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REPLICATING PORTFOLIOS FOR INSURANCE LIABILITIES

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The views expressed in this article are those of the author and are not necessarily shared by ING.

INTRODUCTION

In this article I will discuss a recent development in the risk management of insurance companies, namely replicating portfolios for insurance liabilities. This development is a next step for improving the asset liability management of insurance companies and integrating them fully in today's financial markets.

"Vanishing Swaps, Asian *Basket Options, Double Knock Outs en CMS Caps; no science fiction titles but products traded in today's financial markets. ...But where these products have been invented only recently by investment banks, insurance companies have off*ered these derivatives as part of their products for decades."

This is how I started an article in AENORM (vol. 50, 2005) in which I argued for insurance companies to embrace market consistent valuation and risk management. Since then, with the help of Solvency II taking shape, life insurers are spending an increasing amount of time on building an infrastructure for risk based solvency reporting. Furthermore the emergence of European Embedded Values (EEV) has increased the industry's awareness for options and guarantees in insurance products. Moving towards risk based solvency measurement includes building models to calculate the fair value, or equivalently market consistent value, of insurance liabilities. Risk analysis requires a market consistent balance sheet under different economic scenarios. Having such an infrastructure allows not only for timely reporting but also provides unique insights in the portfolio which allows insurers to better manage their business on an economic basis[1]. The outline of the remainder of this article is as follows, first I discuss replicating portfolios as a representation of insurance liabilities. Second I explain the need for having such a representation. Third, I discuss replicating portfolios in practice. Finally, I conclude.

WHAT IS A REPLICATING PORTFOLIO?

As mentioned in the introduction insurance products share many characteristics with standard derivative contracts. Take for example profit sharing contracts, where profit sharing takes place when returns are high but not when returns are low. This is very similar to call options on a stock or payer swaptions[2]. See also Bouwknegt and Pelsser (2001). Similar, a guarantee in a unit linked contract is nothing less than a put option on the underlying investment funds. When seen through the eyes of a financial specialist many features of insurance contracts can be translated into financial products.

Taken a bit further this insight can be used to let liabilities be represented by a portfolio of financial products in risk calculations as well. If insurance contracts share so many characteristics with certain derivative contracts, why not capture the risk profile of insurance liabilities by mapping them onto a set of standard financial instruments? One of the techniques used by insurance companies to get market consistent values for their liabilities is based on a set of risk neutral scenarios[3]. Under these scenarios[4] the liability cash flows are calculated, discounted and averaged to give an estimate of the market consistent value of the liabilities. However we can also use the information provided in those cash flows in a different way. We can define a *replicating portfolio* as a portfolio of standard financial instruments which matches the cash flows generated by the liabilities *as good as possible*. It is a key ingredient of the approach that these standard instruments are well understood, easy to value and also easy to produce cash flows for. Finding the replicating portfolio then reduces to some form of cash flow matching optimization problem. See also Oechslin et al. (2007).

WHY REPLICATING PORTFOLIOS?

If this can be accomplished using actual liability portfolios it would mean a significant simplification of all calculations involving insurance liabilities. Normally liabilities would have to be valued using time consuming Monte Carlo simulations under every scenario a risk manager would like to consider. This is typically many different scenarios; thousands even, for many risk factors in an Economic Capital calculation (a solvency measure based on fair values of assets and liabilities, which typically is intended to equal a 1 year Value at Risk at a certain confidence level). This is hardly possible to do in practice, running the scenarios through a liability model typically takes hours. This means

1 Instead of an accounting basis which might not give the correct incentives to produce shareholder value.

2 A payer swaption is an interest rate derivative which pays out when interest rates are above a certain strike level.

3 Valuation using a set of stochastic risk neutral scenarios is referred to as valuation using Monte Carlo simulation. In general analytical valuation or more efficient valuation techniques are preferable to Monte Carlo simulation. However this technique fits in nicely with the traditional Embedded Value projection systems companies have been using for some time.

4 For finding a replicating portfolio one can also use real world scenarios instead of risk neutral.

evaluation of portfolios over more than 10,000 scenarios is virtually impossible.

