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RISKS AND REWARDS

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Managing Funding Ratio Risk and Return

by Aaron Meder

Asset-liability management is at the top of many pension managers' minds. The key to successful pension-plan investing is finding an investment solution that manages the volatility of asset returns relative to liabilities and generates enough return so that the plan's commitment is fulfilled.

The traditional asset-only approach to pension investing has resulted in portfolios invested in 60 percent to 70 percent equities with the remainder in average duration nominal bonds. These investment policies may be efficient in an asset-only framework but are exposed to unrewarded risk when evaluated relative to liabilities. The asset-only framework does not properly integrate the liability's fundamental exposures to interest rates, inflation and growth. These unrewarded risks were masked by the bull market of the '90s, and subsequently exposed during the perfect storm of falling equities and falling interest rates during the 2000-2002 period.

Constructing an investment policy that achieves both objectives more efficiently is best demonstrated using a case example. We focus on the plan's funding ratio (value of assets divided by value of liability) since it is the funding ratio that ultimately drives plan costs. We will show how funding ratio risk (volatility of the funding ratio) can be significantly reduced without reducing expected return.

Our case example, ABC Corporation, currently has $927 million in assets, a funding ratio of 90 percent, typical final salary liability profile and a typical asset allocation as described in Figure1 and Figure 2 on page 5.

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Selling What Sells

by Nino Boezio

Over the years we have all witnessed high-flying funds and strongly performing asset classes. We have also seen investments that had their day in the sun, but later no one wanted them anymore (at least for a period of time).

One of the hottest sectors the past several years has been resource funds and resource companies. We have had a substantial run-up in this area, and many are expecting this trend to continue to the end of the decade. However, we know this has not always been the case. The resource sector has had its ups and downs like every other, and languished for many years. In part the recent strength has arisen because China entered the world stage to buy up various commodities (in order to support its growing economy), but also because global investors have gone to such vehicles as gold to hedge against the falling U.S. dollar.

There is one thing we always have to keep in mind (and this is also borne out in technical analysis) that strength begets strength, and weakness begets weakness. Additionally, people do not notice certain investments to be either good or bad, until the trend is well under way. I recall a conversation I had with an investment advisor several years ago, who said a fund promoter made a presentation to him on a resource fund that was just being marketed. This advisor rather angrily said to the promoter, "Where were you two years ago, when it would have been the best time to buy this fund? Why now? We already have had a substantial run-up!" The promoter responded, "Two years ago no one would have bought this fund!"

And that is the rub. We often are just plain investors who want someone else to take the risk and the pains of being first and the initial risk taker, and then we finally may jump on the bandwagon, when many others also are getting on the train. Then we complain that we did not get in earlier, and in some cases, we do not want to get in anymore, because we do not want to chase the investment. And then, if and when we do get on board, we sometimes stay on the bandwagon much too long, because we are afraid to lose out on further gains, or we are afraid of being laughed at for exiting when everyone is still in, or we are insecure about being put on the defensive for acting contrary to the "street" and the common beliefs. Or otherwise, we just get accustomed to the idea that this trend will continue "forever" (which is a mentality that is certainly taking some hold today in the Canadian environment, regarding demand for oil).

Selling Hope and Faith Is a Tough Game

Being sold on hope and faith (but without evidence) that an out-of-favor sleepy stock or asset class will soon wake up and begin to move is difficult. I have seen funds or investments that I thought should come to life and they do not. People want something tangible, and often this evidence only comes by visible activity on the price (valuation), and that action does not start according to our own timetable. In addition, some of the smartest portfolio managers often get fooled. They buy a cheap stock that has attractive valuation measures by almost any standard, and the stock just sits there, and sits there and sits there. Eventually they have to pull the plug and buy something else that should move, because their investors cannot just wait patiently forever, and the overall performance of the fund languishes because of those one or two securities that refuse to budge.

Patience is a Virtue, but It Has an Opportunity Cost

I have often heard that we should follow the smart money. And I have at times bought investments that I understood to have also been bought by the smart money or the corporate insider. But there would rarely be an indication from the smart money or corporate insider that the security would soon be moving, but rather that it was likely a solid investment. At least if the smart money is buying, perhaps they are just being impatient or afraid of missing the boat, rather than being concerned about getting in too early. They have the comfort of knowing that they are in for the ride when the stock does finally begin to move. So if the insiders are buying, you hope that have a good grasp of fundamentals. Of course there have been the Enrons, where even some of the senior management (supposedly) did not fully grasp all of the inner workings of the company, but just thought it was a good investment and hence bought more.

I also used to receive other types of public information on what corporate insiders were doing, and then I would try to follow them. But then the investment goes down, not up. Obviously there is no perfect formula for making money, and even smart people can blow it.

When to Get in, or out—Or at Least Pause

We may have heard the story of Joe Kennedy (the father of President John F. Kennedy) who sold out the vast fortune he made in stocks in the 1920s, when a shoeshine boy gave him a stock tip. He got concerned that the run-up got out-of-hand, when people who did not know anything about stocks, were now giving advice like the professionals.

Fear and greed apparently are very much alive and well in the investment world, even today. Eventually when everyone is talking positively of an investment or asset class, then likely everyone who wanted to buy it has done so, and there is no one else left to buy. And when everyone is trashing an investment and its prospects, there are few left who really want to sell. Of course when we get to that extreme stage, it does not mean we are poised for a turnaround, but rather at a point where we need to seriously consider that the primary trend is over and finished. Market behavior has not changed over the decades, and hence we still have booms and busts in all sorts of investments.

Illustration of Extreme Thinking—The Current "Pain" of the Canadian Dollar

This whole article was inspired primarily by what I now describe below, regarding the behavior of the Canadian currency. For our U.S. readers, you may or may not appreciate the following discussion, even though many of you may understand where people are coming from.

In the 1990s, the Canadian dollar slid dramatically, from an exchange rate of about 86 cents to one U.S. dollar at the end of 1989, to 65 cents at the end of 1998 (it went as low as 62 cents in 2002). There was even talk of it going down towards 50 cents. The Canadian currency was often touted as the northern peso (apologies to our Mexican friends).

I have often heard that we should follow the smart money. And I have at times bought investments that I understood to have been also bought by the smart money or the corporate insider.

Yet, as we know in the early part of this decade, concerns about the U.S. economy and its strength, the direction of U.S. interest rates and currency flows instituted by central banks (away from the U.S. dollar to the Euro, to balance and diversify their currency reserves) all put pressure on the U.S. currency worldwide. The Canadian currency (relative to the U.S. dollar) therefore went from 62 cents in 2002 to over 77 cents in 2003, to over 80 cents in 2004, to 86 cents near the end of 2005 and to 90 cents at time of this writing. Canadian investors have therefore been screaming the past few years, for their foreign investments have not been yielding much return, after considering currency shifts. "Why so much investment abroad, especially in the United States," some asked? There was (and still is) an attitude like, "Wasn't it obvious that the Canadian currency was going to go up? Did people not understand the problems underlying the U.S. dollar? Why did you not hedge against the U.S. currency? After all, we are Canadians—is it therefore not prudent to put all (or the majority) of one's investments in Canadian equities since we live in Canada, and thus most of our personal liabilities reside here (and forget all the Nobel Prize research of international diversification)?"

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Academic theory about global diversification has been hammered viciously in the Canadian environment the last several years. It is incredible how all of the education over the years about diversification, investing internationally, reducing volatility, increasing the opportunity set, etc., etc., has suddenly gone the way of the dodo.

On the other hand, American investors were rewarded for diversifying internationally, as their currency dropped relative to most others, enhancing return. The academics were right for Americans, but wrong and contrary to the view held by many "informed" Canadians.

It is always funny how these things work further. Mutual fund companies in Canada responded in recent years to the outcries, with funds that were "purely" or "highly" of Canadian content, to accommodate the screaming investors (but these funds were now poorly diversified globally). Everyone became afraid that the 25 percent appreciation in the Canadian dollar over 2003-5 was not over, and some have been talking as though another 25 percent appreciation is still in the cards. Foreign investment funds were simply not as popular, and thus selling poorly. And it turned out that those fund companies who catered to the screams of investors with funds that had higher Canadian content, have significantly increased assets under management, while those that stayed the course of international diversification lost ground. And those Canadian-focused funds showed relatively better performance numbers (again due to currency effects), which attracted even more fund buyers.

Even if the global investment promoters and academics could (in the past) win a Nobel Prize for theory, they would not be able to pay for a plane trip to collect the prize, if they tried to live and die off their research on global diversification, in Canada.

Eventually Canadian investors who buy heavily Canadian focused funds will be bitten for disregarding common sense and riding on emotion. Canadian investors can still earn gains over the next year or so if commodity prices and oil continue to rise and the U.S. dollar therefore continues to be relatively less attractive, but they need to be cautious and stop looking in the rear-view mirror. This is a lesson investors worldwide always have to learn, and it does not seem to sink in overall, regardless of where an investor lives.

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People Need to Think, Not Just React

Trends do continue for a time, and sometimes a long time, but I have often found that when most people begin to think a certain way, the trend's remaining lifespan will be short. And when the trend reverses direction, it will wipe out all those who got on the bandwagon late or even midway in the game (even if they made significant gains in the short-term) because it takes too much for them to change their minds and to realize that they are now wrong. And unfortunately the investment industry, afraid of losing business and assets, faces considerable pressure to accommodate the fears (and sometimes the greed) of investors, by giving them what they want. These attitudes all work to exaggerate the trends in one direction even further, resulting in a more severe backlash when things do turn around and reverse.

Conclusion

People have short memories, especially when it comes to sound education. Emotions often overrule common sense. And emotions are often interpreted with too much confidence as though they are truly fact.

Despite all of the fanfare of international diversification and prudent investing, we still have too much rear-view mirror investing, and it permeates the reaction of sales today. If one does not adhere to what investors want, it can hurt new sales. Many investors still need to learn to look ahead (not behind) and consider that the world can change against them. They need to respect the findings of academic theory that international diversification has its merits, and not disregard it completely because of recent activity, especially due to one factor such as currency shifts. Otherwise that one factor can also cause severe investment damage in the opposite direction, and these financial mistakes may not even be recouped over a couple decades.

