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Abstract

This paper develops a methodology that can be used by insurers to construct predictive models for their own insurance cash flows. The insurance cash flow components evaluated include premium flows, policy loans, and cash value surrenders. Also, the paper evaluates several hypotheses in the insurance literature that attempt to explain insurance cash flows.

Though the results are theoretically consistent, they produce some interesting contrasts to findings of similar studies for whole life policies. For example, these results confirm that: (i) the credited rate strategy is important to policy performance; (ii) the emergency fund hypothesis appears to apply to policy loan utilization, premium payments, and total insurance cash flows; (iii) the arbitrage potential with regard to policy loans is reduced; and (iv) direct recognition of policy loans seems to be effective in reducing the disintermediation risk of traditional whole life insurance policies with fixed policy loan rates.

Although policyholders do increase their use of policy loans as inflation increases, the overall results suggest that they tend to increase contributions to their universal life policies in order to maintain levels of protection in real terms. Finally, interest rate risk does exist for companies issuing universal life because changes in market interest rates lead to decreases in premiums and in total insurance cash flows. This lends support to the alternative funds hypothesis.

Key words and phrases: *credited interest rate, policy loans, cash values*

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1 Introduction

1.1 Universal Life

Universal life insurance can be described as a flexible premium, flexible benefit life insurance policy consisting of a savings or cash value account and a term or pure insurance component. Charges for expenses and pure insurance protection are deducted from, and interest is credited to, the cash value account (generally on a monthly basis). The policyholder decides on the timing and amount of premium payments, subject to certain limits. Premium payments received from the policyholder are credited to the cash value account. Universal life is characterized by a high degree of disclosure. The interest credited each month is stated, as are the expenses and pure insurance charges. This split of the traditional whole life policy components that is characteristic of universal life insurance is referred to as *unbundling*.

The interest or credited rate on the policy is adjusted on a regular basis in line with market interest rates. The credited rate usually is guaranteed for no more than one year, with a permanent rate guarantee of from 4 percent to 4.5 percent. Unlike traditional whole life policies, universal life policies often permit partial withdrawals. In addition, policy loans are permitted. Universal life policies are characterized as being *loan intolerant*, however, as they generally provide either variable policy loan rates or directly recognize policy loan utilization in the credited rate.

The introduction of universal life insurance policies in 1979 resulted from significant changes in the insurance and financial services industry. Changes in the economy as a whole contributed to their introduction and subsequent popularity as well. Deregulation in the financial services industry has led to even greater demand for life insurance products that are competitive with other investment vehicles. A Federal Trade Commission (1979) report alleging a 1.3 percent return on whole life insurance heightened consumer dissatisfaction with traditional cash value policies.

Given the premium and benefit flexibility, as well as crediting of market rates of interest, universal life gained popularity. Based on figures obtained from the *Life Insurance Fact Book* over several years including (1983-1991), universal life sales increased from 12 percent of ordinary premium in 1983 to sales of over 32 percent in 1985. These same features, however, contributed to the modest decline in its popularity in the latter part of the 1980s, with sales of universal life representing only 27 percent of ordinary life premiums in 1991. Universal life insurance remains an important product representing 24 percent of ordinary life insurance in force in 1991.

The high interest rates of the late 1970s and early 1980s created a massive outflow of funds from existing cash value products as policyholders took policy loans at unprecedented levels and surrendered policies to take advantage of high market interest rates.[1] Policy loan problems for some insurers became severe—replacement of their own in-force business with a direct recognition policy was seen as the only solution. High inflation rates contributed to the increasing dissatisfaction with traditional cash value policies because premiums and benefits generally were fixed in amount, with no specific provision for adjustment in the amounts as a result of inflation.

1.2 Objectives

The significant flexibility provided to the policyholder by universal life, coupled with the unbundled structure and extensive disclosure of policy provisions and charges, makes it a particularly interesting insurance product to model. These features undoubtedly increase the sensitivity of universal life cash flows to changes in both endogenous and exogenous factors. This increased sensitivity also makes it more important that the insurer understand the factors that influence universal life cash flows.

Thus the objective of this paper is threefold:

- First, to present a methodology that can be used by insurers to construct predictive models for their own insurance cash flows. A set of significant exogenous economic input variables is identified for each cash flow component. These variables then are used to develop models for the components of universal life cash flows.

- Second, the paper evaluates several hypotheses in the insurance literature that purport to explain insurance cash flows. This evaluation provides an assessment of the significance of specific factors in explaining insurance cash flows. Identifying specific factors should aid actuaries in the product development process. The insurance cash flow components evaluated include premium flows, policy loans, and cash value surrenders.

[1]The policy surrender rate grew steadily from 8.1 percent in 1980 to a peak of 12.3 percent in 1985. Policy loans reached 9.3 percent of assets in 1981 before beginning a steady decline over the past decade; see *Life Insurance Fact Book*, 1994.

- Third, the paper exposes actuaries to the non-actuarial literature on insurance cash flows.

2 Review of the Literature

This section discusses some of the potential theoretical relationships between the input and output variables. First, several hypotheses that have been proposed in the literature to explain insurance cash flows are described. Next, the results of several prior studies related to insurance cash flow modeling are discussed. Then hypothesized relationships are presented for each of the groups of cash flow variables. These groups are, generally, premium flows, policy loan flows, and cash value surrenders.

2.1 Cash Flow Hypotheses

Several hypotheses have been advanced to explain cash flows in insurance policies.[2] The *arbitrage/yield spread hypothesis* suggests that policyholders are influenced by differences between the credited interest rate and market interest rates. As this spread (credited interest rate minus market interest rate) increases, premium payments would be expected to increase while policy loans and surrenders would be expected to decline. In the case of policy loans, the arbitrage/yield spread hypothesis asserts that policyholders are motivated by differences between the policy loan rate and market interest rates (Bykerk and Thompson, 1979). As this spread increases, the level of policy loans will increase.

