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INVESTMENTS

Intelligent financial planning for life

MICHAEL A. H. DEMPSTER

AUTOMATION

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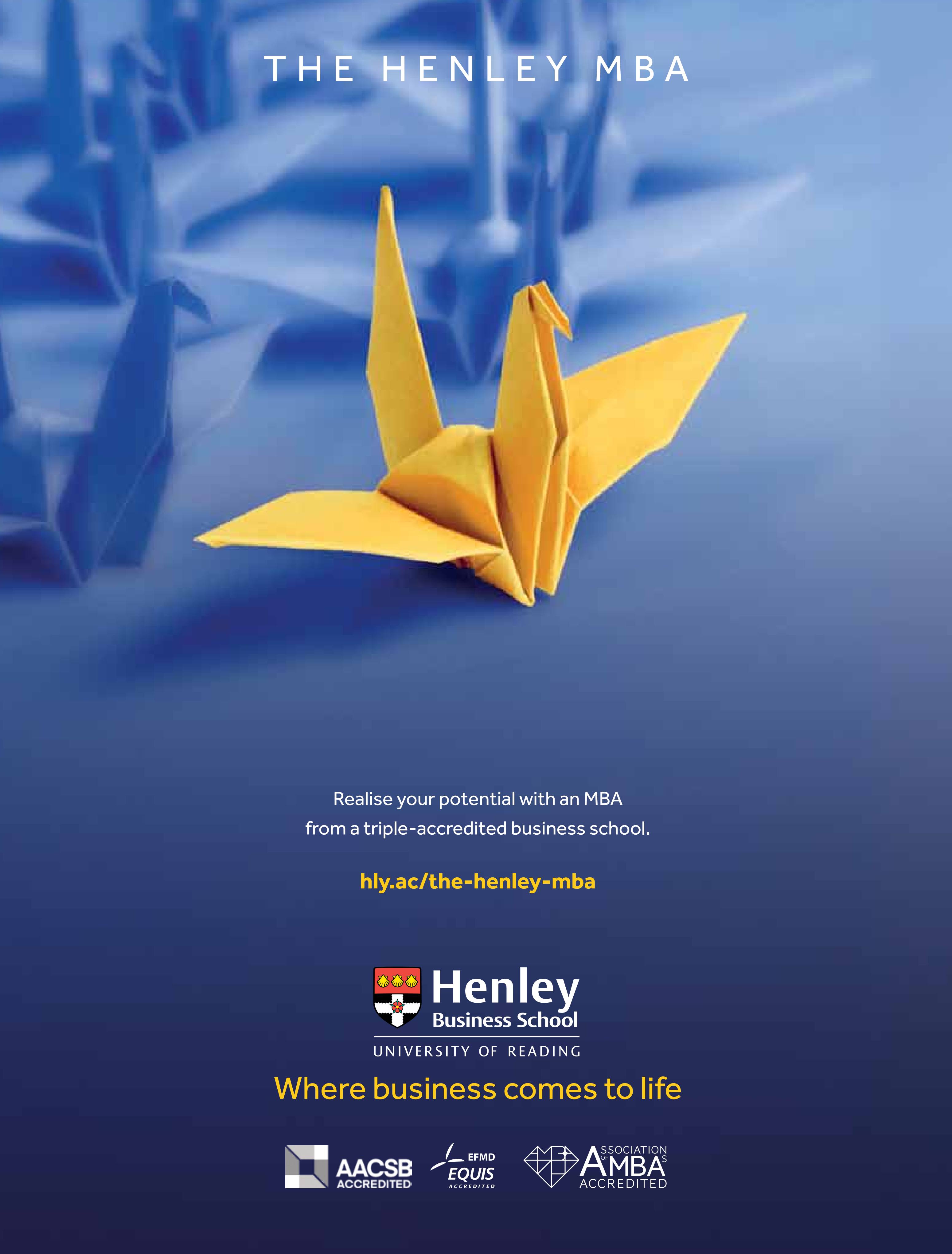
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Intelligent financial planning for life