From Page 1

Figure 1

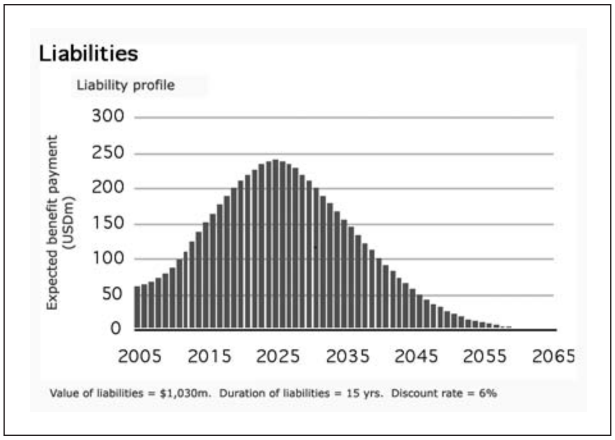
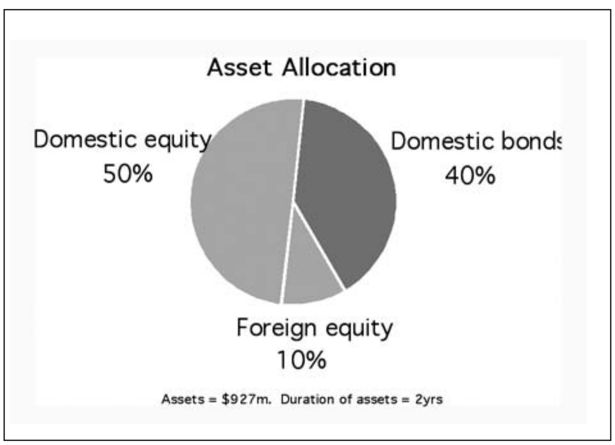


Figure 2



To evaluate how assets behave relative to liabilities we explicitly model the liability in the same framework in which we model assets. To do this, we focus on the fundamental factors that influence both assets and liabilities. Recognizing that pension liabilities are the present value of deferred wages and inherently sensitive to changes in interest rates and wage growth, the fundamental factors we select are real rates, inflation, economic growth, the equity premium and the bond premium. By understanding how sensitive both assets and pension liabilities are to these fundamental factors, we are able to derive correlations between assets and liabilities that capture the inflation and wage growth risks in addition to the interest rate risk of the liability. With these correlations, we can then develop a portfolio of assets that mimics the exposure of the liability.

For ABC Corporation this liability-mimicking asset portfolio (LMAP) consists of 80 percent long duration nominal bonds, 10 percent equities and 10 percent inflation-linked bonds. The LMAP is the low risk investment in our framework. This means that investing in this portfolio results in the best chance of tracking the liability as it grows and evolves over time. In addition, this is also the appropriate investment benchmark because if the return on the fund's assets beats the return on the LMAP, all stakeholders should be satisfied since the pension promises under-

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Table 1

	Asset-only approach	Funding ratio focused approach
Liability exposures	None	Term structure, inflation, growth
Low risk investment / Benchmark	Cash	Liability mimicking asset portfolio

Table 2

Risk/Return (1yr)	Current (60/40)
Return vs. liability	2.3%
Correlation (A,L)	56%
Funding ratio risk	11%
Prob. FR below 80%	9%
VaR (5%, $millions)	(150)

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lying the liability will be paid. Table 1 highlights the fundamental differences between the traditional asset-only framework and our funding ratio framework.

With the LMAP calculated, we are ready to analyze the funding ratio risk of ABC's pension plan. Since the LMAP is designed as a best offset to the liability's risks, funding ratio risk can be described as the volatility of a portfolio of assets that is long the investment policy and short the LMAP. Using our proprietary model we are able to analyze the funding ratio risk for ABC Corporation's pension plan given their current investment policy in Table 2.

ABC Corporation's current policy is expected to earn 2.3 percent in excess of the expected liability 'return' as denoted in Table 2. Expected liability return is defined as the return due to the passage of time, i.e., the interest cost of 6.0 percent. We've made the simplifying assumption that future service costs are met with future contributions for this case example, and therefore exclude future service costs from the calculation of liability 'return.'

... the majority of the assets' interest rate exposure comes from the short end of the curve. This means that even if the level of interest rates stays the same, but the slope and/or shape of the yield curve changes, the plan's funding ratio may be impacted.

While this return may be adequate to defease the plan's obligations over the long haul, the policy has a funding ratio risk of 11 percent, which means that the plan should expect its funding ratio to drop by at least 11 percent approximately once every seven years. In addition there is a 5 percent chance of the deficit increasing by at least $150 million over the next year. Large drops in funding ratio and increases in the deficit can have significant adverse consequences, not only for a pension plan, but also for the plan sponsor's earnings, cash flow and balance sheet. Given the nature of looming pension reform, these large drops in funding ratio will carry more severe and immediate penalties. Further, for corporations where the plan is large relative to the size of the company, the risk of a large drop in funding ratio should be carefully analyzed.

While there are many sources of funding ratio risk, there are three major sources:

1. **Interest rate risk or the duration mismatch between assets and liabilities:** When the duration of the portfolio differs from the duration of the liability, changes in the level of interest rates will impact the value of assets and liabilities in different amounts, thus causing a change in the funding ratio. ABC Corporation's current duration mismatch is large and amounts to approximately 13 years (15-year liability duration minus the two-year duration of the investment portfolio). Further, the majority of the liability's interest rate exposure comes from the long end of the curve and the majority of the assets' interest rate exposure comes from the short end of the curve. This means that even if the level of interest rates stays the same, but the slope and/or shape of the yield curve changes, the plan's funding ratio may be impacted. Thus, for ABC Corporation, large changes in the level, slope or shape of the yield curve can cause large changes in the plan's funding ratio.

2. **Inflation risk:** ABC's liabilities are linked to salary growth and thereby to wage inflation. In addition, many plans have benefit payments that are indexed to inflation (*e.g.*, most of the U.K. plans and the majority of public sector U.S. plans). If actual inflation differs significantly from assumed inflation and the inflation exposure remains unhedged, the funding ratio will be exposed to inflation risk. ABC Corporation's current policy has no allocation to inflation-linked assets.

3. **Equity market risk:** Plans with high allocations to equities in their asset allocation are exposed to a third source of funding ratio risk—equity market risk. While a small allocation to equities will be beneficial for long-term hedging purposes, a high allocation to equities will increase short-horizon risk considerably. ABC Corporation currently has half of its pension plan's assets in domestic equities.

The ALIS approach

There is no simple one-size-fits-all solution to the pension problem. We are faced with the challenge of building, measuring and managing investment policies that reduce funding-ratio risk while generating enough return to keep the expected cost of defeasing the obligation at a tolerable level.

ABC Corporation could invest in the LMAP and this would be the low risk investment. This means that investing in this portfolio results in the best chance of tracking the liability as it grows and evolves over time. However, by definition, the LMAP is meant to mimic the liability, not outperform it. Thus, it will not provide an expected return in excess of the liability and therefore future service benefits and benefits earned by future participants could only be defeased by future cash contributions.

Often, this low risk strategy will be too expensive for plan sponsors to maintain over the long run. Therefore, in most cases, we do not recommend investing in the low risk portfolio, but only measuring investment risk against it. The challenge is to find the most efficient way to allocate more assets to "higher returning" asset classes, such as equities, while minimizing the amount of unrewarded risk taken versus the liability. This can be approached in two steps. First, hedge unrewarded (liability) risk, and, second, generate returns more efficiently.

Step 1: Hedge unrewarded risk

First, we must tackle the duration mismatch by reducing interest rate risk—the liability's largest risk factor. Under most market conditions a plan is not rewarded for a duration mismatch between assets and liabilities. By reducing or eliminating it, we can decrease funding ratio risk significantly. Interest rate derivatives can be used to synthetically represent the interest rate exposure of the liability within selected key rate duration buckets, essentially eliminating the funding ratio risk attributable to changes in the level, slope, and shape of the yield curve. For example, interest rate swaps can be a very efficient way to accomplish this. Additionally, utilizing derivatives to hedge requires far less capital than cash investment, thus, freeing up capital to be invested in "higher returning" assets.

Next, we look at inflation risk. The active cash flows of ABC's plan are sensitive to salary growth. One part of overall wage growth is wage inflation and wage inflation is linked to general inflation. As a result, the plan needs exposure to asset classes with cash flows that vary with inflation, such as inflation-linked bonds. This is exactly why ABC Corporation's LMAP includes an allocation to inflation-linked bonds. Plans that provide inflation indexation to retirees are even more sensitive to inflation changes and would require a larger allocation to inflation-linked bonds or inflation swaps.

Finally, we consider real wage growth risk. The active cash flows of ABC's plan are not only linked to wage inflation, but also to real wage growth. Real wage growth is linked with economic growth through labor's share of productivity increases. Equities' cash flows through corporate earnings are also related to economic growth and will provide a long-term link to changes in the liability cash flows attributable to future real wage growth. This is why ABC Corporation's LMAP includes an allocation to equities.

Thus, by adding an interest rate swap overlay and shifting 10 percent of their assets from nominal bonds to inflation-linked bonds, ABC Corporation can hedge their liability risk with minimal changes to their current cash investment portfolio. The benefits of hedging liabilities this way can be seen below as the first step in Figure 3.

Step 2: Efficient return generation

To defease the liability as it evolves over time and manage the long-horizon economic cost of the plan, we must also focus on return generation. ABC Corporation's plan has three weaknesses in its approach to return generation.

- First, it concentrates almost all of the market exposure to domestic assets. Simply by diversifying their equity exposure across the globe, allocating a larger percentage of overall equity beta to foreign equity and emerging market equity, ABC Corporation can increase expected return and decrease funding ratio risk.

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- Second, ABC has a poor balance between alpha and beta. ABC Corporation's current investment policy only has a 1 percent relative risk budget. By allocating more risk to active management, ABC Corporation can reduce its allocation to market risk and maintain or even increase the returns they need. As a result, allocating more risk towards active management provides an opportunity to further reduce funding ratio volatility and increase return.

- Lastly, ABC Corporation does not take advantage of the illiquidity premium that certain asset classes offer. Like most pension funds, many of ABC Corporation's obligations don't come due for over 30 years so they are in a unique position to take advantage of the illiquidity premium the market grants for assets classes such as private equity and real estate. Taking this final step can further increase return while providing even more diversification.

Thus, to improve return generation we consequently allocate assets to a wider investment universe in search of alpha and we better diversify and dynamically manage the sources of market return. Visually, the benefits of first hedging the liability and then generating return more efficiently can be seen in Figure 3 below.