The *emergency fund hypothesis* asserts that policyholders view their insurance policies as sources of needed funds in cases of emergency (Wood, 1964; Rejda, 1966; Outreville, 1990). Hence, higher policy loan demand, lower premium payments, and increased policy surrenders may be expected during periods of high unemployment or low earnings.

The *alternative funds hypothesis* relates to the availability of funds in credit markets (Schott, 1971; Pesando, 1974). This hypothesis suggests that when alternative sources of funds are difficult to obtain, policyholders may turn to their insurance policy for funds either through increased policy loans, increased policy surrenders, or decreased premium payments.

[2]See Carson and Hoyt (1992, p. 242) for a description of these hypotheses with respect to policy loan demand. Cargill and Troxel (1979) provide a cogent discussion of these concepts and of the effect of inflation on life insurance demand.

The *rising prices/inflation hypothesis* states that policy loan demand increases, surrenders rise, and premium payments decline as the need for additional sources of income becomes greater in periods of rising prices (Day and Hendershott, 1977). A contrary hypothesis for the direction of premium flows during periods of inflation, however, is the *real protection hypothesis.* This hypothesis asserts that increased purchases of insurance may occur during periods of inflation as policyholders seek to maintain a level of real insurance protection (Houston, 1960; Neumann, 1968; Fortune, 1972; Cargill and Troxel, 1979).

2.2 Insurance Cash Flow Modeling

Numerous prior studies have investigated the relationships between various economic and institutional variables (input variables) and insurance cash flows (output variables). Several of these have devoted special attention to the impact of various input variables on policy loan demand (Schott, 1971; Pesando, 1974; Bykerk and Thompson, 1979; Carson and Hoyt, 1992). Others also have considered premiums flows and surrender activity (Cummins, 1975; Schott, 1977; Berger, 1983; Curry and Warshawsky, 1986).

Curry and Warshawsky (1986) look at the impact of various input variables on aggregate insurance cash flows from 1952 to 1985. They find that rising nominal market interest rates gave policyholders the opportunity to earn higher rates of return than those available on traditional cash value life insurance which led to an increasing flow of funds away from such products. Lapses and surrenders also increased as market interest rates rose. In addition, they find that as interest rates rose above the contractual loan rate, policyholders exercised the option to take advantage of an arbitrage opportunity by borrowing against their cash values to invest in assets earning current interest rates.

Schott (1977) performs insurance cash flow analysis based on data from his company, The Equitable. He points out that a reasonable proposition is to take individual cash flow items and test each for statistical associations with life insurance or external economic and financial variables. He indicates, however, that multicollinearity and functional instability of the parameters must be viewed as potential problems.

Berger (1983) analyzes the impact of various input variables on life insurance cash flows at Metropolitan Life. He finds that life insurance surrenders can be explained by a model containing only the unemployment rate and the yield on three month Treasury bills. Increases in unemployment are found to lead to increased surrenders, and increases in the T-bill rate also are found to generate increased surrenders.

Several prior studies have devoted special emphasis to modeling policy loan flows. Schott (1971) investigates the impact of various input variables (including the four to six month commercial paper rate and the percentage change in the money supply) on the net increase in policy loans.[3] Cummins (1975) and Berger (1983) consider modeling policy loan flows. Bykerk and Thompson (1979) also perform a comprehensive analysis of policy loan demand. In addition, Carson and Hoyt (1992) assess the impact that redesigned policy loan provisions in life insurance policies and changes in financial markets have had on the demand for policy loans after 1980.

2.3 Hypothesized Relationships Between the Input and Output Variables

Several hypotheses have been proposed to explain variations in the cash flows of insurance policies. These hypotheses lead to the expected analytic relationships between the various insurance cash flows or output variables (premiums, policy loans, and policy surrenders) and the input variables (unemployment, interest rates, inflation, yield spread, and others) that are presented in Table 1.

Market interest rates are used to test the alternative funds hypothesis. Higher interest rates reflect reduced availability of funds in credit markets. Also, if interest rates represent the returns available from alternative investments, a decline in these rates would make the guarantees in a universal life policy more attractive. Hence, premium flows would be related negatively to interest rates, while the demand for policy loans and surrenders would increase with increases in these rates. The change in the money supply, CHGM1, also is used to measure the availability of funds in credit markets. Specific definitions of the variables mentioned in the next several paragraphs are provided in Table 2.

SPREAD1 and SPREAD2, the differences between the credited rate and market interest rates, are used to test the arbitrage/yield spread hypothesis. As the yield differential for investing dollars in the universal life policy increases relative to other options, premium flows increase and loan utilization and surrenders decrease.

[3] In particular, Schott (1971) found that the four to six month commercial paper rate and the percentage change in the money supply produced the highest adjusted R^2. He also tested net changes in consumer credit and changes in consumer prices.

Table 1
Expected Relationships Between Input and Output Variables

	Input Variables						
Output Variables	CRATE	SPREAD	ARBIT	CHGM1	INFLATE	UNEMPLOY	EARN
NEWPREM	-	+		+	+ or -	-	+
RENPREM	-	+		+	+ or -	-	+
REPPREM	-	+		+	+ or -	-	+
NISSUE	-	+		+	+ or -	-	+
NPAY	-	+		+	+ or -	-	+
LNREPAY	-		+	+	-	+ or -	- or +
NEWLOAN	+		-	-	+	+	-
TLOAN	+		-	-	+	+ or -	- or +
NETFULL	+	-		-	+	+	-

Notes: CRATE = Credited interest rate; SPREAD = Yield spread; ARBIT = Loan rate - Credited rate; CHGM1 = Change in money supply; INFLATE = Rate of inflation; UNEMPLOY = Unemployment rate; EARN = Earnings.