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ABSTRACT

This paper is concerned with the use of currently available technology to provide individuals, financial advisors, and pension fund financial planners with detailed prospective financial plans tailored to an individual's financial goals and obligations. By taking account of all prospective cash flows of an individual, including servicing current liabilities, and simultaneously optimizing prospective spending, saving, asset allocation, tax, insurance, etc., using dynamic stochastic optimization, this paper addresses the title by comparing the results of such a goal-based fully dynamic strategy with representative current best practices of the financial advisory industry. These include piecemeal fixed allocation portfolios for specific goals, target-date retirement funds, and fixed real income post-retirement financial products, all using Markowitz mean-variance optimization based on the very general goal of minimizing portfolio volatility for a specific portfolio expected return over a finite horizon. Making use of the same data and market calibrated Monte Carlo stochastic simulation for all the alternative portfolio strategies, we find that flexibility turns out to be of key importance to individuals for both portfolio and spending decisions. The performance of the adaptive dynamic goal-based portfolio strategy is found to be far superior to all the industry's Markowitz-based approaches. Superiority is measured here by the certainty equivalent increase in expected utility of individual lifetime consumption (gamma) and the extra initial capital required by an individual to put the dominated strategy on the same expected utility footing as the optimal dynamic strategy (initial capital gap). These empirical results should put paid to the commonly held view amongst finance professionals that the extra complexity of holistic dynamic stochastic models is not worth the marginal extra value obtained from their employment. We hope that such approaches implemented in currently available technologies will rapidly find acceptance by individuals, financial advisors, and pension funds to the genuine benefit of individual investors.

[1] This article is based on Dempster et al. (2016), whose authors I would like to thank for their painstaking and cheerful collaboration.

1. INTRODUCTION

Currently available technology can provide individuals, financial advisors, and pension fund financial planners with detailed prospective financial plans tailored to an individual's financial goals and obligations. By taking account of all prospective cash flows of an individual – including servicing current liabilities, and simultaneously optimizing prospective spending, saving, asset allocation, tax, insurance, etc., using dynamic stochastic optimization – the "iALM intelligent robo advisor" may be used to compare the results of a goals-based fully "dynamic" strategy with representative current best practices of the financial advisory industry. These include piecemeal fixed allocation portfolios for specific goals, target-date retirement funds, fixed real income post-retirement financial products, and commercial robo advisors, all of which use mean-variance optimization to address the very general goal of minimizing portfolio volatility for a specific portfolio expected return over a finite horizon.

iALM's design involves a synthesis of ideas and concepts. An objective data-driven, goal-based utility function is constructed from the personal data entered into the system by a user. Overall, the system's design is very much based on the personal situations, preferences, data, and flexibility that are the hallmarks of behavioral finance. The focus on personal finance comes from economics; models from mathematical finance are calibrated to historical data and used for asset return forecasting; network flow models from decision sciences are used to trace all of the model's cash flows; and stochastic optimization techniques are applied to solve a multi-level scenario-based problem under uncertainty over a very long horizon. Using patented software, the optimizer divides the planning period to the horizon into major portfolio rebalance points corresponding to the timing of a client's major financial decisions, such as house purchase and retirement. Even if you do not have control of the market, through iALM you can still have control of your life.

Making use of the same annual data and market calibrated Monte Carlo stochastic simulation for alternative portfolio strategies, in our experiments, as in our general experience, we have found that "flexibility" is of key importance to individuals for both portfolio and spending decisions. We have seen that the performance of the adaptive dynamic goals-based portfolio strategy is far superior to the industry's Markowitz-based approaches, as measured by the extra initial capital required by an individual to put the dominated strategy on the same expected utility footing as the optimal dynamic strategy. These empirical results should put paid to the commonly held view amongst finance professionals that the extra complexity of holistic dynamic stochastic models is not worth the marginal extra value obtained from their employment.

2. FINANCIAL PLANNING CHALLENGES

Financial planning for the benefit of individuals is based on a variety of approaches internationally. These range from simple heuristic approaches for selecting portfolios to approaches incorporating the joint stochastic optimization of asset allocation, contributions to different savings vehicles, and setting flexible saving and withdrawal rates. As affordable computing power and bandwidth continues to increase and the solution efficiency of large stochastic optimization problems expands, ever more complex financial planning tools are emerging. As we enter the age of big data, this trend will surely continue. Despite the relentless march of development, simple heuristic methodologies and mathematical approaches long criticized in the research literature continue to enjoy widespread acceptance by the financial planning industry. An important contributing factor to this divergence of approach is the difficulty of measuring and understanding the incremental benefits of incorporating more of the real-world complexities of household lifecycle financial planning. The results of complex stochastic modeling have gained most widespread acceptance by the general public in areas such as meteorological modeling, where it is easy for the man on the street to judge efficacy and benefit.

