行政院國家科學委員會補助專題研究計畫成果報告

※※※※※※※※※※※※※※※※※※※※※※※※※
※　　　　　　　　　　　　　　　　　　　　　　　　※
※　　　　　資產負債管理之模型風險分析　　　　　※
※　　　　　　　　　　　　　　　　　　　　　　　　※
※※※※※※※※※※※※※※※※※※※※※※※※※

計畫類別：□個別型計畫　　□整合型計畫

計畫編號：NSC　90-2416H-004-011

執行期間：　90 年　8 月 01 日至　91 年 7 月 31 日

計畫主持人：王儷玲

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份

□赴大陸地區出差或研習心得報告一份

□出席國際學術會議心得報告及發表之論文各一份

□國際合作研究計畫國外研究報告書一份

執行單位：　國立政治大學風險管理與保險學系

中　華　民　國　91　年　12　月　18　日

中文摘要

在保險公司的經營管理中，利率風險是影響公司財務健全非常重要的因素，為了避免利率風險，資產負債管理經理人經常採用傳統的免疫理論來降低此風險。然而傳統免疫理論模型假設利率是平行移動的，而後續研究文獻已將傳統免疫理論模型推廣到利率變動是一個隨機過程。然而，過去的文獻並未考慮由於利率的期間結構可能遵循不同的模型，因此保險公司在作資產負債管理時將可能面臨模型風險。本研究探討在不同利率期間結構模型下保險公司免疫策略的不同，更進一步以模擬分析方式衡量保險公司模型風險的可能損失。我們的模擬分析結果顯示，忽略模型風險的重要性將使保公司錯估淨值，因此也會造成公司資產與負債期間的錯置(mismatch)，如此將對保險公司的淨值造成重大衝擊。我們發現當利率變異性較高、長期利率水準較低以及利率回速率(drift rate)較低時，保險公司的模型風險較高。另外，模擬分析結果也顯示不管是短期或長期的財務規畫，都不應該忽略模型風險的重要性。

關鍵詞 ：資產負債管理、免疫理論、利率風險、模型風險

I. Abstract

It is well known that insurance companies can adopt a so-called classical immunization strategy to hedge the interest rate risk against a firm's surplus. With certain adjustments, this strategy has been proven to be applicable even when the interest rate is under a stochastic process. However, the literature has recognized various models for interest rate and has proposed different interest rate paths under alternative models. This paper explores and measures the model risks for surplus management in an insurance company. We show that mismodeling the interest rate could not only misevaluate a firm's surplus but could also cause the mismatch of a firm's assets and liabilities and further create a negative shock on the firm's surplus. The results of our simulation demonstrate that the cost of failing to recognize model risks can be extremely high. Furthermore, we find that a high volatility in the interest rate, a low level of long-term interest rate, and a low momentum in the drift rate increase the model risks for surplus management. Our simulation results also suggest that asset-liability managers should not ignore the possible impacts of the model risks no matter when they undertake short-term or long-term financial planning.

Keywords: asset and liability management, immunization strategy, interest rate risk, model risk

II. Introduction and Research Purpose

The so-called classical immunization strategy, setting the duration of assets equal to the asset/liability ratio times the duration of liabilities, has been generally suggested by the literature (Bierwag, 1987; Grove, 1974; and Reitano, 1992) for immunizing interest rate risk against the surplus of an insurance company. Bellhouse and Panjer (1981), Beekman and Fuelling (1990), Frees (1990), Norberg (1995), and Lai and Frees (1995) explore the impact of stochastic interest rates on the reserves of life insurance. On the other hand, Briys and Varenne (1997) and Tzeng, Wang, and Soo (2000) have extended the traditional duration-approach to address the case where the interest rate follows a stochastic process. Tzeng, Wang, and Soo (2000) show that, with certain adjustments, the classical immunization strategy can still be applied for surplus management under stochastic processes for insurance companies. Although this line of research has provided some insightful strategies for asset-liability management of insurance companies, most papers focus on the change in interest rates but overlook the cost of mismodeling the process of interest rates.

Many previous studies have characterized the stochastic behavior of the interest rate. Vasicek (1977) recognized the mean-reverting of the interest-rate change. Cox, Ingersoll, and Ross (1985) further alleged that interest rate volatility is proportional to the level of the interest rate. In addition, many other models—such as those of Dothan and Feldman (1986); Ho and Lee (1986); Chan et al. (1992); and Heath, Jarrow, and Morton (1992)—have also provided alternative models for explaining the nature of interest rate processes. These early studies recognized varied models for interest rates and proposed the differences in interest rate paths under alternative models.