If a liability portfolio can be reduced to simple financial instruments for which there's market information available to value them, for which analytical valuation formulas exist then this makes valuation almost instantaneous and also makes more sophisticated risk calculations possible. See figure 1 for a graphical explanation. The simplification comes in evaluating the liability in each 1 year scenario used to determine VaR and hence Economic Capital.

REPLICATING PORTFOLIOS IN ACTION: AN EXAMPLE OF PROFIT-SHARING

After introducing the concept and its benefits it is time to see whether this can actually work on real liability cash flows. Consider a regular profit sharing portfolio with part of the profit sharing over 3% and another part over 4%. We use the actual cash flows projected by the liability model from an ING Business and, using the insights from Bouwknegt and Pelsser (2001), replicate using bonds and swaptions. The results are displayed in Figure 2 and Table 1. Figure 2 shows a scatter plot of portfolio cash flows vs. liability cash flows. Table 1 shows the value of the replicating portfolio under current market circumstances and a number of stress scenarios. The results are excellent, there's a maximum of 5% difference between the sensitivity of the replicating portfolio and the result produced by the internal model for market consistent valuation.

Not only does this significantly reduce the time to evaluate risk calculations. In addition the replicating portfolio helps us understand profit sharing contracts in terms of financial instruments! Furthermore the replicating portfolio can be used for liability driven investment and as a risk management tool: financial risk under fair value accounting of these products can be hedged using swaptions and zero bonds.

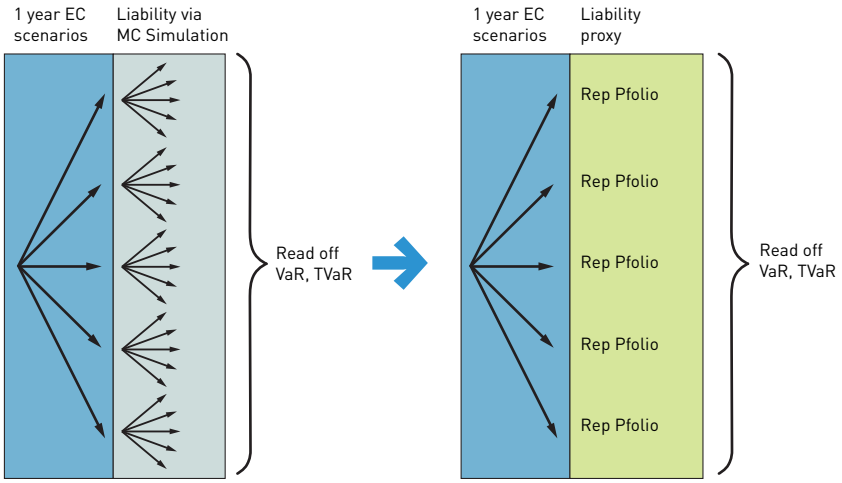

FIGURE 1

Economic Capital calculations without and with replicating portfolios. In the former, time consuming scenario based methods need to be employed for the Fair Valuation (equivalently Market Consistent valuation) of insurance liabilities. Since all components of the replicating portfolio can be valued using simple formulas, in the latter method, the calculation of the Value at Risk or Tail Value at Risk is simplified considerably.