Some progress has nevertheless been made in measuring the benefit of different approaches to individual financial planning. For example, Morningstar introduced measuring the increase in the certainty equivalent income in moving from a benchmark approach to the approach recommended by an advisor, but this measure is arguably too abstract to gain popularity amongst clients purchasing financial advice. This article uses a new strategy comparison measure that is more intuitive, namely the "initial capital gap," which is the extra capital needed now to put the benchmark approach on the same expected utility footing as the recommended approach.

Here we analyze and decompose the value added by the stochastically optimized holistic goal-based approach to financial planning embodied in the iALM "intelligent" robo advisor. For example, we measure the benefit of incorporating flexible "dynamic recourse" decision-making and test the strategy for individuals' saving toward retirement and other financial goals. The industry standard mean-variance approach to asset allocation incorporated in robo advisors, a fixed drawdown in terms of real income post retirement, and alternative savings vehicles are all considered. Our aim is to contribute to the understanding of whether the techniques currently used by the financial planning industry are inefficient in not making use of existing technologies and if so, how large these inefficiencies are.

A wide view is taken of what constitutes financial planning for individual benefit, including financial advisors meeting and advising individuals, the decisions of defined contribution trustee boards, and products marketed by the industry meant to address aspects of the lifecycle consumption problem, such as target-dated funds and living annuities. Significant differences exist in the best advice delivered for each focus and in the manner by which this advice is derived. In all cases, an entity claims to be an expert advisor, dispensing advice with a view to positively influencing the lifetime consumption of an individual household or many individual households. In a recent examination by the U.S. General Accounting Office of the common purpose in all these practices they were found wanting to varying degrees [GAO (2014)].

3. OUR STUDY

The literature on optimal investment strategies for retirement, and more generally optimal financial planning, is vast. However, the unique experiments discussed here aim to compare different solutions of the individual asset liability management problem within a common framework. For these experiments, two simple U.K. profiles were chosen: a young individual and a retired individual, both of whom are taken to be single for simplicity. We shall refer to these as Profiles A and B, respectively. The individual in Profile A is 30 years old, has no savings, earns £60k gross (equal to about £45k after tax) and has spending goals for "minimum," "acceptable," and "desirable" sterling amounts corresponding to 30k, 40k, and 50k, pre-retirement and to 7.5k, 40k, and 70k upon planned retirement at 65 (all in today's pounds sterling). The £7.5k per annum minimum amount post retirement represents the current U.K. subsistence level. The individual in Profile

B is 65 years old, has just retired and does not earn a salary. He has £600k in initial savings, and his post-retirement spending goals for minimum, acceptable, and desirable amounts correspond to 7.5k, 40k, and 70k.

We examine three types of solutions for these profiles:

- Solutions with various "static" asset allocations, "fixed" from the beginning, and only spending decisions being optimized.
- Solutions with "fixed spending" levels and only investment decisions being optimized.
- A fully "dynamic" solution with both investment and spending decisions being optimized.

Using multiple channels or portfolio wrappers with different tax treatments and asset allocation limits, portfolio addition and withdrawal (drawdown) amounts are set optimally in the fully dynamic solution. Our experiments decompose more granularly the value added by optimizing the optimal expected value of lifetime utility with this fully dynamic strategy and measure the benefits of incrementally incorporating:

- An optimal asset allocation informed by mean-variance optimization (MVO).
- Varying the level of risk of the mean-variance optimal strategy.
- Selecting an MVO strategy that is optimal with regards to a utility of lifetime income objective.
- Dynamic strategies that are only allowed to vary across time.
- Fully flexible dynamic recourse decision-making with path dependent decisions (allowing a different strategy depending on the Monte Carlo scenario up to the point of each decision.

Each of these steps adds complexity to the problem to be solved and all current solutions used in practice ignore one or more of these features to make the problem easier. The impact of each of these incremental complexities are very poorly understood by practitioners and they are often dismissed as unnecessary (or dubbed "spurious"), even by modeling experts. Such dismissals are not usually based on evidence, but they explain why the holistic features of iALM, or an equivalent approach, are deemed unnecessary.