Investment Proposal

Our recommendation includes the use of bonds, and interest rate swaps to manage the impact interest rate changes have on the funding ratio. The remainder of the solution includes a well-diversified portfolio, including domestic equities and inflation linked

Figure 3

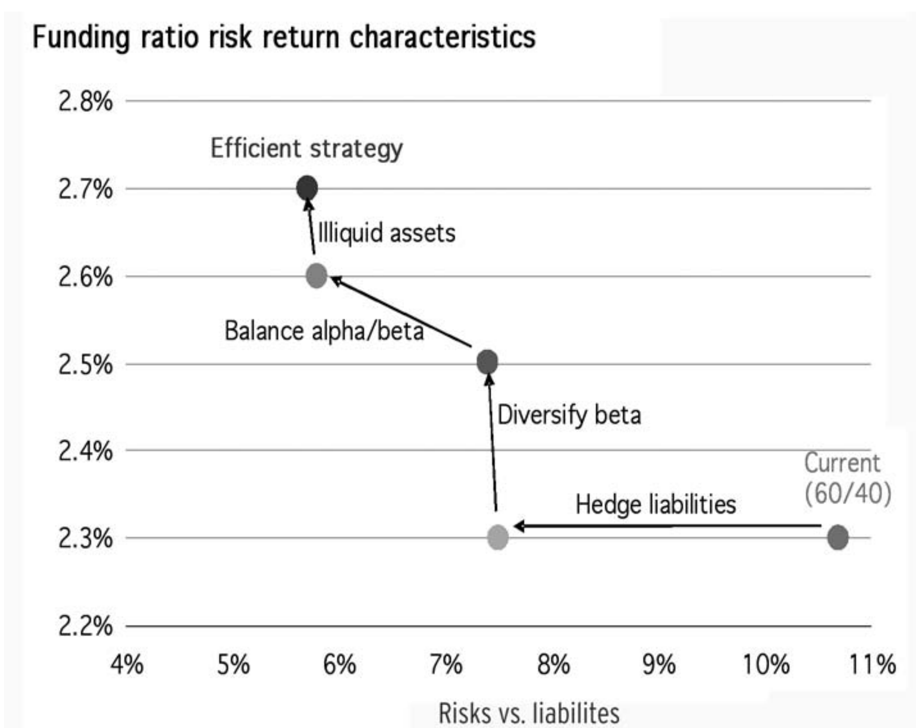

Table 3

Investment policy	60/40	Efficient
Domesticbonds	40%	33
Foreign bonds	0	12
Inflation-linked bonds	0	15
Domestic equity	50	15
Foreign equity	10	10
Emerging market equity	0	5
Private equity	0	5
Real Estate	0	5
Total	100%	100%
Active Risk	1%	2%
Information ratio	0.50	0.50
Asset Duration	2	4
Overlay Duration	0	11
Liability Duration	15	15
Duration Gap	-13	0
Exp Return over liability	**2.3%**	**2.7%**
Correlation (A,L)	**56%**	**94%**
Funding ratio volatility	**11%**	**6%**
Prob. of FR below 80%	**9%**	**<1%**
VaR (5%, $millions)	**(150)**	**(81)**

bonds to track the wage growth of the liabilities, and an allocation to illiquid assets to provide further diversification and additional expected return. We also allocate more risk to active management, which allows us to offset the reduced return from lowering the overall equity exposure. Of course, if the manager does not actually deliver a positive alpha, then the expected benefits of active management will not be realized. The current allocation and proposed "efficient" allocation can be seen in Table 3 above.

As Table 3 shows, by taking this approach:

- The correlation between assets and liabilities has been increased significantly and therefore the funding ratio risk has almost been cut in half.

- The probability to fall below 80 percent funding ratio decreased from 9 percent to <1 percent and the worst 5 percent of outcomes are now significantly more tolerable.

- The expected return on assets relative to liabilities has actually increased from 2.3 percent to 2.7 percent. This is mainly due to the fact that capturing a broader set of return opportunities and expected returns from dynamic management of market, currency and security selection and the allocation to the higher returning asset classes of private and emerging market equity more than offsets the reduced overall exposure to equity markets.

Less Volatility, Better Returns

This example illustrates how modern investment tools along with innovative asset-liability modeling techniques can help pension plans reduce funding ratio risk while keeping or even increasing the expected returns. Thus, this concept offers a promising new approach to sponsors who are willing to lead the way and implement investment solutions that are based on their real objectives—their liabilities.

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Implications of Real World Customer Behavior in Risk Neutral Hedging

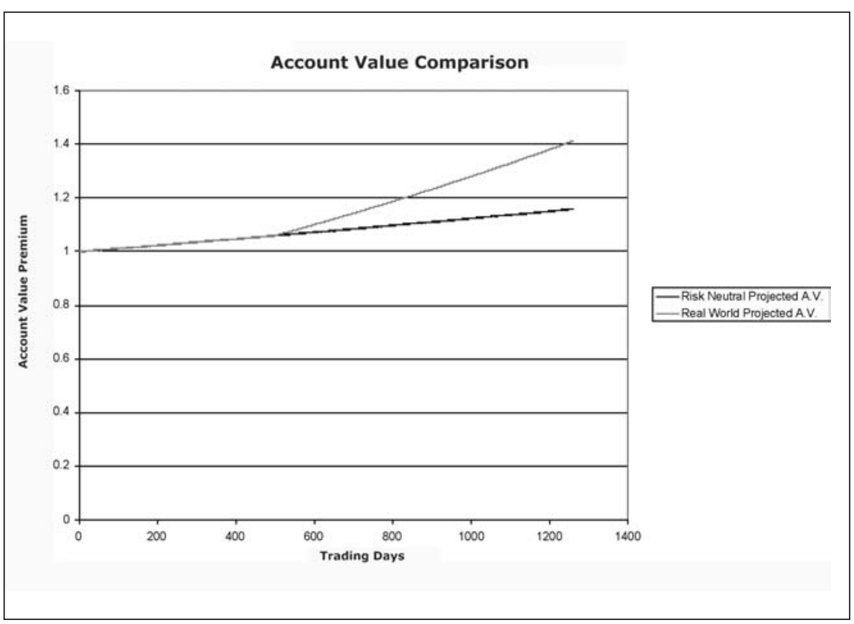
by Mark Evans

Some have suggested using real world assumptions for determining customer behavior when calculating hedge positions to support minimum guarantees for variable annuities. Real world is also referred to as realistic. This article discusses a simple simulation model that analyzes the implications of this approach.

This involves what happens at future nodes in Monte Carlo simulations used to calculate option values and associated greeks. Real world customer behavior might be employed in a hedging program by basing customer behavior at a specific future node in a specific simulation path not on the account value for that node projected on a risk neutral basis from the current time, but on a real world projection from the current time. This will be referred to as the real world shadow account.

Table 1 below gives an example. Here, we are at the end of the second policy duration for a contract being hedged. The lower curve represents a risk neutral path starting at year two. The upper curve represents the real world shadow account starting from the same point at year two. When using the real world shadow account approach to hedging, all calculations are based on risk neutral projection of account value, except that customer behavior will be based on the real world shadow account. In this article we will also look at hedging results where customer behavior is based on the risk neutral projections of account value. This will be referred to as risk neutral customer behavior.

Table 1



This article will show that the use of a real world shadow account will result in an under-hedge or partial hedge. This will result in hedge income falling short of option payoffs for adverse (falling market) paths.

This article starts by describing the model used to simulate the hedging process. In this model, interest rates and volatilities are assumed to be fixed. Hence, only delta hedging is required. This is achieved by the use of futures contracts. Next, some modeling considerations are discussed that provide additional background to help support the remainder of the article and information helpful to the reader wishing to reproduce these results. Then, the article presents the numerical results of the modeling followed by a discussion of why the results occur. Lastly, other considerations are discussed.

Model Description

The model is based on a guaranteed return of 125 percent of premium at the end of 10 years. In other words, this is a 10-year European put struck at 125 percent. The premium in the model is $100,000 so the strike is $125,000. The customer has the option to surrender the contract for the account value at the end of five years. Otherwise, there are no decrements for mortality, surrender or partial withdrawal. There are no fees or other deductions from the account value. The risk free interest rate is 3 percent, the real world equity growth rate is 10 percent and the volatility is 14 percent for both. The entire account value is in equities. Thus the account value growth equals the assumed equity growth. Unless otherwise stated, typical Black-Scholes assumptions are used.

To simulate delta hedging, the model uses daily rebalancing during the first five years. It produces two sets of greeks, one set projecting the account value on a risk neutral basis for the purpose of determining customer behavior and one set using a real world shadow account. The first set will be referred to as risk neutral greeks, and the second set will be referred to as real world greeks. The same random normal variables are used for both sets of greeks. Delta is calculated by shocking up and down by 1 percent, taking the difference of the two shocked paths, and dividing by 2 percent. Delta is applied to each trading day's percentage stock market change, increased by interest imputed from the corresponding short position or futures position. Hedging cash flows are accumulated at 3 percent. The hedging simulation assumes an initial cash position equal to the option value calculated assuming risk neutral customer behavior.

The persistency factor is equal to (-1) times the put delta at the end of five years where the strike is $125,000 and the current asset level is equal to the account value at the end of five years. The put delta is based on a 10 percent interest rate. Note this corresponds to the real world equity growth rate. This will be discussed at greater length later in this article. Volatility is based on 14 percent. Since the customer receives the total return and there are no account fees, the dividend is assumed to be zero. Thus the persistency factor approaches 100 percent as the account value at the end of five years approaches zero and the persistency factor approaches zero percent as the account value at the end of five years approaches infinity. For the graph on the previous page, the persistency factor is .019 for the real world projected account value while it is .075 for the risk neutral projected account values.

This method is arbitrary and other methods could be employed. It does have the desirable characteristics of:

1) Causing the customer to be more likely to retain the contract when the option is more valuable since the delta is related to the probability of payoff,
2) Smoothness,
3) Being continuous,
4) Being well-behaved, and
5) Being intuitive.

The method is not intended to represent an optimal exercise function. In practice, variable annuity minimum guarantees tend to be priced using "semi-optimal" exercise functions where customers are more likely to persist when embedded options are of greater value, but customers do not behave in an entirely optimal fashion.

Since the customer can only surrender at the end of five years, after that point the notional amount of the option is fixed so the option value at the end of five years can be valued analytically using the standard Black-Scholes formula for a European put. The inputs for calculating the option value are the same as for the delta calculated in the paragraph above except the interest rate is 3 percent to reflect the market price based on capital markets pricing.

This is much simpler than any actual variable annuity minimum guarantee, but this is path dependent and contains dynamic customer behavior. Thus, this model permits analysis of real world customer behavior.

Modeling Considerations

The initial option values, one based on risk neutral projection of account values to drive customer behavior and one based on a real world shadow account, are based on 2 million scenarios. This can actually be done very quickly, because here we are not trying to produce daily results. We just need one random variable to determine the account value at the end of five years. As mentioned earlier, at the end of five years, customer behavior is applied and then the value of the option at that point is directly calculated by the Black-Scholes formula for a put. The large number of scenarios increases the accuracy of the option value that in turn is very important for simulating the hedge. Statistical sampling errors in the initial value tend to have a larger impact on the simulation than corresponding errors in subsequent greek calculations.

In practice, variable annuity minimum guarantees tend to be priced using "semi-optimal" exercise functions where customers are more likely to persist when embedded options are of greater value, but customers do not behave in an entirely optimal fashion.

The model uses daily rebalancing assuming 252 trading days annually during the first five years, antithetic scenarios and parallel shock paths for calculating delta to reduce modeling error. For each model day in simulating hedging along a given path, greeks are determined using 2000 random scenarios plus associated shock scenarios. Each random scenario corresponds to a single random normal variable which is multiplied by the square root of the time from the model day to the fifth contract anniversary. This produces an account value that determines the value of the five-year put option, and the delta to determine the persistency factor. The product is then discounted back to the current model day.

Thus, while the model is a stochastic on stochastic model, it can be run on a PC in several hours using VBA.

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The model can use previously determined normal random variables read in from a spreadsheet to produce daily stock changes, or it can produce normal random variables on the fly to produce daily stock changes. For simulated hedging, greeks calculated after time zero are always based on normal random variables produced on the fly.

The following outline summarizes the modeling steps:

1. Calculate initial option values
   a. 2 million scenarios.
   b. First five years covered by one random variable.
   c. Calculate persistency based on delta of a put.
   d. Calculate option value of five-year put based on account value at end of five years.
   e. Discount step d. above five years at 3 percent to get present value for scenario.
   f. Done based on both a risk neutral account value projection to predict customer behavior and using a real world shadow account.