This paper first identifies model risks in surplus management of an insurance company. By adopting the two most commonly used interest rate models—Vasicek (1977) and Cox, Ingersoll, and Ross (1985)—we measure the cost of model risks in two ways: miscalculation of a firm's value and mismatch of a firm's assets and liabilities. Using simulation, we demonstrate that mismodeling the interest rate not only causes an insurance company to misevaluate a firm's surplus but also could mismatch a firm's assets and liabilities and further create a negative shock on the firm's surplus. Furthermore, we show that the cost of failing to recognize model risks can be extremely high.

III. Empirical Findings and Conclusion

This paper identifies model risks against an insurance company's surplus by comparing two commonly used interest rate models—Vasicek (1977) and Cox, Ingersoll, and Ross (1985).

In the first part of simulation, we compare the differences in parameters between Vasicek (1977) and Cox, Ingersoll, and Ross (1985). We find that differences in parameters between these two interest rate models are higher when the long-term interest rate level is low, the volatility of the interest rate is high, and the momentum of the drift rate is low. In other words, a low level of the long-term interest rate, high volatility of the interest rate, and low momentum of the drift rate increase the model risks. However, we do not have a conclusive finding with respect to an increase in the time horizon. Thus, managers in insurance companies should not ignore the possible impact of the model risks whether they are engaged in short-term or long-term financial planning.

In the second part of the simulation, we evaluate the cost of mismodeling. We measure the costs of model risks in two ways: miscalculation of the firm's value and mismatch of the firm's assets and liabilities. The result of the simulation demonstrates that failing to recognize the model risks could cause substantial misevaluation of the firm's assets and liabilities. In addition, the simulation results also show that mismodeling could causes a mismatch of the firm's assets and liabilities and exposes the firm's surplus to interest-rate risk. The results further show that the cost of failing to recognize model risks can be extremely high. Because of mismodeling, misevaluation could cause about a 9.3% negative shock on a firm's surplus, while a mismatch of a firm's assets and liabilities could also cause at least a one-percent fluctuation by one percentage change in the interest rate.

IV. References

Babbel, David F., C. B .Merril, and W. Planning. "Default Risk and the Effective Duration of Bonds." Financial Analysts Journal 53 (1997): 35-44.

Barber, Joel R., and Mark L. Copper. "Is Bond Convexity a Free Lunch?" The Journal of Portfolio Management, Fall 1997: 113-19.

Barney, L. Dwayne. "The Relation Between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry: Comment." The Journal of Risk and Insurance 64 (1997): 733-38.

Becker, David N. "A Generalized Profit Released Model fro the Measurement of the Return on Investment for Life Insurance." Transaction of the Society of Actuaries 40 (1988): 61-114.

Beekman, J. A., and C. P. Fuelling. "Interest and Mortality Randomness in Some Annuities." Insurance: Mathematics and Economics 9 (1990): 185-196.

Bellhouse, D. R., and H. H. Panjer. "Stochastic Modeling of Interest Rates with Applications to Life Contingencies—Part II." Journal of Risk and Insurance 48 (1981): 275-287.

Bierwag, Gerald O. "Duration and the Term Structure of Interest Rate." The Journal of Financial and Quantitative Analysis 12 (1977): 725-42.

-------. Duration Analysis: Managing Interest Rate Risk. Cambridge, MA: Ballinger Publishing Company, 1987.

Bierwag, Gerald O., Charles J. Corrado, and George G. Kaufman. "Duration for Portfolios of Bonds Priced on Different Term Structures." Journal of Banking and Finance 16 (1992): 705-14.

Bierwag, Gerald O., George G. Kaufman, and A. Toevs. "Bond Portfolios Immunization and Stochastic Process Risk." Journal of Bank Research, Winter 1993: 282-91.

Bierwag, Gerald O., Iraj Fooladi, and Gordon S. Roberts. "Designing an Immunized Portfolio: Is M-squared the Key?" Journal of Banking and Finance 17 (1993): 1147-70.

Briys, Eric, and Francois de Varenne. "On the Risk of Life Insurance Liabilities: Debunking Some Common Pitfalls." The Journal of Risk and Insurance 64 (1997): 673-94.

Chan, K.C., G. Andrew Karolyi, Francis A. Longstaff, and Anthony B. Sanders. "An Empirical Comparison of Alternative Models of the Short-Term Interest Rate." The Journal of Finance 47 (1992): 1209-27.

