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Critical Analysis of Stochastic Optimization Models with Reference to Assets and Liabilities Management

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ABSTRACT

Stochastic modelling is a form of financial model that is used to help make investment decisions. This type of modelling forecasts the probability of various outcomes under different conditions, using random variables. Stochastic modelling presents data and predicts outcomes that account for certain levels of unpredictability or randomness. Companies in many industries can employ stochastic modelling to improve their business practices and increase profitability. In the financial services sector, planners, analysts, and portfolio managers use stochastic modelling to manage their assets and liabilities and optimize their portfolios. The purpose of this research article is to provide a snapshot of the field of Asset Liability Management (ALM) from a theoretical and modelling perspective. Asset-Liability Management has grown considerably complex making use of advanced mathematical techniques and computation. Stochastic programming seems intuitively the best choice out of the available ALM techniques for strategic asset liability management. This approach helps in multi-period investment decisions, portfolio rebalancing and accommodating uncertainty by examining few economic states in he future. This study provides an overview of the evolution of ALM from the idea of asset-liability matching to sophisticated techniques like stochastic programming. This research study has given an insight to the new researchers and ALM practitioners in corporate finance and in other business entities to easily understand the application of the models used in asset liability management.

Keywords: Asset allocation, risk-integration, ALM models, duration, immunization, stochastic programming

Introduction

Stochastic Models, use lots of historical data to illustrate the likelihood of an event occurring, such as your client running out of money. These types of financial planning tools are therefore considered more sophisticated compared with their deterministic counterparts. A stochastic model will not produce one determined outcome, but a range of possible outcomes, this is particularly useful when helping a customer plan for their future. Stochastic models can reflect real-world economic scenarios that provide a range of possible outcomes your customer may experience and the relative likelihood of each. By running thousands of calculations, using many different estimates of future economic conditions, stochastic models predict a range of possible future investment results showing the potential upside and downsides of each. A stochastic model also has the ability to avoid the significant shortfalls inherent in deterministic models, which gives it the edge. Managing drawdown effectively and choosing suitable investment strategies requires the ability to model investment risk and return realistically. The problem is that nearly all strategies and solutions are currently designed using an assumed fixed rate of investment return throughout retirement. This is obviously unrealistic and ignores the important effect that the sequence of returns and volatility has on drawdown outcomes. The problem of ignoring specific risk factors not only applies with deterministic modellers, but also with a commonly used type of simple stochastic model - mean, variance, co-variance (MVC) models. For instance, MVC models provide time-independent forecasts, which means that they ignore the fact that specific investment risks change over time depending on the combination of assets held within the customer's portfolio.

Literature Review

The main aim of ALM is maintaining a structural balance with optimal investment in assets and temporal equilibrium in the balance sheet with a view to jointly evaluate risks and rewards associated with assets and liabilities and satisfying current and future goals. The traditional piece meal approach to management of risks on a stand-alone basis is no longer viewed as a healthy practice and hence there is a growing inclination towards managing risks in an integrated fashion (Rosen and Zenios, 2006). Asset-Liability Management addresses the risks arising due to mismatch in asset liability structure emanating from either difference in liquidity or changes in interest. In a narrower sense, it has been defined as the process that deals with interest rate risk management (John Brick, 2012) "The continuous process of formulating, implementing, monitoring and revising strategies related to assets and liabilities to achieve an organization's financial objectives, given the organization's risk tolerances and other constraints" (Abbott et al., 2003). A financial institution faces different types of risks such as credit, liquidity, market and operational risk. Modern risk management follows an integrated risk management approach for managing enterprise-wide risks assuming that different risks like interest rate risk, market risk, and liquidity risk are all interrelated (Rajan and Nallari, 2004). From an ALM perspective, some of these risks may

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originate endogenously (e.g. operational risk) while others might arise from the exogenous environment (e.g. market risk) while still others might arise from the interplay of exogenous and endogenous factors (e.g. liquidity risk). ALM is a banking response to the external and internal risks so that their collective impact on the bank is minimized. Although management of short-term risks, requiring tactical risk management, is important for effective implementation of ALM, yet ALM generally has a long-term orientation making it a strategic discipline (Choudhry, 2007). ALM helps to determine a long-term configuration of assets for repaying liabilities in future, whether as a single cash outflow or a series of cash outflows over multiple periods. ALM has several benefits: representation of a company's overall picture in terms of its liabilities; the quantification of risks and risk preferences; better preparation and handling of future uncertainties; and, increased efficiency and better overall performance. Despite the widely accepted benefits of ALM, implementing an ALM framework is a rather daunting task because objectives of each institution are unique and differ from others in terms of constraints, risk tolerances and other contextual factors making it difficult to develop a robust ALM model which integrates various individual components like policy constraints, institutional goals, assets, liabilities etc. in a meaningful way. Second, quantifying changing risk preferences in a mathematical language is far from trivial. Third, it is not easy to develop an optimization algorithm for making asset allocation decisions by realistically considering all bank-specific factors. Finally, it is not easy to develop forecasts for long-term strategic decisions because they are influenced by factors which are highly dynamic in nature may not be readily available to the corporate business and banks. Financial institutions generally analyze risk from an event-driven perspective and Global Derivatives Study Group (1993) categorizes the following risks as the event-driven risks:

a) Market risk: Risk that is generated from market forces like changes in asset-prices, exchange rate, Interest rates, derivative contracts etc. Such risk factors are dependent on collective market rates or indices.

b) Liquidity risk: Risk that stems from a mismatch between cash inflows and cash outflows at the current or some future point of time. Liquidity risk is of two types: market liquidity risk and funding liquidity risk. Funding liquidity is related to lack of access to funds and captures a bank's inability to raise required funds to meet anticipated and unanticipated current and future liabilities without affecting its daily operations or future financial health (Rosen and Zenios, 2006) While as market liquidity risk or trading liquidity risk arises when a bank finds it difficult to offset a position or establish a new position at the prevailing market price due to market disruption or inadequate market depth".

c) Credit risk: Risk of loss that arises due to the potential non-payment of obligations by an obligor. Credit risk can be direct or indirect. Downgrade risk (perceived default in the future) and default risk (actual failure to pay or honour obligations which have become due) are direct credit risks. Indirect credit risk arises when a third party's credit quality changes unfavourably. For example, when a country's credit quality gets downgraded, this results into a change term structure of interest rates which ultimately affects the financial contract values.

