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Dynamic risk management of the lending rate policy of an interacted portfolio of loans via an investment strategy into a discrete stochastic framework

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Abstract

Lending rate policy via an appropriate investment strategy for an interacted portfolio of loans into discrete stochastic framework is examined in this paper. A bank optimization model with several control variables, stochastic inputs and a smoothness criterion described by a quadratic functional is proposed for managing the task. The state variable of the system corresponds to the accumulated surplus profit or loss can oscillates deliberately absorbing fluctuations in the different parameters involved. The theoretical model is solved using standard linearization and advanced stochastic optimization techniques resulting in analytic formulae for the control variables. These solutions are actually feedback mechanisms of the past accumulated surplus profit or loss of each sub-portfolio of loans. At the end, a numerical application is presented deriving a smooth solution for the development of the controllers.
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1. Introduction

In recent years, more and more financial institutions have devoted important resources to manage in an appropriate way their lending rate policy for the different portfolios of loan in an effort to maximize profits, and to mitigate the ill effects of allocation inefficiency that may arise from changes in international, national and local economic and business conditions, changes in the trend, volume and severity of past due loans and loans graded as low quality, changes in the experience, ability, and depth of lending management and staff, changes in the credit risk profile of the loan portfolio as a whole etc, see Bank for International Settlements (2006). In a parallel direction, the Federal Reserve Board (2006) claims that ensuring stronger capital levels and good risk management at the banking organizations are critical to the health of the banking and financing system. The respective literature for optimal loan models considering default-risk and asset portfolios is very rich. A brief presentation of the most important papers is provided in the next paragraphs.

Sealey (1980) presents a model of the depository financial intermediary under uncertainty, where its distinguishing characteristics are the *deposit rate-setting behaviour*, *resources costs*, and *non-linear risk preferences*. It is obvious that the

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above parameters involved play a crucial role in determining the optimal loan portfolios and deposit rate decisions. Ho and Saunders's (1981) paper showed that the *intermediation margin* depends on four important factors: the degree of managerial risk aversion; the size of transactions undertaken by the bank; the bank market structure; and the variance of interest rates. Furthermore, the major implications of Slovin and Sushka's (1983) research work are that the commercial lending rates are primarily a function of open market interest rates and under normal conditions the settings of the loans are dichotomized from conditions in deposit markets. Few years later, Allen (1988) expands Ho and Saunders's (1981) model by showing that the pure interest rate spreads may be reduced when *cross-elasticities* of demand between bank products are considered. Among Zarruk's (1989), and Zarruk and Madura's (1992) findings are that the changes of bank capital, bank capital requirements and deposits as well, lead to the analogous changes of intermediation margin, and unrelated changes in borrowing and lending margins, respectively. Wong (1996) explores the determinants of optimal bank interest margins by constructing a simple firm — theoretical model under multiple sources of uncertainty and risk aversion. He comes to the conclusion that *the bank interest margin is positively related to the bank's market power to the operational costs, to the degree of credit risk, and to the degree of interest-rate risk*. Angbazo (1997) empirically confirms that banks with more risky loans and higher interest-rate risk exposure would select loan and deposit rates in order to achieve higher net interest margins. Additionally, Nakamura et al. (2001) propose a stochastic model which evaluates quantitively the expected cost, including the costs for bankruptcy and mortgage collection, and they discuss the adequate lending rate analytically and numerically. Finally, Machauer and Weber (1998) provide sufficient evidence for the relation between the loan terms and the risk that borrowers are willing to take. Analyzing data from five leading German banks, they found that *lending rate premiums and lines of credit are related to borrower credit ratings while collateral showed no clear relation*.

Quite recently, in Edelstein and Urosevic's (2003) research work, the optimal lending rate contracts under the conditions of risky, symmetric information for multi-period (dynamic) models is analyzed. According to their work, the optimal lending rate depends on the *volatility*, and *co-variation* among the market interest rate, borrower collateral, and income, as well as the time horizon and the risk preferences of lenders and borrowers. Moreover, Stanhouse and Stock (2004) take into consideration the determination of optimal loan and deposit rates, as well as the phenomenon of loan prepayments and deposit withdrawals.

Furthermore, the bank institution managers should be compensated with the risk that borrowers are not always consistent with their repayments. It is obvious that loans are priced according to the involved risks, and the capital profits that the management desires. However the most recent time period a contradictory question is always being raised about whether the financial institutions should provide *cheap* loans in order to attract more customers for other profitable business or not. Something really interesting has been shown by Fried and Howitt (1980), and Petersen and Rajan (1995). They showed that the welfare is enhanced by smoothing of lending rates in relation to borrower risk and market interest rates.

In this paper, the main contribution is to introduce and develop a general stochastic discrete-time, large-scale model for managing the lending rate policy for different sub-portfolios of loans in a way that financial institution managers are seeking for. Thus, the paper connects the lending rate policy of an interacted portfolio of loans with discrete stochastic control theory. Although optimal control theory was developed by engineers to investigate the properties of dynamic systems of difference or differential equations, it has also applied to financial problems. Nowadays with the vast developments in computer science, more and more large-scale macroeconomic models were being developed and widely used for forecasting and policy analysis. Moreover, if we take also into consideration these developments and the important theoretical tools, such as stochastic dynamic programming, the linear quadratic programming, the state feedback controllers etc., the introduction of the control theory into the economic systems began a much more attractive proposition. Tustin (1953) was the first to spot a possible analogy between the industrial and engineering processes and post-war macroeconomic policy-making (see Holly and Hallett, 1989, for further historical details). More recently, in the vast literature of banking, Jobst et al. (2006) develop a modeling paradigm which integrates credit risk and market risk in random dynamical framework and use multistage stochastic programming tools. From this point of view, a method of controlling over time some major variables is introduced buffering any kind of fluctuations, in order to absorb partially or completely the probable unexpectedness in micro- and/or macro-economic conditions, in external factors as competition, legal and regulatory requirements or other worsen random events. Moreover, the financial institution managers desire to keep the profit for the bank close to a specified trajectory.

Furthermore, since the bank has a certain total capacity for providing loans, and its customers are not always consistent with their repayments, at each time, a different amount is repaid through the installments. This amount is normally smaller, but at some exceptions may take values greater, as a consequence of borrowers paying with some time delay two, three or more installments to the bank. Moreover, the financial institution has to pay several kinds of operational expenses, to

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