Christensen, Peter Ove, and Bjarne G. Sorensen. "Duration, Convexity, and Time Value." The Journal of Portfolio Management, Winter 1994: 51-60.

Cox, John C., Jonathan E. Ingersoll, and Stephen A. Ross. "Duration and the Measurement of Basis Risk." Journal of Business 52 (1979): 51-61.

-------. "A Re-Examination of Traditional Hypotheses About the Term Structure of Interest Rates." The Journal of Finance 36 (1981): 769-99.

-------. "A Theory of the Term Structure of Interest Rates." Econometrica 53 (1985): 385-407.

Dothan, L. Uri. "On the Term Structure of Interest Rates." Journal of Financial Economics 6 (1978): 59-69.

Dothan, Michael U., and David Feldman. "Equilibrium Interest Rates and Multiperiod Bond in a Partially Observable Economy." The Journal of Finance 41 (1986): 369-82.

Douglas, L. G. "Bond Risk Analysis: A Guide to Duration and Convexity." New York: New York Institute of Finance, 1990.

Fong, H. Gifford, and Oldrich A. Vasicek. "A Risk-Minimizing Strategy for Portfolio Immunization." The Journal of Finance 39 (1984): 1541-46.
Frees, E. W. "Stochastic Life Contingencies with Solvency Considerations." Transactions of the Society Actuaries, 42 (1990): 91-129.
Gagnon, Louis, and Lewis D. Johnson. "Dynamic Immunization Under Stochastic Interest Rates." The Journal of Portfolio Management, Spring 1994: 48-54.
Grove, M. A. "On Duration and Optimal Maturity Structure of the Balance Sheet." Bell Journal of Economics and Management Sciences 5 (1974): 696-709.
Heath, D. C., Robert A. Jarrow, and Andrew Morton. "Bond Pricing and the Term Structure of Interest Rates: A New Methodology for Contingent Claims Valuation." Econometrica 60 (1992): 77-105.
Ho, Thomas S., and Sang Bin Lee. "Term Structure Movements and Pricing Interest Rate Contingent Claims." The Journal of Finance 41 (1986): 1011-29.
Ingersoll, Jonathan E., Jr., and Stephen A. Ross. "Waiting to Invest: Investment and Uncertainty." Journal of Business 65 (1992): 1-29.
Lai, S. L., and E. W. Frees. "Examining Changes in Reserves Using Stochastic Interest Models." Journal of Risk and Insurance 62 (1995): 535-574.
Lee, Sang Bin, and He Youn Cho. "A Rebalancing Discipline for an Immunization Strategy." The Journal of Portfolio Management, Summer 1992: 56-62.
Moller, Christian Max. "Duration, Convexity, and Time Value." The Journal of Portfolio Management, Winter 1994: 51-60.
-------. "A Counting Process Approach to Stochastic Interest Rate." Insurance: Mathematics and Economics 17 (1995): 181-92.
Norberg, G. "A Continuous-Time Markov Chain Interest Model with Applications to Insurance." Journal of Applied Stochastic Models and Data analysis 11 (1995): 245-256.
Reitano, Robert R. "Non-Parallel Yield Curve Shifts and Spread Leverage." The Journal of Portfolio Management, Spring (1991): 82-87.
-------. "Non-Parallel Yield Curve Shifts and Immunization." The Journal of Portfolio Management, Spring (1992): 36-43.
-------. "Non-Parallel Yield Curve Shifts and Stochastic Immunization." The Journal of Portfolio Management 22 (1996): 71-78.
Staking, Kim B., and David F. Babble. "The Relation Between Capital Structure, Interest Rate Sensitivity, and Market Value in the Property-Liability Insurance Industry." The Journal of Risk and Insurance 62 (1995): 690-718.
Tzeng, Wang, and Soo. "Surplus Management under a Stochastic Process." Journal of Risk and Insurance 67 (2000): 451-62.
Vasicek, Oldrich. "An Equilibrium Characterization of the Term Structure." The Journal of Financial Economics 5 (1977): 177-88.
Vetzal, Kenneth R. "A Survey of Stochastic Continuous Time Models of the Term Structure of Interest Rates." Insurance: Mathematics and Economics 14 (1994): 139-61.
Zenios, S. A., M. R. Holmer, R. Mckendall and C. Vassiadouzeniou. "Dynamic Models for Fixed-Income Portfolio Management Under Uncertainty." Journal of Economic Dynamics and Control 22 (1998): 1517-41.