Table 2
Endogenous and Exogenous Variables

Variable	Description of the Variable
Panel A: Premium Activity	
NEWPREM	Total amount of premiums received from new policyholders;
RENPREM	Total amount of premiums received from existing policyholders;
REPPREM	Total amount of premiums paid by cash values transferred from old policies;
NISSUES	Number of new policies issued;
NPAY	Number of premium payments made;
Panel B: Policy Loan Activity	
LNREPAY	Amount of outstanding loans repaid in the month;
NEWLOAN	Amount of new loans made in the month;
TLOAN	Total amount of outstanding loans;
Panel C: Surrender Activity	
NETFULL	Total amount of full cash value surrenders after adjustment for surrender charges;
Panel D: Other Internal Variables	
CRATE	Current credited interest rate for all funds received in the month;
CASHVAL Value	Aggregate cash value of all existing policies;
LOANRATE	This is the policy loan rate, including opportunity cost. LOANRATE = 8 + (CRATE - 4), where 8 percent is the contractual loan rate and (CRATE - 4) represents the opportunity costs because the loaned cash value is credited with only the guaranteed rate;

Table 2 (cont.)

Endogenous and Exogenous Variables

Variable	Description of the Variable
Panel E: Interest Rates	
CD	Average yield on 90 day certificates of deposit;
CPAPER	Average yield on 30 day commercial paper;
AAA	Average yield on corporate bonds rated Aaa;
BAA	Average yield on corporate bonds rated Baa;
TBILL3	Average yield on three month Treasury bills;
TBILL6	Average yield on six month month Treasury bills;
TBILLYR	Average yield on one year Treasury bills;
TNOTE	Average yield on five year Treasury securities;
TBOND	Average yield on long-term Treasury securities;
Panel F: Other Economic Variables	
INFLATE	Unadjusted monthly inflation rate (CPI-W);
UNEMPLOY	Percentage of unemployed civilian workers;
EARN	Average weekly earnings of production or nonsupervisory workers of major corporations;
CONINT	Rate on short-term consumer loans from nonbank financial institutions;
CHGM1	Monthly percentage change in the money supply (M1);
Panel G: Combined Endogenous/Exogenous Variables	
SPREAD1	Yield differential between the credited rate and the yield on 90 day certificates of deposit, i.e., CRATE - CD;
SPREAD2	Yield differential between the credited rate and the yield on three month T-bills, i.e., CRATE - TBILL3;
ARBIT	Arbitrage, i.e., Loan Rate - Credited Rate.

The spread between market rates, such as TBILL3 and CPAPER, and the loan rate paid on policy loans (LOANRATE) is used to test the arbitrage hypothesis. The greater the spread, the greater the incentive for the policyholder to utilize policy loans. Due to the provision for direct recognition of policy loans that is used by the company being evaluated, however, the arbitrage variables may be insignificant.[4]

The unemployment rate, UNEMPLOY, and the level of earnings, EARN, are used to test the emergency fund hypothesis. Hence, premium flows are related negatively to UNEMPLOY, while the demand for policy loans and surrenders increases with increases in UNEMPLOY. The expected correlations for EARN are reversed. The impact of UNEMPLOY on loan repayments, LNREPAY, is unclear because increasing unemployment may make repayment difficult for many policyholders, but it will lead to increased policy surrenders which will result in loan repayments if the surrendered policies have outstanding loans.

The inflation rate, INFLATE, is used to test between two competing hypotheses, the inflation/rising prices hypothesis and the real protection hypothesis. The first suggests a negative relationship between premium flows and INFLATE, while the demand for policy loans and surrenders increases with increases in INFLATE. The real protection hypothesis suggests a positive correlation between premium flows and INFLATE.

Additionally, the amount of outstanding loans, TLOAN, represents the amount of loans available for repayment. Hence, the correlation between LNREPAY and TLOAN is expected to be positive. As the amount of cash value, CASHVAL, places a cap on the amount of loans that can be made, increases in cash value are expected to be related positively to NEWLOAN.

3 Data Sources

3.1 Endogenous Data

The endogenous insurance data represent the experience of a large stock life insurance company's universal life policy from the end of

[4]The universal life policy of the company considered in the study provides that the loaned cash value is credited with only the guaranteed rate, 4 percent. The contractual loan rate is 8 percent. Hence, the effective loan rate is LOANRATE = 8 + (CRATE − 4), where the second term represents the opportunity cost of borrowing. Note that the arbitrage potential, TBILL3 − LOANRATE, reduces to SPREAD2, a constant. In other words, due to the direct recognition of policy loans in this policy, the arbitrage and yield spread concepts are linked closely.

the third quarter of 1982 to the end of the first quarter of 1986. The data are monthly observations. Attempts were made to collect data from additional insurers that offer universal life policies. A number of insurers, however, could not provide the requested data due to the lack of comprehensive databases on their universal life policies. Other insurers had existing databases, but considered the requested data to be proprietary.

Nevertheless, use of this insurer's universal life insurance data is not expected to bias the results for the following reasons. First, the sampled insurer is relatively large, being among the top 40 life insurers and among the top 20 stock life insurers based on life insurance in force. Second, the sampled insurer's universal life policy features are reasonably representative of the policies being offered by other insurers and its policy is approved in all states. Hence, although only one insurer is represented, the behavior of policyholders across the U.S. is reflected in the cash flows. Several other insurance cash flow studies have been forced to rely on data from one insurer (Schott, 1977; Berger, 1983). Finally, the sampled insurer's policy loan and surrender experience over the estimation period is generally equivalent to the experience in the industry.[5]

3.2 Exogenous Data

The exogenous economic data come from several government publications. The interest rate data represent the averages of weekly rates for each month of the observation period. The weekly rates are taken from *U.S. Financial Data*, which is published by the Federal Reserve Bank of St. Louis. The data for unemployment and earnings are taken from *Employment and Earnings*, and the data for inflation are taken from *CPI Detailed Report*, both published by the U.S. Department of Labor, Bureau of Labor Statistics. Finally, the data for the consumer interest rate and the change in the money supply (M1) are taken from the *Federal Reserve Bulletin*, published by the Federal Reserve Board. The data variables considered in the study are presented in Table 2.