2. Calculate random paths
   a. Use an option value based on risk neutral customer behavior as the initial hedge cash position.
   b. 252 trading day steps per year for five years for a total of 1,260 steps.
   c. Calculate delta for each day based on 2000 scenarios.
   d. Each of the 2000 scenarios uses a random variable to predict index change from trading day to the end of five years.
   e. Use delta to determine hedge position and the hedge cash flows.
   f. Accumulate with interest at 3 percent.
   g. Compare with five year put option value at the end of five years to determine hedge effectiveness.
   h. Done based on both a risk neutral account value projection to predict customer behavior and using a real world shadow account.

Table 2

Hedging Simulation—Very Bad Market

Hedging Simulation		Risk Neutral Behavior			Real World Behavior		
Period	Stock Price	Option Value	Cash Position	Delta	Option Value	Cash Position	Delta
0	100,000	4,860	4,860	-21,297	878	4,860	-5,321
126	87,922	8,355	8,352	-32,087	2,177	5,855	-11,457
252	76,869	13,572	13,624	-45,445	4,728	7,935	-22,241
378	66,916	21,147	21,185	-59,033	9,740	12,202	-38,835
504	60,956	27,778	27,866	-67,211	15,683	16,897	-53,433
630	59,821	30,079	30,031	-70,576	19,135	18,336	-60,850
756	60,309	30,469	30,482	-74,837	21,038	18,281	-67,227
882	54,699	39,230	39,100	-77,586	31,510	25,994	-78,092
1008	53,441	42,624	42,531	-79,444	37,307	29,085	-81,908
1134	54,105	43,381	43,287	-83,324	40,608	29,576	-85,221
1260	52,594	47,651	47,554	0	47,651	33,591	0

Model Results

The initial option value using risk neutral customer behavior is 4,860 while the value is 878 using the real world shadow account. Obviously these are very different option values, but we will see that the assumptions used to justify the 878 option value leads to an inadequate hedge.

The model was used to calculate payoffs for 250 paths based on predetermined sets of normal random variables. The drift rate used for these paths was 10 percent. A detailed analysis was performed on the path producing the lowest account value at the end of five years, and therefore the largest option payoff. The account value at the end of five years was 52,594 producing an option value at the end of five years of 47,651. Using risk neutral greeks, the hedges produced a cash position of 47,554 at the end of five years while using the real world greeks produced a cash position of 33,591. The risk neutral difference is due to daily versus continuous rebalancing and statistical error in calculating delta. The cause for the significant shortfall using real world greeks is illustrated in the following table on the bottom.

Table 2 is taken from the hedging simulation. It shows the hedge cash position and delta at the end of every six months. The actual simulation produces this same information for each trading day. In the earlier periods, the real world behavior delta is much lower because the real world shadow account results in a lower expected persistency. For example, at the end of one year, the stock price is 76,869, which is used as the starting point for calculating both the risk neutral behavior delta and the real world behavior delta at that point. Both the risk neutral behavior analysis and the real world behavior analysis shown above are following the same real world base path, only the hedging approach varies. The risk neutral behavior delta is -45,445 while the real world behavior delta is -22,241. This is because the real world behavior deltas are calculated assuming a projected account value at the end of five years that is (1.1/1.03)^4 = 1.3 times that used to calculate the risk neutral behavior deltas. The higher account values produce a lower estimated persistency.

In later periods, the real world shadow account and the risk neutral projection converge as time approaches five years. Thus the deltas align more closely, and in fact the real world deltas become slightly larger as the put delta is very close to -1 and the 1 percent shock applied to the account value has a bigger impact on the shadow account than the risk neutral projection. But it is too little, too late as the real world cash position is already hopelessly behind.

Table 3 to the right is based on the path producing the largest account value at the end of five years. Here the understated real world deltas work to the advantage of the real world hedging simulation as the lower deltas result in smaller cash outflows as a result of the rising market.

The hedging simulation was performed for an additional 98 real world paths using both risk neutral greeks and real world greeks yielding the following statistics for the 100 real world paths:

		Risk Neutral	Real World
Error:	Average:	0.19	2,685.31
	Std. Dev.	186.98	2,515.16
	Maximum	621.73	4,481.90
	Minimum	(426.63)	(14,060.66)

It is also interesting to look at the hedging error as a function of ending five-year account value graphically in Table 4 to the right.

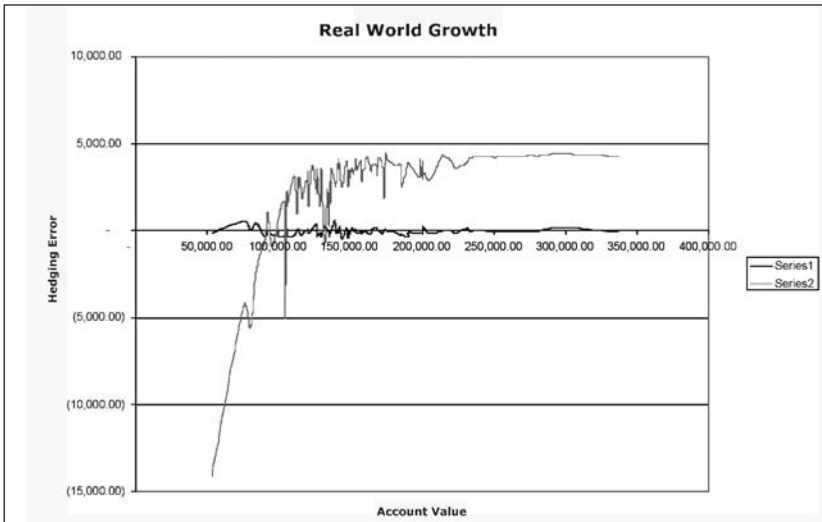
Series 1 in Table 4 shows the hedging error associated with risk neutral that is essentially zero. Series 2 shows the hedging error associated with real world that is very negative for in the money paths, but positive for out of the money paths. For the higher account values, the real world hedging error appears to approach an upper bound. In fact, this upper bound can be calculated easily. When the value of the option at the end of five years is near zero, the real world shadow account results in a lower delta based on an expected option cost of 878. As long as there is not material value to the option at the end of five years, then the hedging costs will approach 878 on a present value basis. Compared to the initial hedging cash position of 4,860, this produces a difference of

Table 3

Hedging Simulation—Very Good Market

Hedging Simulation		Risk Neutral Behavior			Real World Behavior		
Period	Stock Price	Option Value	Cash Position	Delta	Option Value	Cash Position	Delta
0	100,000	4,860	4,860	-21,297	878	4,860	-5,321
126	109,934	2,979	3,059	-15,083	535	4,425	-3,502
252	140,778	710	672	-4,644	101	3,947	-848
378	163,322	192	165	-1,559	25	3,911	-242
504	197,764	28	-2	-289	3	3,942	-39
630	215,939	5	-21	-69	1	3,998	-9
756	226,005	3	-26	-35	1	4,057	-7
882	225,710	1	-28	-12	0	4,117	-3
1008	237,735	0	-29	-4	0	4,178	-1
1134	288,086	0	-29	0	0	4,240	0
1260	335,960	0	-30	0	0	4,303	0

Table 4



3,982 which accumulates with 3 percent interest to 4,616 which is close to the 4,482 maximum hedging error shown on page 13.

The real world hedging curve in the graph above is very choppy for the money paths. This has to do with the actual development of the path. If the market drop occurs early when the delta is significantly understated, then significant under-hedging results and there is a large negative hedging error. If

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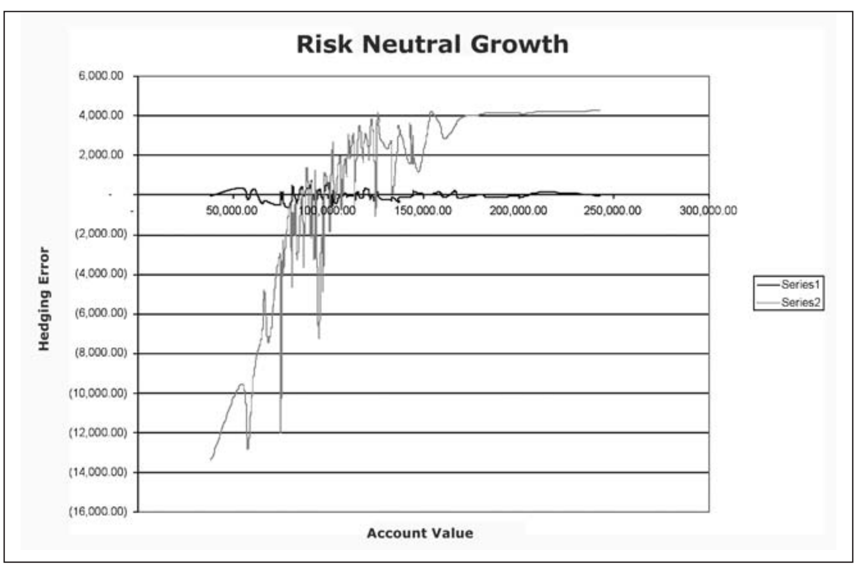
the market does not drop until later, then hedging error is small even if the ending account value is small. A practical implication is that the hedging error is not well behaved in that there is not an easy way to predict or describe it. While one may view use of a real world shadow account as a partial hedge, it lacks proportionality, tail protection, etc. that one might desire from a partial hedge.

The above analysis was performed based on 100 random scenarios that assumed real world drift rates of 10 percent. Under this assumption, the real world hedging produces better results on average, but significantly underperforms in down markets. The point here is that even if one is correct in assuming the expected growth rate is 10 percent, that does not mean that use of a real world shadow account produces an unbiased hedge. This is another example of diversification or averages failing to address capital market risks in the manner they address mortality, morbidity and many other risks.

At this point, the problems with using a real world shadow account in hedging calculations have been demonstrated. Looking at what happens with risk neutral paths provides some additional insight. It is often helpful to look at issues assuming both risk neutral and real world scenarios.

Table 5



A similar hedging simulation was performed on the corresponding 100 risk neutral paths (based on a drift rate of 3 percent) yielding the following statistics:

		Risk Neutral	Real World
Error:	Average:	(0.68)	149.80
	Std. Dev.	248.68	3,839.34
	Maximum	739.91	4,269.28
	Minimum	(590.96)	(13,345.96)

The results appear graphically in Table 5 below. Once again, Series 1 in the above shows the hedging error associated with risk neutral that is essentially zero. Series 2 shows the hedging error associated with real world. We get similar results, except that now the average hedging error is not significantly different from zero for either the risk neutral greeks or real world greeks. The average hedging error for Series 2 would be zero with continuous rebalancing, and infinite scenarios because any hedging strategy will have an expected error of zero across a distribution of risk neutral paths. This is easy to see in the simple case of a hedging strategy consisting of holding cash. The initial cash position would be equal to the risk neutral option value that would then grow at the risk neutral rate. Along any given path, the cash position could dramatically over- or under-perform, but on average would give the correct result. In this example, the bias would still remain with continuous rebalancing, and infinite scenarios causing a large standard deviation of the hedging error per sample path.

