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Optimizing Replicating Portfolios for the Life Insurance Industry

In life insurance, replicating portfolios (RPs) serve multiple purposes including compliance with Solvency II. A new paper reveals how one major insurer has made one particular RP optimization approach an integral part of its risk management efforts.

Replicating portfolios (RPs) have recently emerged as an important tool for the life insurance industry, used for the valuation of companies' liabilities. In the insurance context, an RP is a pool of a finite number of selected financial instruments designed to (approximately) reproduce the cash flows or present values of liabilities across a large number of economic scenarios. Insurance companies can use RPs for asset liability management (ALM) and performance management, for risk management, for capital and value calculations, and for management information purposes. Furthermore, and maybe most importantly, RPs are a useful tool in the context of the Solvency II Directive.

"For the insurance industry, new capital requirements, valuation techniques, and governance and reporting standards are set out in Solvency II."

The Solvency II Directive is a new European Union regulatory framework and came into effect on January 1, 2016. It aims to harmonize and modernize European insurance supervision. Similar to the objectives of the Basel II framework for the banking and finance industry, Solvency II sets out to establish new capital requirements, valuation techniques, and governance and reporting standards for the insurance industry. For example, the new capital requirements should ensure that an insurance company has a sufficient amount of capital to avoid bankruptcy over the coming year with a confidence level of (at least) 99.5 percent. The directive's regulatory requirements include certain quantitative elements, such as the Solvency Capital Requirement (SCR). Solvency II allows insurance companies to build their own internal models to determine their SCR or to use a standard formula provided by the regulators. The computation of metrics such as the SCR requires insurance companies to calculate the 'fair' (or 'market-consistent') values of their insurance liabilities. When these liabilities are long term and dependent on market conditions—as are, for example, the values of life insurance policies—valuing them accurately quickly becomes a very complex exercise. Several different techniques for the valuation of life insurance liabilities have become increasingly popular in recent years, among them approaches based on RPs.

"There are three principal steps to a replicating portfolio optimization process for liability cash flows."

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The full paper can be found at http://bit.ly/2cDus1W.

An RP optimization process for liability cash flows consists of three main steps. In the first step, different future economic events are determined and scenarios for the liabilities of the insurance company and for a set of candidate assets for the RP are simulated for each of these events. In a second step the weights of the candidate assets are determined in an optimization model to reproduce the liabilities of the insurance company as closely as possible. Finally, in the third step, the quality of the RP is examined in the light of several tests.

"Zurich has made the RP model an important element in its risk management efforts."

A new paper by four authors including SFI's Karl Schmedders is based on a collaboration between the University of Zurich and the Zurich Insurance Group Ltd (Zurich) and documents the second and third steps of an RP optimization process in the life insurance industry. The paper discusses the formulation of an optimization problem for determining an RP. In particular, useful constraints that allow RPs with favorable properties to be found are discussed in detail. During the discussion of the third step, several out-of-sample tests for the evaluation of RPs are proposed. The main quality test—described in the paper and conducted by Zurich—is a market value test that includes out-of-sample scenarios that represent extreme market conditions. In addition to the theoretical formulation of an RP optimization model and the subsequent tests, the authors also present the numerical results of the model's implementation using three large-scale, real-life data sets provided by Zurich. Furthermore, a thorough sensitivity analysis of the optimal RPs is presented and their strengths and weaknesses are examined.

The paper also discusses in detail how Zurich has taken advantage of the RP optimization model developed. The model has become an important part of risk management efforts at Zurich and serves three major purposes for the company. First, RPs ensure considerably faster calculations than full liability revaluation models. In RP models the number of future economic scenarios can be reduced by a factor of between several hundred and several thousand compared to (tedious) iterative liability models based on a stochastic-on-stochastic approach.

"Understanding balance sheet liabilities is made easier by the RP model."

Second, the RP model is a useful tool for understanding the liabilities in the balance sheet. The foundation for the management of Zurich's investment position is the company's understanding of the liabilities it has accepted onto its balance sheet. RPs are fundamental to achieving this objective as they allow a 'total balance sheet' perspective to be formed at group level—that is to say, a consolidated view that results from aggregating all individual business units in the insurance group. This can be understood by thinking about the replication process as a translation exercise that takes cash flows as inputs and returns financial instruments, thus 'translating' liabilities into a common language shared with the other side of the balance sheet—the assets.

"Today's strict regulatory requirements for insurance companies make RPs more pertinent still."

Third, RPs are well suited to today's strict regulatory requirements for insurance companies. RPs represent the claims of life insurance policy holders and are thereby an important part of Zurich's Economic Capital Model (Z-ECM), which assesses the economic capital consumption of the company's business. Since the most recent financial crisis, when banks suffered massive losses on derivatives priced under little-understood formulas, the regulatory environment has favored the use of transparent models over so-called black boxes. The alignment between those models used for internal decision-making and those used for regulatory purposes is a requirement that regulators place on insurance companies to ensure the highest quality of results in both. In this context, Zurich uses Z-ECM as the basis for its Swiss Solvency Test (SST) reports. Thus, RPs are used both in Z-ECM and in SST models.

Key Words
Liability cash flows
Out-of-sample tests
Replicating portfolios
Solvency II

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