[5]In 1985 the industry surrender rate was 12.3 percent while the surrender rate for the sampled insurer was 14.8 percent. The percentage of assets in policy loans for the industry in 1985 was 6.6 percent and for the sampled insurer the figure was 7.9 percent. For the sampled insurer the percentage of universal life insurance in force in 1985 relative to ordinary life insurance was 6.2 percent. The comparable figure for the industry was 8.9 percent.

4 Empirical Estimation Procedure

The first step in the estimation procedure is to determine a set of input or independent variables that can be justified as predictors of the insurance cash flow variable being considered. Second, the correlations between the various independent variables and the cash flow variables are examined to determine whether the correlations confirm the expectations identified in Table 1 and to gain some insight into the predictive power of the individual independent variables. Also, evaluation of the correlation matrix allows an initial assessment of how severe potential problems of multicollinearity may be.[6]

Third, the ridge trace plots are calculated for the set of independent variables to determine which variables appear to have coefficients that stabilize quickly and are nonzero. The ridge trace for each independent variable is calculated using the procedure RIDGEREG in the SAS statistical package.[7] The results indicate a subset of variables that should be considered for elimination from the model, specifically, those that have either unstable or zero coefficients.

Fourth, ridge regression is used to allow estimation of the coefficients without the negative and confounding influences introduced by multicollinearity, which is present in most of the estimations. Ridge regression achieves this by adding small positive amounts to the diagonal of the $X'X$ matrix.[8] This produces biased regression estimates but can reduce the mean standard error. A discussion of ridge regression is found in Hoerl and Kennard (1970a, 1970b, 1976).[9]

In applying the regression analysis, backward elimination and forward stepwise regression are used. The ridge regression model is compared against the same model estimated by ordinary least squares (OLS) regression. This comparison permits assessment of the impact, if any, that multicollinearity has on the estimation. If the results are not greatly different, the OLS regression model is preferred due to the unbiased-

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[6]*Multicollinearity* refers to the mathematical estimation problems associated with estimating parameters in a regression model in the presence of high levels of cross-correlation between independent variables. Multicollinearity is not necessarily a problem if the sole purpose of the regression model is prediction of the dependent variable.

[7]*SAS* Version 5.18. Cary, N.C.: SAS Institute, Inc., 1986.

[8]Here X' denotes the transpose of the matrix X.

[9]An alternative procedure for the estimation of the models in the presence of multicollinearity would be principal components analysis. Principal components analysis has the advantage over ridge regression of producing unbiased estimators. Unfortunately, the calculation in principal components analysis makes the results difficult to interpret because the estimator is a mixture of all of the original coefficients. Greene (1993: 273) points out that it is unlikely that these combinations can be interpreted in any meaningful way.

ness of OLS regression estimates. During the ridge regression analysis, the RP-criterion, which is developed in Erickson (1981), also is evaluated to assess the appropriateness of the model.[10]

Finally, the residuals from the regression model are analyzed. The residuals are evaluated to determine if any nonstochastic trend is present over time. Also, the residuals are checked for heteroscedasticity[11] and to assess whether higher order terms of the independent variables are indicated. Appropriate adjustments are made if any violations of the model assumptions are identified from the residual analysis.

Schott (1977) points out that one potential problem with cash flow analysis is the need to forecast values for the independent variables in order to obtain estimates of the cash flow variable. After some comparative analysis of the regressions, it is determined that this potential problem can be addressed by lagging the input variables at a small cost in loss of predictive power. Therefore, as indicated by the $(t-1)$ subscripts on most of the input variables, the majority of the input series are lagged one month.

Insurers have an interest in estimating insurance cash flows, but they also care about identifying the specific factors that influence these cash flows. Identifying these specific factors is important as part of the product development process. As a result of this twofold interest by insurers, the best model identified is the model that explains the greatest amount of variation, as measured by R^2, and in which the independent variables are each statistically significant.

Extrapolation of regression results beyond the range of estimation should be done with caution. This includes applying the results estimated below without modification to other time periods or to other insurers. The analysis has been framed in the context of the general hypotheses (emergency fund, inflation/rising prices, alternative funds) to increase the likelihood that the results will be relevant to insurers in general. The results below give insurers some direction in identifying the factors that are likely to impact insurance cash flows and demonstrate the mechanics of the regression modeling procedure.

[10]The optimal model has the minimum ridge prediction (RP) value.

[11]*Heteroscedasticity* refers to the problems generated in regression analysis when the variance of the residuals is not constant. Specifically, in several of the models various variance-stabilizing transformations of the dependent variable are utilized. These include square root, log, and inverse transformations.

5 Parameter Estimation for the Cash Flow Models

5.1 Estimated Cash Flow Models for Premiums

The best model identified for NEWPREM, the aggregate flow of premiums from policyholders purchasing new policies, results from regressing ln(NEWPREM) on the input variables BAA, INFLATE, UNEMPLOY, and SPREAD1.[12] The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here.[13] The model is:

$$\begin{aligned} log(\text{NEWPREM}_t) \quad = \quad & 18.7 - 0.461 \times \text{BAA}_{t-1} \\ & + 0.645 \times \text{INFLATE}_{t-1} \\ & - 0.157 \times \text{UNEMPLOY}_{t-1} \\ & + 0.277 \times \text{SPREAD1}_{t-1} \end{aligned} \qquad (1)$$

with coefficient of determination: $R^2 = 0.732$.[14]

As anticipated, new premium flows are sensitive to the yield premium available for investing dollars in a universal life policy as opposed to other options. This is supported by the positive sign on SPREAD1 and conforms with the expectations of the arbitrage/yield spread hypothesis. The negative sign on UNEMPLOY indicates that increases in unemployment could be expected to reduce the amount of new premiums paid, which supports the emergency fund hypothesis. The single input