The model assumes customer behavior based on a put delta that used the real world equity growth rate of 10 percent for both risk neutral greeks and real world greeks. Unlike the real world shadow account, this customer behavior assumption does not introduce a bias into the hedge result. The calculation is only a function of a judgement of customer behavior, and does not violate any risk neutral principles (subject to earlier disclaimers about optimal exercise). This is an important distinction. A customer behavior function based on risk neutral projected account values during the first five years does not violate any risk neutral principles, regardless of the input parameters with regards to the customers view of the future relative to the end of the fifth contract year. In other words, if one assumes that customer behavior will be based on a put delta of 10 percent and customers really behave that way, the hedge will be accurate. If one assumes that customer behavior will be based on a put delta based on 3 percent and customers really behave that way, the hedge will be accurate. If one assumes that customer expectation will be based on a put delta based on 7 percent and customers really behave that way, the hedge will be accurate. If one assumes that customer behavior will be based on ignoring the time value of money and customers really behave that way, the hedge will be accurate. On the other hand, if one assumes customers will behave one way, and the assumption is wrong, then the hedge will be inaccurate.

Why?

Customer behavior describes reactions to specific conditions at a future point in time. The more accurate the assumptions surrounding customer behavior, the more accurate the hedge. The real world shadow account, however, modifies the specific conditions at a future point in time that are used to predict customer behavior. This modification results in an inaccurate hedge, even if the customer behavior function is correctly predicted.

Conceptually, hedging exchanges an uncertain account value return with a return based on the risk neutral interest rate. If we hedge by shorting an asset, we receive cash when we short that we can earn interest on at the risk neutral rate. If we use futures, the price decay imputes the same interest earning. Hedging cash flows are then invested at the risk neutral rate, not the real world rate associated with equities. Thus our hedging simulation is inconsistent if we assume a real world shadow account at the same time we have exchanged an uncertain equity growth for the risk neutral rate.

One may argue that risk neutral weights adverse paths too heavily. This has been the subject for some debate, but when hedging a path associated with a down market, whether that down market is caused by a negative deviation associated with the volatility portion of Brownian motion or a lower drift rate, is both undeterminable and irrelevant. The fact that a path is a low probability path does not change the fact that the hedge applies to the path you experience and to be fully hedged, one cannot use a real world shadow account. In this example, the cost to be fully hedged is the 4,544 associated with the initial option value using risk neutral customer behavior.

Other Considerations

This article is based on a simple example. The conclusions still apply with stochastic interest rates and/or stochastic volatilities. While this article discusses real world shadow accounts as employed directly in a hedging program, other techniques using real world account projections in some manner to determine customer behavior will lead to an under-hedge as well.

Mark Evans, FSA, MAAA, is vice president and actuary with AEGON USA, Inc. in Louisville, Ken. He can be reached at mevans@aegonusa.com.

Past Highlights of *Risk and Rewards*

10 Years Ago –

The December 1995 issue had two articles on genetic algorithms and another using chaos theory to explain movements in Treasury bond yields. That issue turned out to be pretty much the peak of actuarial interest in artificial intelligence and chaos theory. According to an electronic search of the actuarial library, there was an article in *ARCH* in 2001 on neural networks and genetic algorithms. The only other references to chaos theory appeared in 1996.

15 Years Ago –

In November 1990, former SOA President Jack Bragg explained his theory of economic series. The theory identified four categories of economic periods, each with different implications for inflation, interest rates and the stock market. Coincidentally, the December 1995 issue of *Risks and Rewards* reported that Bragg's theory had been adopted by an actuarial committee on mortgage defaults.

Indirect Property Investing—An Alternative to Direct Ownership?

by Nancy Holland

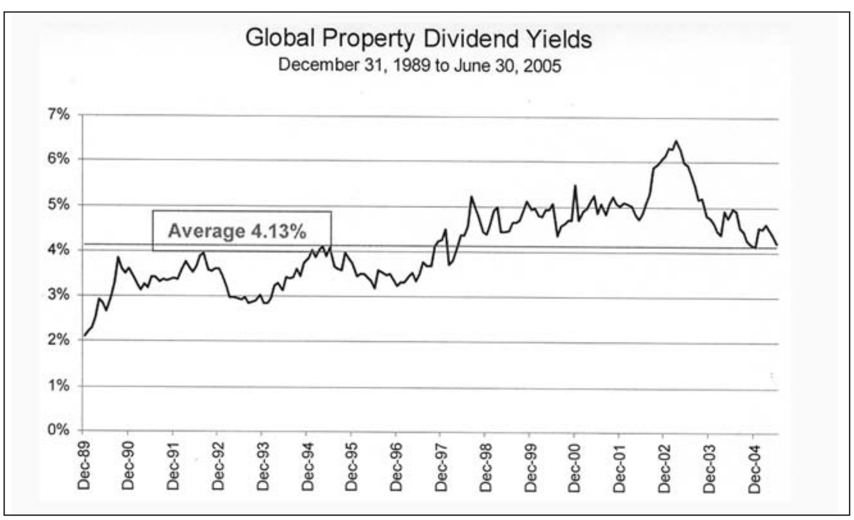
Nancy Holland, is Global Head of Property with ABN AMRO Asset Management in Chicago, Illl. She can be reached at (312) 884-2337 or via e-mail at nancy.holland@abnamro.com.

As institutional investors seek alternative sources of return and income, their attention has returned to real estate. Investors can access the real estate markets in two general ways:

- *Direct real estate:* Directly owning real estate properties, either individually or through pools; or
- *Indirect real estate:* Purchasing equities of listed real estate companies.

Historically, pension funds have used direct investments in real estate. The asset class offers some very attractive features, including a stream of rental income, the ability to hedge inflation, potential for capital gains and diversification.

At the same time, investing directly in real estate —whether by owning buildings or by participating in pools of buildings—has a number of drawbacks as well. Not the least of these drawbacks are illiquidity and the lack of a meaningful asset valuation most days of the year. When these drawbacks made their presence felt in the early 1990s, many pension funds reduced their exposure to this asset class—once they were able to do so.



Source: GPR, ABN AMRO Asset Management

Perhaps it is not a coincidence that the early 1990s also witnessed the rapid expansion of a new, liquid way to invest in the real estate markets—the real estate investment trust or REIT. In 1990, REITs accounted for under 20 percent of the total market capitalization of U.S. real estate investment, while by 2000 REITs had become about 70 percent of the (much larger) total. This vehicle, together with similar publicly traded real estate equities, has grown in use worldwide. But does indirect real estate offer pension funds a way to access the benefits of direct ownership of real estate described above?

Meeting Pension Funds' Objectives

In fact, indirect real estate investment does provide income (based on rents and hence linked to inflation), growth potential and diversification.

The graph on this page shows the historical dividend yield of the Global Property Research 250 Index, a global index of listed real estate equities. Over the 15 years through mid-2005, the dividend yield of the index has averaged over 4 percent per annum.

In addition, as shown in the following graph on the next page, over the last 20 years indirect real estate has provided the same return as global equities.

The graph on the next page also suggests that at times indirect real estate moves quite differently from general equities, and this is borne out by the low correlation between the two: For the 10 years ending April 2005, the correlation of the GPR index with the MSCI World Index was 0.5 (all figures in CAD).

Furthermore, a number of U.S. studies have shown that when the differences in the character of the indirect and direct real estate indices are taken into account, the risk and return characteristics of the two approaches are very similar (see for example Public versus Private Real Estate Equities—A risk-return comparison, Joseph L. Pagliari, Kevin A. Scherer and Richard T. Monopoli, *The Journal of Portfolio Management, Special Issue 2003*).

Thus, indirect real estate investing can meet the same objectives as direct real estate.

Additional Benefits of Indirect Real Estate

Because indirect real estate investing uses listed equities, it incorporates all the benefits of the listed equity markets including liquidity and transparency. Capital requirements are minimal and lock-up requirements non-existent. In addition, indirect real estate makes it much easier for institutional investors to obtain broad diversification across geographic regions and real estate industry sectors.

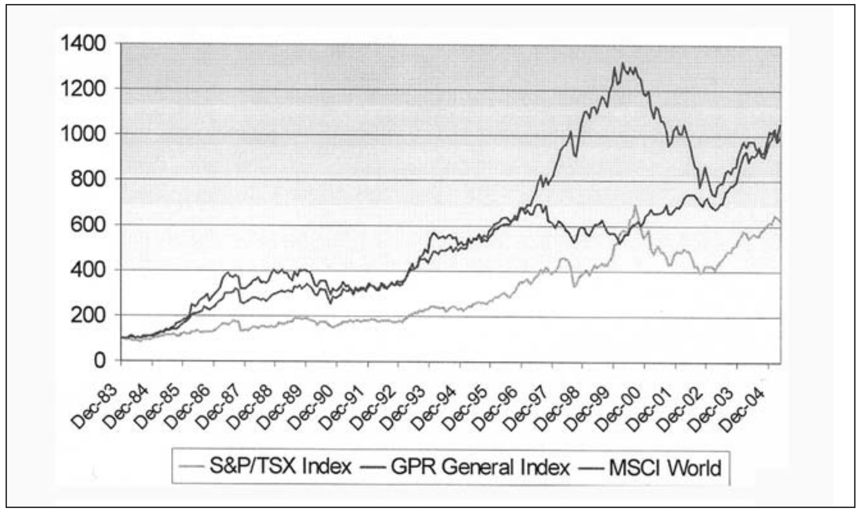
As the chart to the right makes clear, geographic diversification makes excellent sense, as no one region of the world systematically under- or over-performs:

Real estate is very much a local phenomenon; office rents in Singapore have little to do with warehouse rents in Chicago, for example. Indeed, unlike general equities where the correlation across different countries is quite high and the main contribution to diversification comes from industry and stock-specific factors, country diversification is high in the indirect real estate markets. The chart below illustrates this fact by breaking out the country components of the GPR 250 Index in a five-year risk/return scatter graph.

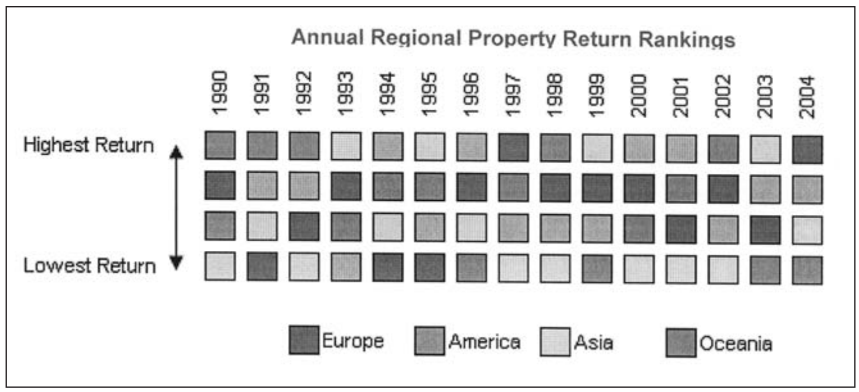
Regional correlations are quite low, and regional dividend yields are also at times countercyclical, so that the global diversification possible through indirect real estate can generate stable returns and yields through time.