4. iALM VERSUS MVO BASED ADVICE

The results presented here show the practical importance of these advanced features. In particular, we compare the fully dynamic iALM optimal strategy with the commonly recommended fixed MVO portfolio strategies, with and without fixed spending. Mis-specifying the optimal risk-return characteristics of the fixed MVO portfolio results in considerable losses to an investor's lifetime wealth. Tables 1 and 2 show that the detrimental effects of applying both fixed spending and fixed static portfolio strategies together is much worse than the sum of their individual fixed detrimental effects. For portfolios that are considered best from the perspective of expected utility over static MVO portfolios on the efficient frontier, that of the retired profile is quite close to the aggressive MVO portfolio, but for the young profile this optimal static portfolio is less aggressive than the corresponding aggressive MVO portfolio, showing that the "more risk" mantra is not always valid even when considering very long investment horizons. The "non-adaptive dynamic" solution adjusts portfolio asset proportions annually independent of the specific Monte Carlo scenario realizations and is a

Table 1: Initial capital gap to the dynamic solution for all strategies

STRATEGY	PROFILE A (000s)	PROFILE B (000s)
Non-adaptive dynamic	92	101
Static allocation – conservative	1500	600
Static allocation – moderate	350	280
Static allocation – aggressive	115	135
Fixed spending	18	200
Fully fixed	200	1380

Table 2: Certainty-equivalent lifetime spending for all strategies

STRATEGY	PROFILE A c-e SPENDING	PROFILE B c-e SPENDING	PROFILE A c-e SPENDING PER ANNUM	PROFILE B c-e SPENDING PER ANNUM
Dynamic	1,997,366	776,055	41,583	38,949
Non-adaptive dynamic	1,824,582	731,029	37,986	36,689
Static allocation – conservative	1,453,344	519,878	30,257	26,092
Static allocation – moderate	1,659,209	647,155	34,543	32,480
Static allocation – aggressive	1,818,123	721,629	37,851	36,217
Fixed spending	1,896,408	614,387	39,481	30,835
Fully fixed	1,724,720	413,477	35,907	20,752

Table 3: Gamma and gamma equivalent alpha of all strategies relative to the dynamic strategy

STRATEGY	PROFILE A GAMMA	PROFILE B GAMMA	PROFILE A GAMMA-EQUIVALENT ALPHA	PROFILE B GAMMA-EQUIVALENT ALPHA
Non-adaptive dynamic	9%	6%	0.21%	0.30%
Static allocation – conservative	37%	49%	0.73%	2.01%
Static allocation – moderate	20%	20%	0.43%	0.92%
Static allocation – aggressive	10%	8%	0.22%	0.37%
Fixed spending	5%	26%	0.12%	1.18%
Fully fixed	16%	88%	0.34%	3.14%

generalization of the life-staged fund strategy offered widely by the industry, in that its dynamic adjustments are made annually instead of periodically in life stages. In all cases, this dynamic strategy outperforms all the static asset allocation strategies. The dynamic iALM strategy, however, achieves even higher lifetime utility through dynamic management of all cash flows. For our experiments, a tolerable portfolio annual loss constraint of 15% was introduced and compared with a portfolio loss tolerance of 100%, i.e., the no portfolio loss penalty, which is used in standard risky advice. The lack of sensitivity to the portfolio loss tolerance of the iALM fully dynamic strategy suggests that with this optimal strategy there can be a cap to the risk of portfolio loss at no significant cost to expected lifetime spend.

Our overall findings are perhaps best understood by the results of the comparative value calculations relative to the dynamic strategy for all the alternative strategies we have evaluated. The strategy comparisons by our initial capital gap comparison measure are reported in Table 1, which shows, for example, that the young individual employing a conservative fixed MVO portfolio strategy would need an initial windfall of £1.5 million to expect to achieve with this strategy the same utility of lifetime consumption as the dynamic strategy would yield with no initial capital. Even for the aggressive static portfolio strategy the initial extra capital needed is seen to be significant for both profiles. Perhaps the worst situation revealed by this measure is that of the just retired individual following a fixed MVO aggressive portfolio strategy with a fixed post retirement drawdown. The retiree would need an extra 1.38

million pounds in savings at retirement to match the prospective expected results of the dynamic strategy for their accumulated £600,000 savings.