[12]The specific variables that appear in the model, BAA versus AAA or SPREAD1 versus SPREAD2, are less important than the broader hypotheses that the specific variables represent because the specific variables are likely to be sensitive to the time period under study. Some previous studies of insurance cash flows, such as Carson and Hoyt (1992), specify the models in terms of changes rather than levels of the dependent variable. In addition, various studies have used constructs known as stock adjustment models. Carson and Hoyt report that the results of the estimation are not altered significantly by the choice of changes versus levels. Also, the coefficients on the stock adjustment construct in their model for policy loans indicate that the stock adjustment framework is not statistically significant. The purpose of the present paper is to evaluate various hypotheses while providing models that can serve to predict the insurance cash flows. It seems that predicting the level of cash flows would be the most useful to practicing actuaries. Therefore, the models are estimated in terms of levels of cash flows instead of changes. Reference to stock adjustment models can be found in Carson and Hoyt (1992, p. 246).

[13]The values in parentheses for the OLS regression models are the t-statistics. Values of 2.00 or greater are statistically significant at no less than the 0.05 level. For the ridge regression models, the values cannot be considered to have a t-distribution due to the biased nature of ridge regression. They can be interpreted in a similar fashion, however, with values above 2.00 suggesting statistically significant relationship.

[14]Throughout this paper, all figures are presented to three significant digits. Small or large numbers are reported using scientific notation.

variable with the most predictive power is BAA. In accordance with the alternative funds hypothesis, the coefficient on this variable is negative which suggests that as money stocks tighten, fewer funds would be used to purchase universal life policies. The positive coefficient on INFLATE seems to suggest that as inflation increases, individuals perceive a need for increased insurance. In reaction to this perception, they increase their nominal purchases of insurance. This increased demand leads to an increase in nominal premium cash flows as inflation rises. This is consistent with the real protection hypothesis.

The best model identified for REPPREM, the aggregate flow of premiums paid by cash values transferred from replacement of old policies (non-universal life policies), results from regressing REPPREM on the input variables BAA, INFLATE, UNEMPLOY, and SPREAD2. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\begin{aligned} \text{REPPREM}_t \quad = \quad & 7.52 \times 10^5 - 3.09 \times 10^4 \times \text{BAA}_{t-1} \\ & + 8.56 \times 10^4 \times \text{INFLATE}_{t-1} \\ & - 3.51 \times 10^4 \times \text{UNEMPLOY}_{t-1} \\ & + 4.52 \times 10^4 \times \text{SPREAD2}_{t-1} \end{aligned} \tag{2}$$

with coefficient of determination: $R^2 = 0.698$.

The results for REPPREM are similar to those for NEWPREM. But there are some differences. First, SPREAD2 replaces SPREAD1 and is somewhat more significant in the model for replacement premium flows. The replacement of SPREAD1 by SPREAD2 is probably not especially important. SPREAD1 is the spread between the credited rate and the yield on CDs, while SPREAD2 is the spread between the credited rate and the 90 day T-bill rate. One interpretation may be that individuals considering new policy purchases are interested in the competitiveness of the policy relative to alternative investments such as CDs. On the other hand, individuals considering replacement of currently held policies are interested in the attractiveness of the policy relative to the risk-free rate in the market.

Second, a comparison of the elasticities with respect to each of the predictor variables suggests the following about the differences between the estimated equations for NEWPREM and REPPREM. The elasticities for INFLATE, UNEMPLOY, and the spread variables are relatively similar between the two equations which suggests little difference in the sensitivity of NEWPREM and REPPREM to these three predictors.

The elasticities for BAA differ substantially between the two equations. The elasticity of NEWPREM with respect to BAA is 3.7, while the similar figure for REPPREM is only 1.2. This seems to suggest that the relative availability of money stocks (alternative funds hypothesis) has less of an impact on the decision to replace an existing policy than it does on the decision to purchase a new universal life policy.

The best model identified for RENPREM, the aggregate flow of premiums paid on existing policies, results from regressing REPPREM on the input variables BAA, INFLATE, UNEMPLOY, and SPREAD2. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\begin{aligned} \text{RENPREM}_t \quad = \quad & 3.01 \times 10^3 - 1.07 \times 10^2 \times \text{BAA}_{t-1} \\ & + 60.0 \times \text{INFLATE}_{t-1} \\ & - 1.25 \times 10^2 \times \text{UNEMPLOY}_{t-1} \end{aligned} \tag{3}$$

with coefficient of determination: $R^2 = 0.925$.

The major difference between the model for RENPREM and the models for NEWPREM and REPPREM is the absence of an interest rate spread variable in the expression for RENPREM. This difference suggests that a certain amount of inertia exists with regard to the payment of renewal premiums. That is, a change in the level of the credited rate relative to the yield available on alternative investments does not have as great an impact on the decision of existing policyholders to make premium payments as it does on the decision of potential policyholders to purchase a universal life policy.

Finally, several additional variables related to premium flows are analyzed. These include NISSUES, the number of new policies issued, and NPAY, the number of premium payments made on existing policies. The best model identified for NISSUES regresses NISSUES on the input variables BAA, INFLATE, UNEMPLOY, and SPREAD2. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\begin{aligned} \text{NISSUES}_t \quad = \quad & 1.01 \times 10^2 - 5.50 \times \text{BAA}_{t-1} \\ & + 5.39 \times \text{INFLATE}_{t-1} \\ & - 1.77 \times \text{UNEMPLOY}_{t-1} \\ & + 2.25 \times \text{SPREAD2}_{t-1} \end{aligned} \tag{4}$$

with coefficient of determination: $R^2 = 0.882$.

The results of the regression are similar to those for NEWPREM and REPPREM. Specifically, the spread between the credited interest rate on the universal life policy and the yield on alternative investments has a statistically significant impact on the number of new policies issued, as well as on the total amount of premium received on new policies.