Conclusion

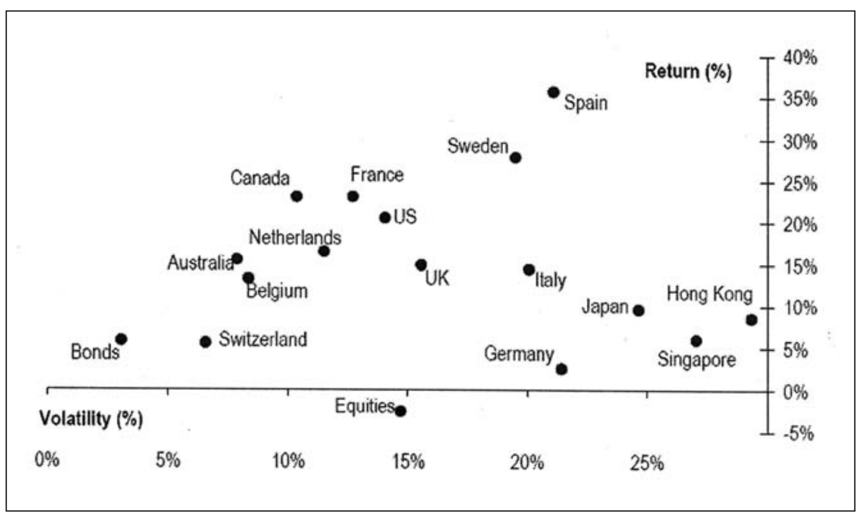
Indirect real estate investing offers pension funds and other institutional investors all of the benefits of direct property ownership while eliminating many of the drawbacks of direct ownership. In addition, indirect investing allows much greater diversification across geographic regions and real estate industry sectors, enhancing further the benefits of the asset class.



Source: ABN AMRO Asset Management – total return indices in CAD



Source: GPR, ABN AMRO, all indices are total return indices, measured in local currencies



Source: GPR Market Update August 2005 — local currencies

The 8th Bowles Symposium

presented by Georgia State University

Editor's Note: This symposium was the Second International Longevity Risk and Capital Market Solutions Conference. It was held in Chicago on April 24, 2006. It was hosted by the Bowles Chair, the American Risk and Insurance Association and the Pensions Institute.

Organized by: Professor Richard MacMinn (American Risk and Insurance Association) and Professor David Blake (Pensions Institute).

Sponsored by: Edmondson-Miller Chair of Illinois State University, the Actuarial Foundation, Society of Actuaries, Bowles Chair of Georgia State University, American Risk and Insurance Association, Lehman Brothers Europe Ltd. and ABN AMRO. The papers referenced here may help investment actuaries keep pace with new developments in this fascinating arena.

Motivation

As populations in countries around the world age, governments, corporations and individuals face increasing risk. Pay-as-you-go state pensions and corporate pension plans are beginning to put severe financial pressures on governments and companies. Mortality improvements, especially at older ages, make it ever more likely that individuals with inadequate pension arrangements will end their lives in poverty.

Capital markets do provide governments, corporations and individuals a means of transferring risks and resources across time as well as across individuals. Similarly, individuals can transfer money forward via security purchases to fund the retirement years. However, existing instruments do not allow agencies, corporations or individuals to effectively hedge the longevity risk that they face.

Instruments can be constructed to alleviate these problems. The mortality-linked securities issued by Swiss Re in April 2005 and EIB/BNP Paribas longevity bond announced in November 2004 to cover mortality surprises on the life and annuity contracts are two recent examples. The EIB/BNP Paribas bond will be the world's first example of a longevity (or survivor) bond. A longevity bond pays a coupon that is proportional to the number of survivors in a selected birth cohort; letting the cohort be the number of individuals turning 65 in the year that the bond is issued, the coupon the following year would be proportional to the number in the cohort that survive to this year. Since this payoff approximately matches the liability of annuity providers, longevity bonds create an effective hedge against longevity risk.

Longevity risk in conjunction with interest rate risk has created problems for the annuity market. The immediate annuity market in the United States is approximately $2 billion per year while the U.K. immediate annuity market is approximately $10 billion per year. As more and more baby boomers retire, annuity markets will grow as will the risk and consequences of underestimating mortality improvements. The whole private sector pension system in developed economies like the United States and United Kingdom are potentially at risk without hedging instruments such as longevity bonds. At the same time, the newly developing economies of Latin America, South East Asia, Eastern Europe and the former Soviet Union states, which are attempting to establish private sector pension systems, often under World Bank guidance, are likely to find that these attempts are frustrated by the absence of annuities markets which cannot get off the ground without the existence of hedging instruments to help annuity providers hedge the longevity risk they face.

Conference Speakers

A Demographer's Perspective of Longevity Risk

Eric Stallard, Duke University; e-mail: *eric@cds.edu*

Political Economy of Government Issued Survivor Bonds

Jeffrey Brown, University of Illinois; e-mail: *brownjr@uiuc.edu*

Peter Orszag, Brookings Institution

The Securitization of Longevity Risk

J. David Cummins, Wharton; e-mail: *cummins@wharton.upenn.edu*

Killing the Law Large Numbers: Is there a Mortality Risk Premium?

Moshe Milevsky, York University; e-mail: *milevsky@yorku.ca*

V. R. Young, University of Michigan

S. D. Promislow, York University

The textbook assumption for pricing life insurance is that mortality risk is completely diversifiable and therefore not priced by markets in economic equilibrium. The law of large numbers is invoked to argue that a large enough portfolio effectively eliminates any idiosyncratic mortality risk. In this paper we challenge this paradigm by arguing that the uncertainty regarding the evolution of the instantaneous force of mortality will induce dependence that cannot be diversified away by selling more claims. We then classify the equilibrium compensation for this risk in terms of the instantaneous Sharpe Ratio. Our paper discusses the theoretical conditions under which this risk premium exists and it provides some empirical estimates regarding its magnitude using a unique database of life annuity quotes. Our results have implications for hedge funds and other institutional investors who are currently in the process of creating a secondary market for life insurance policies. As well, the existence of this mortality risk premium will affect individuals who are examining the optimal age at which to annuitize their pension.

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Conference Speakers

Pricing Life Securitizations and their place in Optimal ILS Portfolios

Morton Lane, Lane Financial LLC; e-mail: *mlane@lanefinancialllc.com*

There have been a half a dozen securitizations of life insurance risks in the past few years adding to the menu of insurance-linked risks that have been securitized. There will be more. While these life securities, typically involving mortality risk, have been similar in form to well known cat bonds, they have their own unique characteristics. This paper looks at the pricing of these life bonds compared with conventional cat bonds. Essentially, these novel bonds were issued at a discount to regular cat bonds and the intriguing question is whether this discount emanates from their unique features or whether the discount is a temporary novelty premium.

At the same time, "longevity" bonds ideas have been circulated which have not found success in the market. The question arises, what price would they have to garner in order to enjoy market success?

Finally, the inclusion of life risks, mortality or longevity, in a portfolio of insurance risk would appear to bring welcome diversification. The paper examines to question of how much capital should be allocated to life in such a portfolio. The question is illustrated with a hypothetical portfolio using important advances in the application of optimization techniques. The answer is not always obvious, life risks are often necessarily bundled together with interest rate risks and prices may or may not always be generous.

Exponential Tilting and Pricing Implications for Longevity Risk

Shaun Wang, Georgia State University; e-mail: *shaunwang@gsu.edu*

Samuel Cox, Georgia State University; e-mail: *samcox@gsu.edu*

Shaun Wang and Sam Cox will present "Exponential Tilting and Pricing Implications for Longevity Risk." This paper applies the exponential tilting economic pricing framework to longevity risk. The implications include 1) the extreme event correlation matters, 2) the natural hedging of life insurance has an offset effect on the risk premium, and 3) large unexpected long-term medical care cost inflation has a positive effect on the risk premium. This exponential tilting pricing framework can be viewed as an extension of the Wang transform method.

Conference Speakers

Creating synthetic survivor bonds

David Blake, City University; e-mail: *d.blake@city.ac.uk*

Kevin Dowd, University of Nottingham; e-mail: *kevin.dowd@nottingham.ac.uk*

Andrew Cairns, Heriot-Watt University; e-mail: *A.Cairns@ma.hw.ac.uk*

Richard MacMinn, Illinois State University; e-mail: *richard@journalofriskandinsurance.org*

This paper examines various ways in which survivor bonds can be created from conventional instruments. This is an important issue because survivor bonds are promising hedge instruments, but governments have proved reluctant to issue them, since they are already a long mortality risk, and there are arguments that natural private-sector issuers of such bonds are also in short supply. To circumvent these problems, we propose two alternative means of creating synthetic survivor bonds: survivor bonds can be created by splitting the coupon payments on existing government bonds, or by combining positions in conventional bonds with survivor swaps. We consider the demand for such instruments and suggest that capital markets institutions might find it profitable to create them.

A Two-Factor Model for Stochastic Mortality with Parameter Uncertainty

Andrew Cairns, Heriot-Watt University; e-mail: *A.Cairns@ma.hw.ac.uk*

This paper examines the evolution of the post-60 male mortality curve in the U.K. and the impact of associated longevity risk. We introduce a two-factor stochastic mortality model and calibrate it against U.K. male mortality data. The first factor affects mortality-rate dynamics at all ages in the same way, and the second affects mortality-rate dynamics at higher ages much more than at lower ages.

The paper then uses this model to price longevity bonds. It proposes a method to risk-adjust the market price of a longevity bond, and this method also takes account of uncertainty in the parameter values on which the model is calibrated. It also uses pricing data from the EIB/BNP longevity bond of November 2004 to make inferences about the market prices of the risks in the model. Based on these, it then investigates how future issues be priced to ensure absence of arbitrage between longevity bonds with different characteristics.

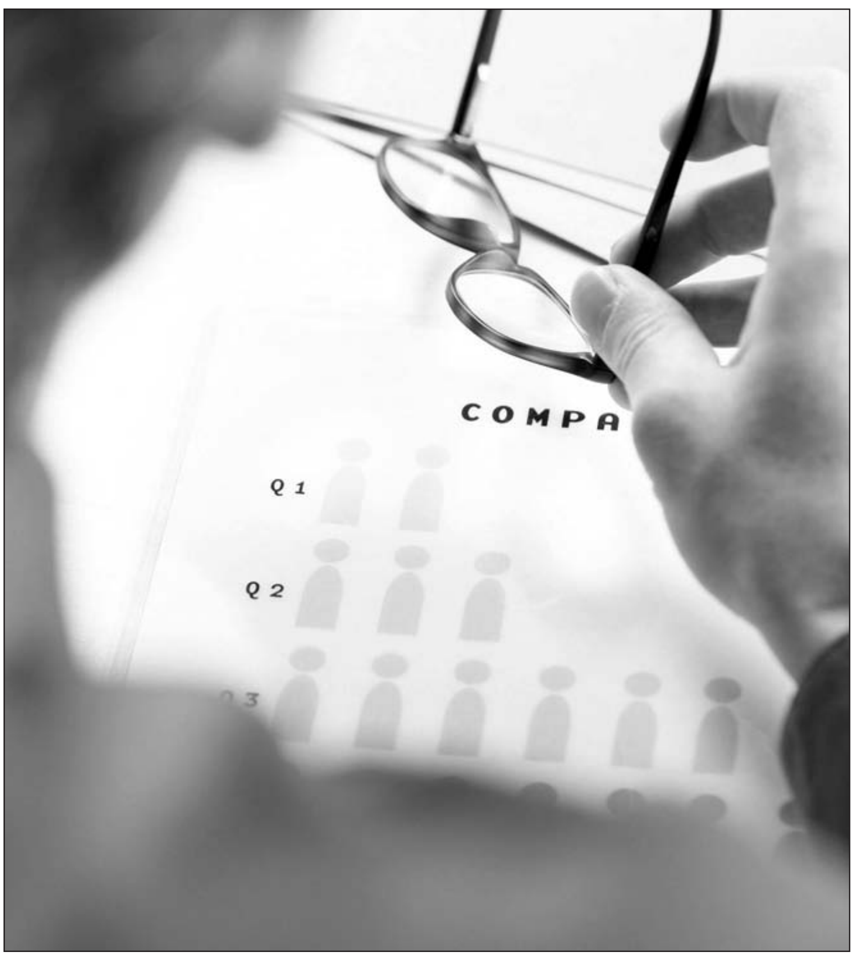
Bull and Bear or Simply All Bull?

by Shane Whelan

The historical development of a science often follows a very natural path. In the endless sequence of hypothesis-test-amended hypothesis, the ordering of the hypotheses is far from arbitrary—history tends to order them by decreasing plausibility.

