2 illustrates the impulse responses of the voluntary termination rate to one standard deviation shock in the unemployment rate and interest rate for up to thirty periods. Different from the results in Kuo, Tsai & Chen (2003), the magnitude of the response to the shock from unemployment rate is negative during the shorter period and turns positive after the fourth period, suggesting an more economically significant impact upon future voluntary termination rates. In such case, an unexpected change in the unemployment rate can influence the voluntary termination rate in the longer future. For example, during a financial crisis, as unemployment rate raises, insurers may not observe immediate increases in the voluntary termination rate, but experience the impact after a longer period. However, it should be noted that the impact of changes in the interest rate overwhelm that of the unemployment rate. Thus, we observed a gradually decreasing voluntary termination rate after the 2008 financial crisis.
3.4. Threshold Cointegration Tests

We proceed further to conduct the Threshold Cointegration Test. First, we examine whether both cointegration and asymmetry adjustment both exists. The results are shown in Table 3.

Table 3  Threshold Cointegration Test

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. The Threshold Autoregression (TAR) Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\rho_1$</td>
<td>$\rho_2$</td>
<td>$F_C$</td>
<td>$F_A$</td>
<td>Lag length</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>-0.330***</td>
<td>-0.008</td>
<td>6.460***</td>
<td>11.756***</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(-3.594)</td>
<td>(-0.125)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. The Momentum Threshold Autoregression (MTAR) Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\rho_1$</td>
<td>$\rho_2$</td>
<td>$F_C$</td>
<td>$F_A$</td>
<td>Lag length</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>-0.338***</td>
<td>-0.019</td>
<td>4.637**</td>
<td>8.181***</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>(-2.947)</td>
<td>(-0.272)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. The numbers in the parentheses are the t-statistics.
2. $F_C$ and $F_A$ are the F-statistics for the null hypothesis of no cointegration and symmetry, critical values are taken from Enders and Siklos(2001)
3. *** p<.01, ** p<.05

$F_c$ and $F_\lambda$ in Table 3 are the F-statistics for the null hypotheses of no cointegration and symmetry respectively. By referring to the critical values in Enders and Siklos (2001), we concluded that both hypotheses are significantly rejected in both TAR and MTAR models. Although there is no presumption on whether to use TAR or MTAR model, TAR model is selected in this study based on AIC. Threshold values are then estimated using Chan’s (1993) method with the following steps:

(1) Sort the estimated residual series from the original regression in ascending order.

(2) Discard the largest and smallest 15% of the series. The remaining 70% of the values are considered as possible thresholds.

(3) For each possible thresholds, estimate equation (2) and (3) in the previous section. The appropriate threshold would be the one that yields the lowest residual sum of squares.

The estimated threshold value for the TAR model in this study is 0.017194.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>The Maximum Eigenvalue Test and the Trace Test of TAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. The Maximum Eigenvalue Test</strong></td>
<td></td>
</tr>
<tr>
<td>Null Hypothesis</td>
<td>Eigenvalue</td>
</tr>
<tr>
<td>None</td>
<td>0.373</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.192</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.036</td>
</tr>
<tr>
<td><strong>B. The Trace Test</strong></td>
<td></td>
</tr>
<tr>
<td>Null Hypothesis</td>
<td>Eigenvalue</td>
</tr>
<tr>
<td>None</td>
<td>0.373</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.192</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.036</td>
</tr>
</tbody>
</table>

Further on, the cointegration test is conducted on TAR basis. To determine the appropriate model, the result the maximum eigenvalue test and the trace test are
shown in Table 4. Interestingly, instead of the previous VAR(2) model, both the maximum eigenvalue test and the trace test show that the model with one cointegration equation is optimal.

The threshold error-correction model introduced in the above section, noted as equation (4), can be expressed as follows:

\[
\begin{align*}
\Delta s_t & = \alpha + \gamma \left[ \mu_{t-1}^+ - \mu_{t-1}^- \right] + \sum \delta_i \left[ s_{t-i} - r_{t-i} + u_{t-i} \right] + \sum \theta_i \left[ \Delta s_{t-i} \right] + \Delta r_{t-i} + \Delta u_{t-i} + \epsilon_t \\
\Delta r_t & = \alpha + \gamma \left[ \mu_{t-1}^+ - \mu_{t-1}^- \right] + \sum \delta_i \left[ s_{t-i} - r_{t-i} + u_{t-i} \right] + \sum \theta_i \left[ \Delta s_{t-i} \right] + \Delta r_{t-i} + \Delta u_{t-i} + \epsilon_t
\end{align*}
\]

(8)

where \( \mu_{t-1}^+ = I_t \mu_{t-1} \) such that \( I_t = 1 \), if \( \mu_{t-1} \geq 0.017104 \) \( I_t = 0 \), if \( \mu_{t-1} < 0.017104 \)