The best model identified for NPAY results from regressing NPAY on the input variables BAA and UNEMPLOY. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\text{NPAY}_t = 3.00 \times 10^2 - 11.9 \times \text{BAA}_{t-1} - 11.0 \times \text{UNEMPLOY}_{t-1} \quad (5)$$

with coefficient of determination: $R^2 = 0.956$.

The results of the regression are similar to those for RENPREM. Interestingly, the spread between the credited interest rate on the universal life policy and the yield on alternative investments does not have a statistically significant impact on the number of premiums paid on existing policies, nor does the spread have a significant impact on the total amount of premium received on existing policies.

The absence of INFLATE as a predictor in the model for NPAY seems to lend some support to the earlier interpretation of the inflation variable in the premium flow models. That is, the positive coefficient on INFLATE in the premium flow models suggests that increased inflation causes policyholders to recognize a need for increased nominal amounts of insurance. In reaction to this, they increase the amount of premium payments. An increase in the number of payments, however, would not necessarily be expected. Again, this result is consistent with the real protection hypothesis.

5.2 Estimated Cash Flow Models for Policy Loans

The best model identified for LNREPAY, the aggregate amount of existing policy loans that are repaid, results from regressing LNREPAY on the input variables TLOAN and EARN. Due to the high cross correlation (r) between the input variables ($r = 0.795$), the results of the ridge regression are reported here. The model is:

$$\begin{aligned} \text{LNREPAY}_t &= -6.06 \times 10^2 + 2.23 \times \text{EARN}_{t-1} \\ &\quad + 9.97 \times 10^{-5} \times \text{TLOAN}_{t-1}. \end{aligned} \quad (6)$$

Bias parameter: $k = 0.0053$;
Coefficient of determination: $R^2 = 0.946$; and
Ridge prediction criterion: RP = 72.58.

As anticipated, policy loan repayments are related positively to level of earnings, EARN, confirming the emergency fund hypothesis. Although UNEMPLOY had the expected sign, it was not significant, given

EARN is already in the model. Particularly noteworthy is the fact that the spread between market interest rates and LOANRATE is not a significant predictor in the regression. This probably is a result of the fact that the universal life policy being considered here is not loan tolerant. Specifically, policy loans reduce credited interest earnings on the portion of the policy cash value supporting the loan to only the guaranteed rate. This apparently reduces the significance of any arbitrage potential. This result contrasts with the findings of previous researchers for whole life policies which traditionally have used a fixed loan rate (Schott, 1971; Cummins, 1975; Bykerk and Thompson, 1979). The result is consistent, however, with the findings of Carson and Hoyt (1992) for policy loan utilization in the 1980s.

The best model identified for NEWLOAN, the aggregate amount of new policy loans, results from regressing NEWLOAN on the input variables CASHVAL and INFLATE. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\begin{aligned} \text{NEWLOAN}_t &= -4.02 + 1.36 \times 10^{-5} \times \text{CASHVAL}_{t-1} \\ &\quad + 96.6 \times \text{INFLATE}_{t-1} \end{aligned} \tag{7}$$

with coefficient of determination: $R^2 = 0.717$.

The predictive power of the model is only slightly reduced by using the value of cash values lagged one month. Increases in the amount available to be borrowed, CASHVAL, increase the amount of new loans. In accordance with the rising prices/inflation hypothesis, an increase in the level of inflation increases the amount of new loans. Again, as seen with respect to loan repayments, the arbitrage variable is not significant in the model. This seems to further support the notion that the loan-intolerant nature of universal life reduces the potential for arbitrage gains through the exercise of the policy loan privilege.

The best model identified for TLOAN, the aggregate amount of outstanding policy loans, results from regressing TLOAN on the input variables CASHVAL, EARN, and SPREAD1. Due to the high cross correlation between the CASHVAL and EARN ($r = 0.887$), the results of the ridge regression are reported here. The model is:

$$\begin{aligned} \text{TLOAN}_t &= 2.46 \times 10^{6} + 4.59 \times 10^{-2} \times \text{CASHVAL}_{t-1} \\ &\quad - 8.99 \times 10^{3} \times \text{EARN}_{t-1} \\ &\quad - 1.61 \times 10^{4} \times \text{SPREAD1}_{t-1}. \end{aligned} \tag{8}$$

Bias parameter: $k = 5.60 \times 10^{-4}$;

Coefficient of determination: $R^2 = 0.985$; and
Ridge prediction criterion: $\text{RP} = 5.87 \times 10^8$.[15]

All of the input variables in the model have the expected signs. As observed with respect to the amount of new loans, increases in the amount available to be borrowed, CASHVAL, increase the amount of total loans outstanding. EARN, which is significant in describing the amount of loan repayments, is also significant in describing the amount of outstanding loans. Of special interest is the fact that SPREAD1 is significant in the model for total loans. Specifically, decreases in the yield spread between the credited rate and alternative investment returns increase the total amount of loans outstanding. That is, failure to maintain a competitive credited rate could lead to disintermediation through increased exercise of the policy loan privilege.

Interestingly, UNEMPLOY is not significant in any of the policy loan models. This is important in light of the prior findings and controversy surrounding the relationship between unemployment and policy loan utilization. Most previous studies find little correlation between unemployment and policy loan demand (Schott, 1971; Cummins, 1975; Bykerk and Thompson, 1979). The general opinion in the industry, however, is that policyholders use policy loans as a source of needed funds in periods of increased unemployment.

Even though the models identified here did not find UNEMPLOY to be a significant variable, some support for the emergency fund hypothesis is suggested. EARN is significant in the model for TLOAN, suggesting that reduced earnings may result in increased policy loans. Also, UNEMPLOY is a significant predictor of premium flows and, due to the discretionary nature of premium payments on a universal life policy, reduced premium payments may serve to replace some of the demand for increased policy loans.