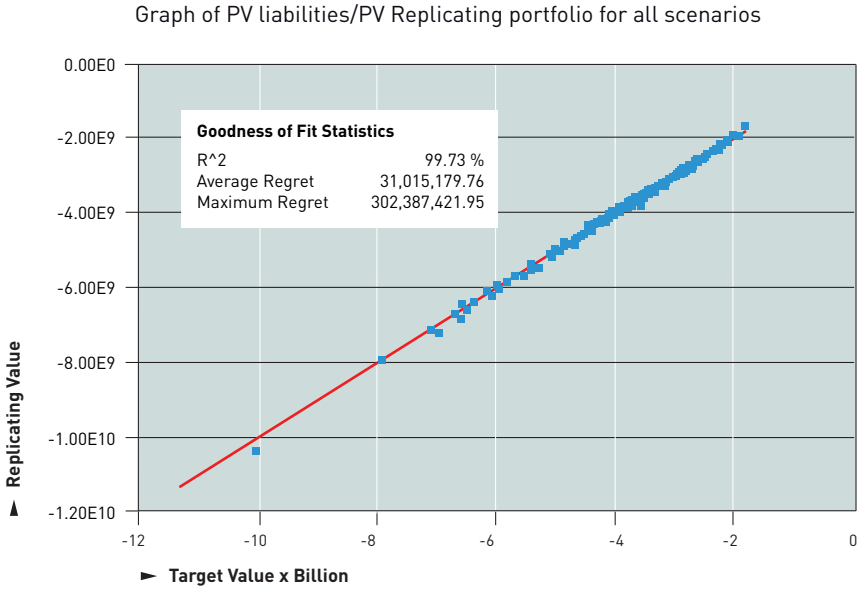

FIGURE 2

Scatterplot of replicating portfolio cash flows against projected liability cash flows from a portfolio of fixed annuities with a minimum guaranteed rate. The fit is extremely good as evidenced by the "Goodness of Fit Statistics".

Life Traditional Portfolio
Change market value of the replicating and target portfolio under different shock scenarios

Shock	Replicating Portfolio	Internal model	Difference	% Difference
-200 bps	–1,257	–1,195	–62	5%
-100 bps	–509	–508	0	0%
Non parallel shock*	–923	–904	–19	2%
EC size down shock	–781	–780	–1	0%
* 150 bps down 10Y, 200 bps down 5Y and 115 bps down 1Y				
current market value	3,364	3,399	–35	–1%

All numbers in in (000 000s)

TABLE 1

Market value and sensitivities of replicating portfolio vs. Internal model outcomes. This shows that replicating portfolio represents the risk profile of the cash flows very well.

REPLICATING PORTFOLIOS AT ING

Although replicating portfolios are interesting from a theoretical perspective they are an extremely powerful tool in practice as well. At ING all calculations for Economic Capital are based on replicating portfolios in ING's Economic Capital System (ECAPS). Because insurance liabilities can now be represented by simple, easy to value financial instruments, Value at Risk (VaR) calculations are executed using Monte Carlo simulations of economic scenarios. Using these Monte Carlo techniques allows for much better calculation of diversification between both different risk types as well as different ING entities. Graphically this process is represented in figure 3 showing the improved accuracy in the Economic Capital model.

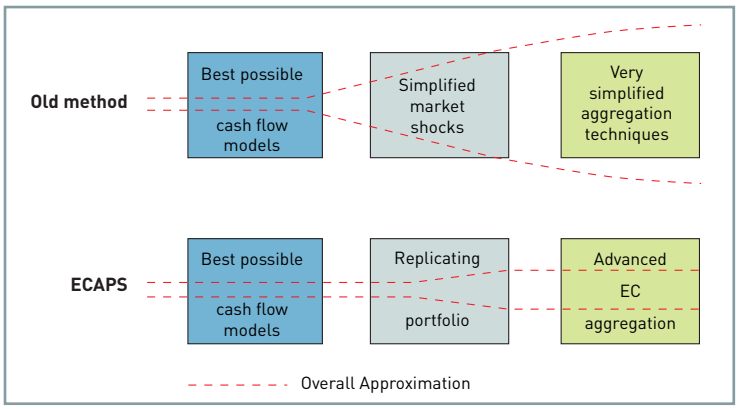

FIGURE 3

Old method vs. current method (ECAPS). The latter is based on replicating portfolios. Because time consuming scenario based methods needed to be employed for the Fair Valuation (equivalently Market Consistent valuation) of insurance liabilities only simplified risk calculations and aggregation techniques could be employed. In the current method although an approximation is made by using the replicating portfolio instead of the "true" liabilities the diversification calculations can be done in a much more sophisticated way.

Furthermore replicating portfolios can be very useful during ALM studies and can support hedging decisions. It is especially these decisions that require an understanding of insurance products in terms of financial products. These insights can also create a better understanding of insurance products during product design and enforce pricing of products in a way that is consistent with both the risk associated with these products and the potential hedge costs.

CONCLUSION

In this article I have discussed replicating portfolios and their merits. I have argued replicating portfolios to be an important tool in risk based solvency calculations where market values of insurance liabilities are needed. In an example using an actual liability cash flow model of a profit sharing contract I have shown a simple replicating portfolio to produce stunning results. Developments in the insurance industry show that this is a technique with a lot of promise for improving practical risk models and ALM decisions.

LITERATURE

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