VAR models lend themselves to efficient vectorized computations which allow the simulation of millions of scenarios within minutes on a personal computer. A major advantage of our calibration approach is that it allows for the incorporation of short-term forecasts and/or long-term views concerning the median values of the risk factors in the model. Such subjective modifications were proposed also in Wilkie & Sahin (2016) and Wilkie (1984). We describe an easy procedure for the specification of the views and provide testable conditions that guarantee that the simulations indeed have the specified median values. One could also consider specifying user views concerning dependencies between various risk factors but we leave this for future research.

Need and Significance of Study

All business corporates and financial institutions face asset/liability management problems on a continuous basis. The assets must be invested over time to achieve sufficient returns to cover liabilities and achieve goals subject to various uncertainties, policy and legal constraints, taxes, and other requirements. Investors, whether individuals or institutions, typically do not properly diversify their asset holdings across markets and time, especially in relation to their certain and uncertain liability commitments. The present research presents an easily readable, up-to-date treatment of asset and wealth management in the presence of liabilities and other portfolio complexities, such as transaction costs, liquidity, taxes, investor preferences (including downside risk control, policy constraints, and other constraints), uncertain returns, and the timing of returns and commitments. The present research addresses the issues involved in the management of investment portfolios for both large financial institutions (such as pension funds, insurance companies, and hedge funds) and individuals concerned with life-cycle planning.

Objectives of Study

To Study the Stochastic Modelling and Assets and Liability Management of Corporate Business

To examine the application of Stochastic modelling for Assets and Liability Management

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To analyse the impact of stochastic optimisation modelling for effective Assets and Liabilities Management

Research Methodology

The research is descriptive and explorative nature. The data mainly used in the research is secondary data to validate and conclude the research.

Research Analysis and Discussion

The first step in the creation of any stochastic model is the identification of the most relevant risk factors that affect the quantities of interest. In the context of pension fund management, the interesting quantities are the investment returns in different asset classes and the pension expenditure. On the liability side, the most important sources of uncertainty are longevity, and price and wage inflation that are often used in indexation of defined benefit liabilities. There are also other macroeconomic risk factors, such as the gross domestic product (GDP), that may affect investment returns or liabilities indirectly. Indeed, it was found in Aro & Pennanen (2014) that GDP has an effect on old age mortality over longer periods of time. In Glover (2018), a similar link was found between old age mortality and average weekly earnings. GDP affects pension liabilities also through inflation which is often used in indexation of the benefits. GDP has statistically significant connections not only with inflation but also with many other factors that affect investment returns.

In a typical pension fund, one can easily identify thousands of risk factors that affect the assets and liabilities. Fortunately, it is often possible to come up with significant reductions in the number of risk factors while still capturing the main distributional properties of asset returns and liability payments. This section reviews some of the most relevant risk factors of a typical pension fund as well as some useful reductions for describing longevity and bond investments.

The stochastic programming approach, which considers the following aspects, is ideally suited to analysing such problems:

• Multiple time periods; possible use of end effects—steady state after the decision horizon adds one more decision period to the model; the trade off is an end-effects period or a larger model with one less period.

• Consistency with economic and financial theory for interest rates, bond

prices, and so on.

• Discrete scenarios for random elements—returns, liabilities, and currencies.

• Scenario-dependent correlation matrixes so that correlations change for extreme scenarios.

• Use of various forecasting models that can handle fat tails.

• Institutional, legal, and policy constraints.

• Model derivatives and illiquid assets.

• Transaction costs.

• Expressions of risk in terms understandable to decision makers.

• Simple, easy-to-understand risk-averse utility functions that maximize long-run expected profits, net of expected discounted penalty costs for shortfalls; pay more and more penalty for shortfalls as they increase (highly preferable to VAR).

• Model as constraints or penalty costs for target violations in the objective function.

• Maintain adequate reserves, cash levels, and regularity requirements. It can now solve realistic multiperiod problems on modern workstations and personal computers by using large-scale linear programming and stochastic programming algorithms.

• Model makes you diversify—the key for keeping out of trouble.

Conclusion

A broad review of asset liability management (ALM) models in this study has shown that the idea of ALM modelling has its roots in Markowitz Portfolio Theory. The basic idea of the theory is risk minimization for a given level of return and vice-versa. The matching of assets with liabilities, which represents the ALM in its simplest form, is also a form of minimizing risk. From a modelling point of view, ALM has grown considerably complex making use of advanced mathematical techniques and computation. Stochastic programming seems intuitively the best choice out of the available

ALM techniques for strategic asset liability management. This approach helps in multi-period investment decisions, portfolio rebalancing and accommodating uncertainty by examining few economic states in the future. Capturing the major states of future is essential for portfolio management. Moreover, the tree structure of stochastic programming is quite helpful in modelling uncertainty. Asset-liability management models should take this behavioural aspect into consideration. Thus, ALM modellers should venture into behavioural finance for more meaningful modelling insights.

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