5.3 Estimated Cash Flow Model for Surrenders

Because the total amount of net surrenders would be expected to increase with the increase in the amount of cash values available upon surrender, the actual output variable considered here is the ratio of net full surrenders (gross full surrenders less deduction of any surrender charges) to aggregate cash values.[16] The correlation of 0.754 between

[15]Note that RP cannot be compared across models. It only is used within a given estimation model to indicate optimal fit. For example, the best fit is obtained by minimizing RP. Here RP is large due to the units of measure for TLOAN.

[16]Data on partial surrenders also are available from the insurer in the study. Activity is reported in only 20 of the 39 months covered in the study. The paucity of partial

NETFULL and CASHVAL supports this conclusion. The best model identified for the ratio of NETFULL to CASHVAL results from regressing the reciprocal of this ratio on UNEMPLOY and UNEMPLOY2. The inverse of the output variable is used as a variance-stabilizing transformation. Also, initial plots of the residuals against UNEMPLOY suggest the need for the quadratic term. Due to the high cross correlation between the input variables ($r = 0.999$), the results of the ridge regression are reported here. The model is:

$$\left(\frac{\text{NETFULL}}{\text{CASHVAL}}\right)_t^{-1} = 3.91 \times 10^4 - 1.07 \times 10^4 \times \text{UNEMPLOY}_{t-1} + 7.31 \times 10^2 \times \text{UNEMPLOY2}_{t-1}. \qquad (9)$$

Bias parameter: $k = 2.00 \times 10^{-5}$;
Coefficient of determination: $R^2 = 0.717$; and
Ridge prediction criterion: $\text{RP} = 4.45 \times 10^4$.

Although the coefficient on UNEMPLOY is negative, this is consistent with the predicted positive relationship between unemployment and surrenders because the regression is performed on the inverse of the output variable. The positive coefficient on UNEMPLOY2 suggests a decreasing impact of changes in UNEMPLOY as the level of unemployment increases. These results support the emergency fund hypothesis.

5.4 Regression Model of Combined Insurance Cash Flows

To assess the impact of aggregating the individual cash flow equations above to form total insurance cash flows, a regression model is fitted to the historical data for insurance cash flows. Insurance cash flows at time t, INSCF_t, are defined as:

$$\begin{aligned}\text{INSCF}_t = \; & \text{TOTAL PREMIUMS} \\ & + \text{POLICY LOAN INCOME} \\ & - \text{NET INCREASES IN POLICY LOANS} \\ & - \text{DEATH BENEFITS} \\ & - \text{SURRENDER BENEFITS} \\ & - \text{EXPENSES \& COMMISSIONS} \\ & - \text{FEDERAL INCOME TAXES.}\end{aligned}$$

surrender activity makes a meaningful modeling of this cash flow impossible. Although it would be interesting to investigate the impact of the surrender charge on policy surrenders, the availability of data from only one insurer, coupled with the fact that the insurer did not vary its surrender charge specification during the period of the study, make this impossible.

The best model identified for INSCF results from regressing INSCF on the input variables BAA, UNEMPLOY, and SPREAD2. The results of the ridge regression are similar to the results using OLS regression, so the OLS model is reported here. The model is:

$$\begin{aligned}\text{INSCF}_t &= 3.34 \times 10^6 - 1.41 \times 10^5 \times \text{BAA}_{t-1} \\ &\quad - 1.34 \times 10^5 \times \text{UNEMPLOY}_{t-1} \\ &\quad + 6.55 \times 10^4 \times \text{SPREAD2}_{t-1} \end{aligned} \tag{10}$$

with coefficient of determination: $R^2 = 0.780$.

Two major results of this estimation are worth noting. First, the variable INFLATE is not present in the regression model for total insurance cash flows. In other words, it appears that inflation is not a significant predictor once death benefits, expenses, commissions, and so forth are netted out of insurance cash flows. This adds additional support to the earlier conclusion that policyholders adjust premium payments in order to maintain real levels of protection.

Second, the three predictors that are significant in the model, BAA, UNEMPLOY, and SPREAD2, are found in the premium flow models. This is not surprising because premium flows are the dominant component of total insurance cash flows. These findings support the alternative funds, emergency fund, and arbitrage/yield spread hypotheses as explanations for total insurance cash flows.

Table 3 provides a summary of the results of the various regression models estimated in the paper.

6 Summary and Conclusions

In this paper, several regression models for insurance cash flows on a universal life policy are developed. The models relate various theoretically justifiable input variables, both exogenous and endogenous, to the relevant cash flow or output variables. The results are theoretically consistent, but produce some interesting contrasts to findings of similar studies for whole life policies.

Several interesting results are found. First, not surprisingly, the credited rate strategy is important to policy performance. New and replacement premium flows are sensitive to the credited rate yield spread, as is the amount of total policy loans. Second, the emergency fund hypothesis appears to apply to policy loan utilization, premium payments, and total insurance cash flows. That is, increases in unemployment lead to decreased premium payments and increased surrenders, as well as