This is certainly true when it comes to studying the capital markets. No sooner had Charles Dow collected data and constructed perhaps the first stock market index than he hit on 'Dow theory.' The hypothesis underlying Dow theory is that market prices tend to trend, either upwards (a bull trend) or downwards (a bear trend). All that an investor must do to make their fortune is to figure out the start and end of a trend. But is this bull and bear idea really all bull?

Being one of the first hypotheses, Dow theory (and more broadly the other supposedly predictive price patterns favored by technical analysts) has been extensively tested. Two landmarks in this literature are Cowles (1934) and Kendall (1953), which concluded that such rules do not identify profit opportunities outside of those due to chance. Later, it was reasoned that even if there were profit opportunities they would, at best, be fleeting—the infamous efficient market hypothesis (EMH).



Dow theory, and technical analysis generally, did not wither away when they failed the academics tests. Using more powerful techniques and considerably more data, academics have once again revisited this persistent hypothesis. And, albeit in a guarded way, they have reversed their earlier conclusions. Taking a glance at the Journal of Finance in recent years, Lo, Mamaysky & Wang (2000) report that head-and-shoulders, double-bottoms and other classic price patterns beloved by chartists "do provide incremental information and may have some practical value."

Technical analysts have developed many trading rules based on diverse patterns in the price series since the time of Dow at the end of the nineteenth century. Trend-exploiting techniques, such as filter rules and moving-average cross-over rules, remain popular, but they are now augmented by more sophisticated precursor patterns, such as head-and-shoulders, broadening tops, triangle tops, rectangle tops, double tops and their inverses. Still, though, the original filter rule remains the most easily motivated trading technique. Here, it is assumed that prices trend, that is, follow the same direction upwards or downwards for a time. The trend is caused by a lagged or staged response of the market to the underlying development in fundamentals or from the propagation of a fashion in the investment community.

To detect the establishing of a trend, it is necessary to filter out the random background noise of the market. Filter rules are designed to do this, waiting for a rise (or fall) of *f* percent from a recent low (or high) before declaring a trend established. One then buys into a rising trend or sells out of a declining one only reversing the trade when the filter rule detects the beginning of the opposite trend. Small filters will occasionally misdiagnose the background noise of the market for the early beginnings of a trend, leading to excessive trading. However, small filters have the advantage that they will detect such trends as are present and exploit them earlier than coarser filter rules. Trial-and-error helps identify the size of the filter that works best.

Previous Studies of Filter Rules

Alexander (1961) was one of the first to report success in applying the simple trend-exploiting rule. He reported that trending in prices seems to be a feature of the U.S. equity market:

> *In particular, if the stock market has moved up x percent, it is more likely to move more than x percent further before it moves down x percent. This proposition seems to be valid for x ranging from 5 percent through 30 percent.*
>
> Alexander (1961).

Alexander (1961) investigated the profitability of filter rules between 5 percent and 50 percent on the U.S. stock market between 1897 and 1959 using monthly index values and compared them to the returns of the passive buy-and-hold strategy. The results were remarkable: "medium filters uniformly yield profits, and the smallest filters yield the highest profits, and very high they are." Over the 30 difficult years, 1929-1959, the 5 percent filter rule gave an annualised return of 36.8 percent (before trading expenses) against the buy-and-hold's paltry 3.0 percent; from 1897 to 1914 the results were 20.5 percent p.a. versus 3.2 percent p.a. from the buy-and-hold; and in the period 1914 to 1929 the returns were 15.8 percent p.a. versus 14.1 percent p.a.

However, Alexander's study made an innocent looking assumption. He assumed the continuity of prices. That is, if the price is 200 one day and 100 the next, then he supposes it must have been possible to trade at 150. However, this property does not hold for security prices, and his filter rules were trading at prices that may not have been available on the market. He revisited his work without this continuity assumption in Alexander (1964) and reports considerably less remarkable results. As he says himself: "The big bold profits of Paper 1 must be replaced with rather puny ones. The question remains whether even these profits could plausibly be the result of a random walk. But I must admit that the fun has gone out of it somehow." From this revised work, and subsequent studies,[1] trending in equity markets is generally found to be significant statistically for filters of the order of 1 percent. However, a trading rule that is based solely on such technical rules is not economically viable because of trading costs. Such rules can only complement buy-and-sell decisions made from other considerations, and simply help to finesse the timing of the trade.

Filter rules have, however, been found to yield significant profits in currency markets. Levich & Thomas (1993a,b&c) conclude from their analysis of trend following technical rules: "Our analysis of daily currency futures prices over the 1976-90 period shows that exchange rates have not evolved randomly. Simple trend-following trading rules have historically earned economically and statistically significant profits."

However, a trading rule that is based solely on such technical rules is not economically viable because of trading costs.

At first sight it appears odd that the currency markets should appear less efficient than equity markets. Currency markets tend to most closely approximate the conditions of the perfect market—market frictions such as dealing costs and information asymmetries are low and the turnover in currency markets, at over U.S.$1.8 trillion a day in value, is considerably greater than that of equity markets. Yet, as was first shown in Meese & Rogoff (1983), fundamental factors such as inflation, interest rates, monetary aggregates and economic growth provide, at best, only a loose anchor to the value of a currency. That is, the fundamental determinants of currency values are, as yet, poorly understood and hence fundamental analysis is not especially rewarding in this market. Accordingly, currency traders tend to rely on technical rules more than their equity counterparts as is borne out by numerous surveys. Finally, in currency markets, there is a type of trader who is not primarily motivated by profit, the central banks.

Equity Markets Studied

We shall investigate the profitability or otherwise of filter rules, covering largely the 1990s, one of the most pronounced equity bull markets of the twentieth century. The number of prices analyzed on the next page is in excess of one and a half million as we attempt to analyze the major stock markets in the world using daily closing prices. The datasets studied are described briefly on page 24.

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[1] Fama (1965), Fama & Blume (1996), and any number of Masters' theses since that time.

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Table 1: Datasets Studied Using Daily Closing Prices

Equity Market	Description of Price Series	Period Studied (inclusive)	No. of Price Series	Data Points per Series	Data Points Analysed
U.S.	Stock Prices	Each Calendar Year, 1990-1999	c. 4,500	c. 254	1,143,000
U.S.	Sector Indices in S&P 500	Jan 1990 – Jul 2000	7	2,675	18,725
U.K.	Stock Prices	Jan 1990 – Aug 2000	71	2,782	197,522
German	Stock Prices	Jan 1990 – Aug 2000	21	2,782	58,422
French	Stock Prices	Jan 1990 – Aug 2000	28	2,782	77,896
Dutch	Stock Prices	Jan 1990 – Aug 2000	15	2,782	41,730
Swiss	Stock Prices	Jan 1990 – Aug 2000	17	2,782	47,294
Irish	Stock Prices	Jan 1991- mid-Aug 2000	29	2,409	69,861

The filter rule we investigate is defined below:

Definition: A filter rule of *f* percent gives a buy signal when the price rises by *f* percent from its most recent trough and, conversely, gives a sell signal when the price declines by *f* percent from its most recent peak.

We examine our stock price and sector indices with six filters, 1 percent, 2 percent, 3 percent, 5 percent, 7 percent and 10 percent. Trading is at end of day quoted prices.

It is assumed that the passive or default strategy is an exposure to the underlying stock. The initial state of the portfolio is therefore a holding of one unit of the stock. If the stock subsequently falls *f* percent from its most recent peak then it is sold and the proceeds are held in non-interest bearing cash until the next buy signal, and so on. The value of the portfolio, thus actively managed, is compared with that of the passive buy-and-hold strategy and the profit or loss readily determined.

First, we studied over 400 large capitalisation stocks each year over the 1990s on the U.S. equity market. The selection rule for stocks was that they had to be a member of the S&P 500 Index over the entire calendar year. The results, in summary form, are given below where the success rate gives the percentage of times the filter rule outperforms the buy-and-hold strategy over the period.

The table on page 25 is saying, quite simply, that filter rules generally do not outperform a buy-and-hold strategy, even before trading costs. We do the same analysis on the seven equity sector indices of the S&P 500 over the decade.

Table 2: Profitability of Filter Rules, U.S. Large Capitalisation Stocks, Annually, 1990-1999.

Filter Size	1%	2%	3%	1%	2%	3%
		Year 1990			*Year 1991*	
No. of Stocks Studied	423			424		
Average No. of Trades	71	45	32	72	47	33
Success Rate	80%	74%	70%	40%	30%	23%
		Year 1992			*Year 1993*	
No. of Stocks Studied	433			438		
Average No. of Trades	71	44	30	70	43	29
Success Rate	39%	27%	26%	39%	31%	27%
		Year 1994			*Year 1995*	
No. of Stocks Studied	443			450		
Average No. of Trades	69	41	27	67	38	25
Success Rate	51%	44%	41%	20%	17%	18%
		Year 1996			*Year 1997*	
No. of Stocks Studied	472					
Average No. of Trades	67	40	27	75	47	31
Success Rate	35%	28%	26%	25%	23%	21%
		Year 1998			*Year 1999*	
No. of Stocks Studied	474			472		
Average No. of Trades	79	53	37	85	58	42
Success Rate	51%	47%	43%	48%	47%	47%

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Table 3: Profitability of Filter Rules, U.S. Equity Sector Indices, 1991-2000.