Table 2 contains the results of the certainty equivalent lifetime spending calculations necessary to compute the Morningstar "gamma" strategy comparison measures, and their per annum values. Focusing on these more easily interpreted annual spending values, we see that fixed spending for the young profile while earning a salary is not a massive burden. The results in Table 2 are in the expected order and do not differ markedly from the two risk tolerances, except for the fixed MVO aggressive strategy, which is consciously risky. The superiority of the full dynamic strategy over all others, including the non-adaptive dynamic strategy, is in clear agreement with the results in Table 1. The fully fixed strategy, although based on the MVO Aggressive portfolio strategy, is poor for both profiles and particularly bad for the retired Profile B. The strategy comparison results, in terms of gamma and "gamma-equivalent alpha" (the extra per annum portfolio return

Table 4: Probabilities of achieving the £40k acceptable target spending level

STRATEGY	PROFILE A PRE-RET	PROFILE A POST-RET	PROFILE B
Dynamic	45%	80%	70%
Non-adaptive dynamic	17%	54%	54%
Static allocation - conservative	5%	0%	0%
Static allocation - moderate	1%	25%	10%
Static allocation - aggressive	15%	50%	50%
Fixed spending	0%	45%	0%
Fully fixed	0%	55%	0%

Figure 1: Young profile dynamic strategy prospective expected asset allocation

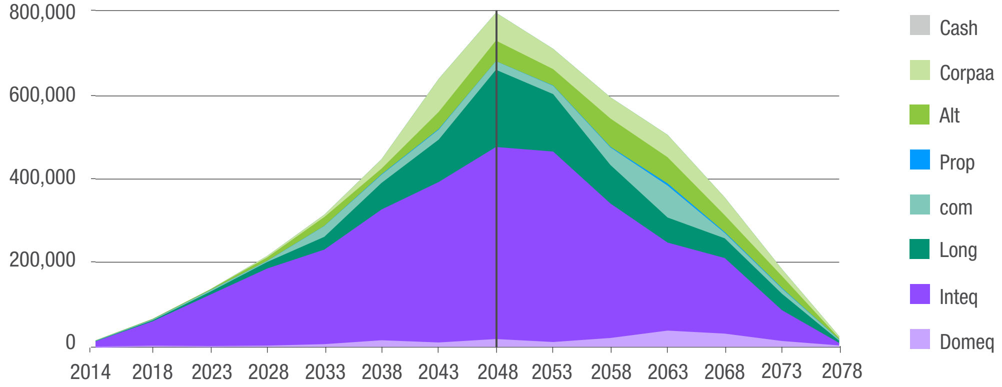
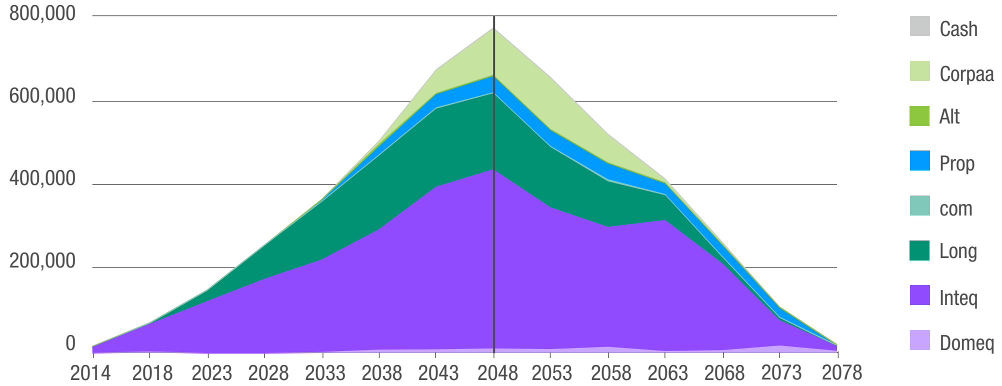


Figure 2: Young profile non-adaptive dynamic strategy prospective expected asset allocation



needed to match the certainty equivalent lifetime spend of the dynamic strategy) are given in Table 3.