Table 3
Regression Model Results

Dependent Variable (Equation)	R^2	Intercept and Independent Variables (Sign of Coefficient) (Value of Coefficient's *t*-Statistic*)				
log(NEWPREM) Equation (1)	73.2%	18.7 (15.09)	BAA (-) (-4.33)	INFLATE (+) (3.19)	UNEMPLOY (-) (-2.32)	SPREAD1 (+) (3.15)
REPPREM Equation (2)	69.8%	7.51×10^5 (5.02)	BAA (-) (-2.57)	INFLATE (+) (3.49)	UNEMPLOY (-) (-4.62)	SPREAD2 (+) (3.94)
RENPREM Equation (3)	92.5%	3.01×10^3 (20.36)	BAA (-) (-9.25)	INFLATE (+) (2.01)	UNEMPLOY (-) (-15.48)	
NISSUES Equation (4)	88.2%	1.01×10^2 (12.98)	BAA (-) (-8.82)	INFLATE (+) (4.23)	UNEMPLOY (-) (-4.48)	SPREAD2 (+) (3.76)
NPAY Equation (5)	95.6%	3.00×10^2 (29.54)	BAA (-) (-15.38)	UNEMPLOY (-) (-18.82)		
LNREPAY Equation (6)	94.6%	-6.06×10^2 (-8.54)		EARN (+) (8.96)	TLOAN (+) (8.00)	
NEWLOAN Equation (7)	71.7%	-4.02 (-0.27)		CASHVAL (+) (9.24)	INFLATE (+) (4.06)	
TLOAN Equation (8)	98.5%	2.46×10^6 (8.37)		CASHVAL (+) (27.18)	EARN (-) (-8.53)	SPREAD1 (-) (-3.60)
$(\text{NTFULL/CASHVAL})^{-1}$ Equation (9)	94.0%	3.91×10^4 (9.14)		UNEMPLOY (-) (-9.67)	UNEMPLOY^2 (+) (10.62)	
INSCF Equation (10)	78.0%	3.34×10^6 (8.36)	BAA (-) (-4.45)	UNEMPLOY (-) (-6.29)	SPREAD2 (+) (2.04)	

*The t-statistics values in parentheses of 2.00 or greater are statistically significant at no less than the 0.05 level.

to decreased total insurance cash flows. Decreases in earnings lead to increased total policy loans. Third, the arbitrage potential with regard to policy loans is reduced. Direct recognition of policy loans seems to be effective in reducing the disintermediation risk that exist in traditional whole life insurance policies with fixed policy loan rates. Fourth, although policyholders do increase their use of policy loans as inflation increases, the overall results suggest that they tend to increase contributions to their universal life policies in order to maintain levels of protection in real terms. This provides support for the real protection hypothesis. Finally, interest rate risk does exist for companies issuing universal life because changes in market interest rates lead to decreases in premiums and in total insurance cash flows. This lends support to the alternative funds hypothesis.

References

ACLI. *Life Insurance Fact Book.* Washington, D.C.: American Council of Life Insurance, 1981-1994.

Berger, L.A. "Asset/Liability Management at Metropolitan Life." Seminar Paper, Wharton School, University of Pennsylvania (1983).

Bykerk, C.D. and Thompson, A.F. "Economic Analysis of the Policy Loan Privilege." *Transactions of the Society of Actuaries* 31 (1979): 261-281.

Cargill, T.F. and Troxel, T.E. "Modeling Life Insurance Savings: Some Methodological Issues." *Journal of Risk and Insurance* 46, no. 3 (1979): 391-410.

Carson, J.M. and Hoyt, R.E. "An Econometric Analysis of the Demand for Life Insurance Policy Loans." *Journal of Risk and Insurance* 59, no. 2 (1992): 239-251.

Cummins, J.D. *An Econometric Model of the Life Insurance Sector of the U.S. Economy.* Lexington, Mass.: Lexington Books, 1975.

Curry, T. and Warshawsky, M. "Life Insurance Companies in a Changing Environment." *Federal Reserve Bulletin* 72, no. 7 (1986): 449-460.

Day, A.E. and Hendershott, P.H. "Household Demand for Policy Loans." *Journal of Risk and Insurance* 44, no. 3 (1977): 411-423.

Erickson, G.M. "Using Ridge Regression to Estimate Directly Lagged Effects in Marketing." *Journal of American Statistical Association* 76, no. 376 (1981): 766-773.

Federal Trade Commission. *Life Insurance Cost Disclosure.* Washington, D.C.: U.S. Government Printing Office, 1979.

Fortune, P. "Inflation and Saving Through Life Insurance: Comment." *Journal of Risk and Insurance* 39, no. 2 (1972): 317-326.

Greene, W.H. *Econometric Analysis.* Second Edition. Toronto: MacMillan Publishing Company, 1993.

Hoerl, A.E. and Kennard, R.W. "Ridge Regression: Applications to Non-orthogonal Problems." *Technometrics* 12, no. 1 (1970a): 69-82.

Hoerl, A.E. and Kennard, R.W. "Ridge Regression: Biased Estimation for Nonorthogonal Problems." *Technometrics* 12, no. 1 (1970b): 55-67.

Hoerl, A.E. and Kennard, R.W. "Ridge Regression: Iterative Estimation of the Biasing Parameter." *Communications in Statistics* A5, no. 1 (1976): 77-78.

Houston, D.B. "The Effects of Inflation on Life Insurance." *California Management Review* 2, no. 2 (1960): 76-79.

Neumann, S. "Inflation and Sales of Life Insurance: Comments." *Journal of Risk and Insurance* 35, no. 4 (1968): 629-635.

Outreville, J.F. "Whole-Life Insurance Lapse Rates and the Emergency Fund Hypothesis." *Insurance Mathematics and Economics* 9, no. 3 (1990): 249-255.

Pesando, J.E. "The Interest Sensitivity of the Flow of Funds through Life Insurance Companies: An Econometric Analysis." *Journal of Finance* 29, no. 4 (1974): 1105- 1121.

Rejda, G.E. "Life Insurance Policy Loans: The Emergency Fund Concept: Comment." *Journal of Risk and Insurance* 33, no. 2 (1966): 317-321.

Schott, F.H. "Cash Flow and Cash Flow Forecasting in the Life Insurance Industry." *Investment Activities of Life Insurance Companies*, Huebner Foundation Lectures (1977): 223-247.

Schott, F.H. "Disintermediation Through Policy Loans at Life Insurance Companies." *Journal of Finance* 26, no. 3 (1971): 719-729.

Wood, G.L. "Life Insurance Policy Loans: The Emergency Fund Concept." *Journal of Risk and Insurance* 31, no. 3 (1964): 411-420.