Therefore, we estimate the threshold error-correction model as follows:

\[
\begin{bmatrix}
\Delta s_t \\
\Delta r_t \\
\Delta u_t
\end{bmatrix}
= \begin{bmatrix}
0.005^{***} \\
-0.004^* \\
0.003^*
\end{bmatrix}
\begin{bmatrix}
1 & 21.835^{***} & -14.845^{***}
\end{bmatrix}
\begin{bmatrix}
s_{t-1} \\
r_{t-1} \\
u_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
0.065 & -0.130^{**} & -0.160^{**} \\
-0.192 & 0.138 & -0.449^* \\
0.171 & 0.194^* & 0.463^{***}
\end{bmatrix}
\begin{bmatrix}
\Delta s_{t-1} \\
\Delta r_{t-1} \\
\Delta u_{t-1}
\end{bmatrix}
+ \begin{bmatrix}
-0.504^{***} & -0.065 \\
-0.339^* & -0.178 \\
-0.054 & 0.112
\end{bmatrix}
\begin{bmatrix}
\mu_{t-1}^+ \\
\mu_{t-1}^- \\
\mu_{t-1}^-
\end{bmatrix}
+ \begin{bmatrix}
\epsilon_t^s \\
\epsilon_t^r \\
\epsilon_t^u
\end{bmatrix}
\]

(9)

The result in equation (9) shows that both the interest rate and unemployment rate significantly affect the voluntary termination rate, supporting both the Emergency Fund Hypothesis and the Interest Rate Hypothesis introduced in the first section of this paper. Furthermore, the change in the voluntary rate responds to a positive discrepancy with negative estimated coefficient. In other words, as interest rate drops dramatically, which is the case during the 2008 financial crisis, we would expect voluntary termination rate in increase, but the magnitude was then adjusted to be less than expected. To examine the responses of voluntary termination rates
from interest rates and unemployment rates, again we carry out an impulse response analysis of (9). Figure 3 illustrates the impulse responses of the voluntary termination rate to one standard deviation shock in the unemployment rate and interest rate for up to thirty periods. The magnitude of the response to the shock from interest rate seems to remain at a constant level after the eighth period, suggesting an economically significant impact upon future voluntary termination rates. More surprisingly, the unemployment rate has a greater impact in magnitude than the interest rate, but in the opposite direction.

![Impulse response analysis of the threshold error-correction model](image)

Figure 3. The Impulse response analysis of the threshold error-correction model:

4. Conclusion

Since recent literatures in time series analysis have shown that many economic variables display asymmetric adjustment paths, this research uses Threshold Cointegration techniques to investigate the relation between life insurance voluntary termination rate and some economic variables, namely the interest rate and unemployment rate.

After the financial crisis, short term interest rate dropped nearly to zero, whereas the voluntary termination rate remained at a certain level. This observation gives raise to the question whether the Interest Rate Hypothesis would be the only
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explanation for policy termination. The results from this study show that both the interest rate and unemployment rate have long term impact on policyholders’ voluntary termination, implying that both the Emergency Fund Hypothesis and the Interest Rate Hypothesis may provide some explanation for life insurance policy voluntary termination. Furthermore, our TAR model found that the voluntary termination rate responds to a positive discrepancy with negative coefficient. In other words, when the actual change in the voluntary termination rate is higher than expected, we should observe adjustment toward the opposite direction in the future.

Nowadays, interest-rate sensitive life insurance products such as universal life insurance and variable life/annuity insurance have gained popularity. Modeling appropriate surrender and lapse behavior of policyholders is essential in life insurers’ asset/liability management. In the Taiwan life insurance market, these interest-rate sensitive life insurance products have also gained certain degree of market share as well, forcing regulator to be more aware of the financial soundness of life insurers. Though our study focus on the U.S. market, the results may be valuable for life insurers and regulators in Taiwan as well.
References


美國壽險保單解約率之研究：門檻共整合模型之應用

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摘要

傳統人壽保險因具有現金價值之累積，保戶可於契約終止前申請解約，取回保單價值準備金或解約金。然保戶的解約行為可能影響保險公司的現金流量，若保險公司無法明確預估解約率，可能對清償能力造成負面影響。過去文獻對於保戶的解約行為理論有二：急用資金假說與利率假說。自 2008 年金融海嘯後，傳統模型對於利率環境的改變與解約率無法提出適當解釋。本研究延續過去文獻之內容，考量金融海嘯之後的利率環境，針對壽險解約率的假說，採用非對稱計量模型，探討在利率環境變動下的解約理論。結果顯示，利率與失業率對解約率均有長期影響，同時支持急用資金假說與利率假說。因此，壽險公司在評估未來的解約率與現金流量時，需多方面考量，審慎為之。

關鍵詞：人壽保險、解約、共整合、門檻自我迴歸

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