Many practitioners will concede that liability optimized approaches make sense, but that such complex analysis is unnecessary because they believe that investors should employ a highly aggressive strategy that will, in the long run, deliver the best results, even when considered in terms of income. These results show that this is simply not true. For the young individual, the dynamic strategy outperformed the static aggressive strategy by well over £100,000 on an initial capital basis and by 10% on a gamma basis. Very few households would deem these differences negligible. The results also show just how detrimental strategies that are traditionally thought of as "conservative" can be.

Table 4 shows the achievement probability results for the target (acceptable) spending level of £40k per annum.

The success probabilities for the static moderate strategy are vastly worse than those for the static aggressive and dynamic strategies. The same holds true for the static aggressive strategy relative to the dynamic strategy. The success probabilities shown in Table 4 represent a powerful and tangible demonstration of just how much difference advanced planning techniques can make. Many modeling practitioners in industry realize that the fully dynamic approach to financial planning is an improvement on current practice and is actually implementable today, but they often jump to the conclusion that its value added will be very marginal. These results for the young and retired profiles show indisputably the value added by fully dynamic strategies. There is no rational debate to be had regarding changes of target achievement from 15% to 45%, or 50% to 70 or 80%, not being significant.

Table 5: Contrast of intelligent versus standard robo-advice

	STANDARD ROBO-ADVISOR	iALM INTELLIGENT ROBO-ADVISOR
Holistic optimization: • Goals (children's education, mortgage, etc.) • Taxes, transaction costs, fees, etc. • Every **goal influences decisions** on all other goals	✗	✓
Future **dynamic** portfolio allocation	✗	✓
Advice on **how much to save**	✗	✓
Accounts for **longevity risk**	✗	✓

Finally, by way of illustration of the iALM intelligent robo-advisor's screens we present for the young Profile A the prospective expected portfolio evolutions over the lifecycle from the initial portfolio allocations. Figures 1 and 2 show these prospective future expected portfolio evolutions corresponding to the dynamic and non-adaptive dynamic portfolio strategies taking account of all transactions costs. Retirement dates are shown by the vertical lines

The overall shape and quantities of the prospective asset allocations over the lifecycle differ quite significantly. There is a far larger allocation to long bonds in the non-adaptive dynamic strategy, because the dynamic strategy has far more de-risking/hedging flexibility. In Figure 2, the prospective expected allocations for the young non-adaptive dynamic strategy look very similar to the heuristic rule of gradually decreasing the share of equity and increasing the share of bonds in the portfolio over an individual's lifetime. The non-adaptive dynamic framework thus generates a life-staging approach to prospective portfolio evolution, but is less effective than the fully dynamic approach for which the equity to bond shift pattern in Figure 1 is significantly less prominent.

Put simply, non-dynamic strategies are not realistic representations of how people actually approach the lifetime consumption problem, as they ignore the interventions that investors will undoubtedly make. Table 5 contrasts the main features of current fixed standard robo-advice with the dynamic intelligent robo-advice of iALM.

5. CONCLUSION

In summary, the iALM intelligent robo-advisor has been employed to demonstrate the positive effects of using a dynamic stochastic goal-based holistic approach to address the lifecycle consumption problem. We decomposed the relative value-added for individual clients or pension fund members using this technology to evaluate the current bases of advice given by the advisory industry to clients. Such advice includes Markowitz mean-variance optimized portfolios with varying degrees of risk aversion; specific goal funds, for example, to cover an individual household's future school or university fees; life-staged funds; and fixed real post-retirement spending, by means of fixed defined contribution pension fund withdrawals or the purchase of an indexed fixed annuity at retirement.

Each of these industry standard bases was embedded in the iALM dynamic stochastic planning system and their relative effectiveness in meeting an individual's goals was evaluated by means of two comparative statistics. Both statistics, "initial capital gap" and "gamma," were based on the optimal expected utility of lifetime consumption and supplemented by spending target achievement probabilities and prospective future portfolio evolutions. The results are surprising, even to us, as the dynamic flexibility embodied in the holistic iALM model significantly outperforms the other approaches – fixed post-retirement spending in real terms being particularly bad. These results will hopefully go some way to convincing the pensions and financial advisory industry and regulators that it is worth the extra effort to employ the dynamic holistic stochastic strategies required to address members and clients' actual needs.

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