Sector		Filter Size					
		1%	2%	3%	5%	7%	10%
Capital Goods	Trades No.	482	256	161	89	46	20
	Gross Profit (%)	24	-38	-49	-71	-57	-38
Energy	Trades No.	570	320	188	95	57	19
	Gross Profit (%)	-41	-69	-66	-66	-67	-30
Financials	Trades No.	532	328	230	106	76	38
	Gross Profit (%)	149	-9	-57	-38	-61	-51
Health care	Trades No.	572	318	198	100	55	40
	Gross Profit (%)	-11	-49	-53	-47	-41	-63
Transport	Trades No.	536	284	192	104	56	32
	Gross Profit (%)	24	44	-17	-51	-33	-34
Technology	Trades No.	643	370	247	137	75	47
	Gross Profit (%)	-21	-45	-64	-76	-57	-69
Utilities	Trades No.	416	196	114	48	34	16
	Gross Profit (%)	-17	-26	-30	-21	-36	-22

Again, the results are disappointing. There are no gains to be made by a trend following strategy within different equity sectors, even before trading costs are taken into account. Finally, we apply the same analysis on individual European stocks.

Table 4: Success Rate of Filter Rules, European Stock Markets, 1990-2000.

Equity Market		Filter Rule					
		1%	2%	3%	5%	7%	10%
U.K.	No. Profitable	65	37	26	17	10	9
	Total	71	71	71	71	71	71
	Success Rate	92%	52%	37%	24%	14%	13%
German	No. Profitable	10	7	5	2	2	2
	Total	21	21	21	21	21	21
	Success Rate	48%	33%	24%	10%	10%	10%
French	No. Profitable	16	9	4	3	1	3
	Total	28	28	28	28	28	28
	Success Rate	57%	32%	14%	11%	4%	11%
Dutch	No. Profitable	8	5	1	2	2	2
	Total	15	15	15	15	15	15
	Success Rate	53%	33%	7%	13%	13%	13%
Swiss	No. Profitable	11	8	6	5	8	6
	Total	17	17	17	17	17	17
	Success Rate	65%	47%	35%	29%	47%	35%
Ireland	No. Profitable	6	6	6	4	8	8
	Total	29	29	29	29	29	29
	Success Rate	21%	21%	21%	14%	28%	28%
Overall	No. Profitable	116	72	48	33	31	30
	Total	181	181	181	181	181	181
	Success Rate	72%	43%	28%	19%	15%	14%

The overall conclusion from this survey of the efficiency of filter rule in bull equity market of the 1990s is that small filters perform better than large filters, with the 1 percent filter performing best of all. However, even the 1 percent filter rule gives unconvincing profits—it seems to outperform a buy-and-hold strategy roughly about half the time and that is before (very high) trading costs are taken into account. There seems little point in assessing the statistical significance of this result when the economic profit is, as Alexander put it, "puny."

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Currency Markets

As mentioned earlier, the literature indicates that currency markets have previously proven fertile ground for technical trading rules, and, in particular, filter rules. In investigating the profitability or otherwise of filter rules, we assume that no position is held at the start of the period but, on the first trigger of the filter rule, the portfolio goes either long or short the currency the currency, as dictated by the rule. From that time onwards, the portfolio is either long or short the currency. Finally, we report the profitability of the trading rule in percent per annum in USD.

Closing daily exchange rate futures prices on the Chicago Mercantile Exchange were used from January 1976 to December 2000 (but since January 1977 in the case of yen futures), for the five major currencies relative to the USD, giving over 6,000 prices per exchange rate. These currency pairs account for over 70 percent of foreign exchange transactions in the euro area according to the 2004 survey by the Bank of International Settlements. We split the period in two: up to the end of 1990 and from the start of 1991, the first period coinciding with that of Levich & Thomas (1993) study (the "in-sample period") and the second being out-of-sample. With the help of Niall Fitzgerald, a graduate student at University College Dublin, we reproduced the surprising results of Levich & Thomas to within four trades and can confirm their findings. The results for filter sizes of 0.5 percent, 1 percent, 2 percent, 3 percent, 4 percent, 5 percent and 10 percent as shown in Table 5.

Table 5: Success of Filter Rules, Exchange Rate Futures Market, 1973-1990 [In Sample]

Exchange Rate Futures		Filter Size						
		0.5%	1%	2%	3%	4%	5%	10%
Swiss Franc - US$	Trades No.	901	533	253	127	78	62	15
	Gross Profit (% p.a. US$)	8.1	6.8	3.7	7.2	10.1	6.7	6.0
	Statistical Significance (<)	1%	5%	-	5%	1%	5%	1%
DM- US$	Trades No.	825	409	195	97	62	41	15
	Gross Profit (% p.a. US$)	2.2	9.3	5.5	7.9	8.1	8.2	3.5
	Statistical Significance (<)	-	1%	5%	1%	1%	1%	5%
C$ -US$	Trades No.	305	121	51	28	15	11	2
	Gross Profit (% p.a. US$)	3.3	3.4	1.7	0.9	1.6	1.1	1.8
	Statistical Significance (<)	1%	1%	5%	-	5%	-	1%
UK£ - US$	Trades No.	791	424	188	106	65	55	14
	Gross Profit (% p.a. US$)	9.9	7.5	7.4	8.4	8.0	4.3	4.5
	Statistical Significance (<)	1%	1%	1%	1%	1%	10%	1%
J¥ - US$	Trades No.	784	410	174	98	60	44	15
	Gross Profit (% p.a. US$)	7.5	8.3	7.0	7.1	10.1	8.4	4.8
	Statistical Significance (<)	1%	1%	1%	1%	1%	1%	1%

From Levich & Thomas (1993), *Internally Diversified Bond Portfolios: The Merits of Active Currency Management.* NBER Working Paper Series No. 4340.

The rows indicating the statistical significance of the rules require elaboration. Levich & Thomas shuffle the daily returns on the futures to come up with, for each shuffle, a new series, which has the same distribution of the original returns. They then investigated how the filter rule performed on the price series with the resultant randomized returns. Redoing this 10,000 times or so, they could see whether the profit from applying the filter rule on the original series was unusually large—occurring in less than 100 cases (so with a p-value of less than 1 percent)—and hence calibrate its statistical significance. In re-estimating the statistical significance, we also estimated it using an alternative method of fixing the number of trades as given by the filter rule and then estimated the probability of a trading rule with that number of trades giving a profit as large as that of the filter rule. Both bootstrap-testing methods reported, surprisingly, almost identical results for the p-values which were, in turn, almost identical to those reported originally by Levich & Thomas.

The passage of time allows us to test the trading rules out of sample. We report the failure of the filter rules below.

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Table 6: Failure of Filter Rules, Exchange Rate Futures Market, 1991-2000 [Out-of-Sample]

Exchange Rate Futures		Filter Size						
		0.5%	1%	2%	3%	4%	5%	10%
Swiss Franc - US$	Trades No.	658	354	150	85	51	37	10
	Gross Profit (% p.a. US$)	1.1	2.7	-0.8	1.4	1.4	2.0	3.5
	Statistical Level							25%
ECU- US$	Trades No.	556	280	122	60	43	29	8
	Gross Profit (% p.a. US$)	1.9	2.9	1.2	4.2	2.7	1.4	3.3
	Statistical Significance (<)		20%		15%	25%		20%
C$ -US$	Trades No.	287	128	49	23	14	5	1
	Gross Profit (% p.a. US$)	0.9	-0.2	-2.3	-0.8	-1.2	1.6	1.7
	Statistical Significance (<)							
UK£ - US$	Trades No.	522	278	124	69	41	33	5
	Gross Profit (% p.a. US$)	-0.2	-1.2	-3.6	-4.4	-1.1	-4.0	1.6
	Statistical Significance (<)							
J¥ - US$	Trades No.	622	350	157	86	50	36	11
	Gross Profit (% p.a. US$)	-2.8	-4.0	-4.4	-1.4	3.0	2.1	3.6
	Statistical Significance (<)							

From Niall Fitzgerald (2004), *Assessing the Profitability of Technical Trading Rules in the Foreign Exchange Market.* Unpublished Minor MSc Dissertion in Statistics, University College Dublin. The moving average cross-over rules studied by Levich & Thomas were also explored out-of-sample, producing similarly disappointing results.

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The results are hardly economically significant and certainly not statistical significant. In the table, we just show results which are significant at the 25 percent level or under—a total of 5 out of 35—which is unremarkable.

All Bull

The extensive analysis presented here appears to justify the conclusion that trend-exploiting rules, strictly filter rules, do not lead to excess returns, but this will not settle the conjecture.

Going back to the *Journal of Finance*, Brown et al. (1998), for instance, already takes issue with this conclusion, pointing out that Dow theory gives high Sharpe ratios and positive alphas compared to a buy-and-hold strategy when due allowance is made lower risk of being out of the market. But, I would rejoin, this is testing an altogether different hypothesis and, in any event, Brown et al. did not allow for the well-documented seasonality in risk-adjusted returns, but that is another article.

The remarkable part of all this study is not whether markets trend or not: it is that we are still actively debating after a century one of the first conjectures of this science. The study of the price formation process has developed so little that we can question if it is a science at all. The pronounced and exploitable patterns identified by Levich & Thomas have disappeared or, maybe, were never really there. Despite the conscientiousness and thoroughness of that piece of research, a mixture of inadvertent data mining with the very limited data, coupled with a publication bias for unexpected results could have produced their findings. If so, then no researcher is immune.

Clever Hans, the horse of Wilhelm von Osten, fooled scientists in Berlin in 1904 by appearing to be able to count and do sums until it was discovered the horse was studying the scientists closer than the scientists where studying the horse. Maybe market traders have picked up the same trick. If so, then these studies are less about finding universal truths and more about monitoring the influence the observer has on observed.

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References

Alexander, S.S. (1961)
Price Movements in Speculative Markets: Trends or Random Walks, Industrial Management Review, Vol. 2, no. 2. pp. 7-26 (also reproduced in Cootner, P.(1964) The Random Character of Stock Market Prices, MIT Press).

Alexander, S.S. (1964)
Price Movements in Speculative Markets: Trends or Random Walks, No. 2. in Cootner, P.(1964) The Random Character of Stock Market Prices, MIT Press.

Brown, S.J., Goetzmann, W.M. & Kumar, A. (1998)
The Dow Theory: William Peter Hamilton's Track Record Reconsidered. Journal of Finance, Vol. 53, 4, August 1998.

Cowles, A. (1934)
Can Stock Market Forecasters Forecast? Econometrica, Vol. 1, pp. 309-324.

Fama, E. (1965)
The Behavior of Stock Market Prices. Journal of Business, 38, pp.34-105.

Fama, E. & Blume, M. (1966)
Filter Rules and Stock Market Trading Profits. Journal of Business, 39, pp. 226-241.

Fitzgerald, N. (2004)
Assessing the Profitability of Technical Trading Rules in the Foreign Exchange Market. Unpublished Minor MSc Dissertion in Statistics, University College Dublin.

Kendall, M. G. (1953)
The Analysis of Economic Time Series – Part I: Prices. Journal of the Royal Statistical Society, Vol. 96, Part I, pp. 11-25.

Levich, R.M & Thomas, L.R. (1993a)
The Merits of Active Currency Risk Management: Evidence from International Bond Portfolios. Financial Analysts Journal, Sept-Oct 1993, pp63-70.

Levich, R.M & Thomas, L.R. (1993b)
The Significance of Technical Trading-Rule Profits in the Foreign Exchange Market: A Bootstrap Approach. Journal of International Money and Finance.

Levich & Thomas (1993c)
Internally Diversified Bond Portfolios: The Merits of Active Currency Management. NBER Working Paper Series No. 4340.

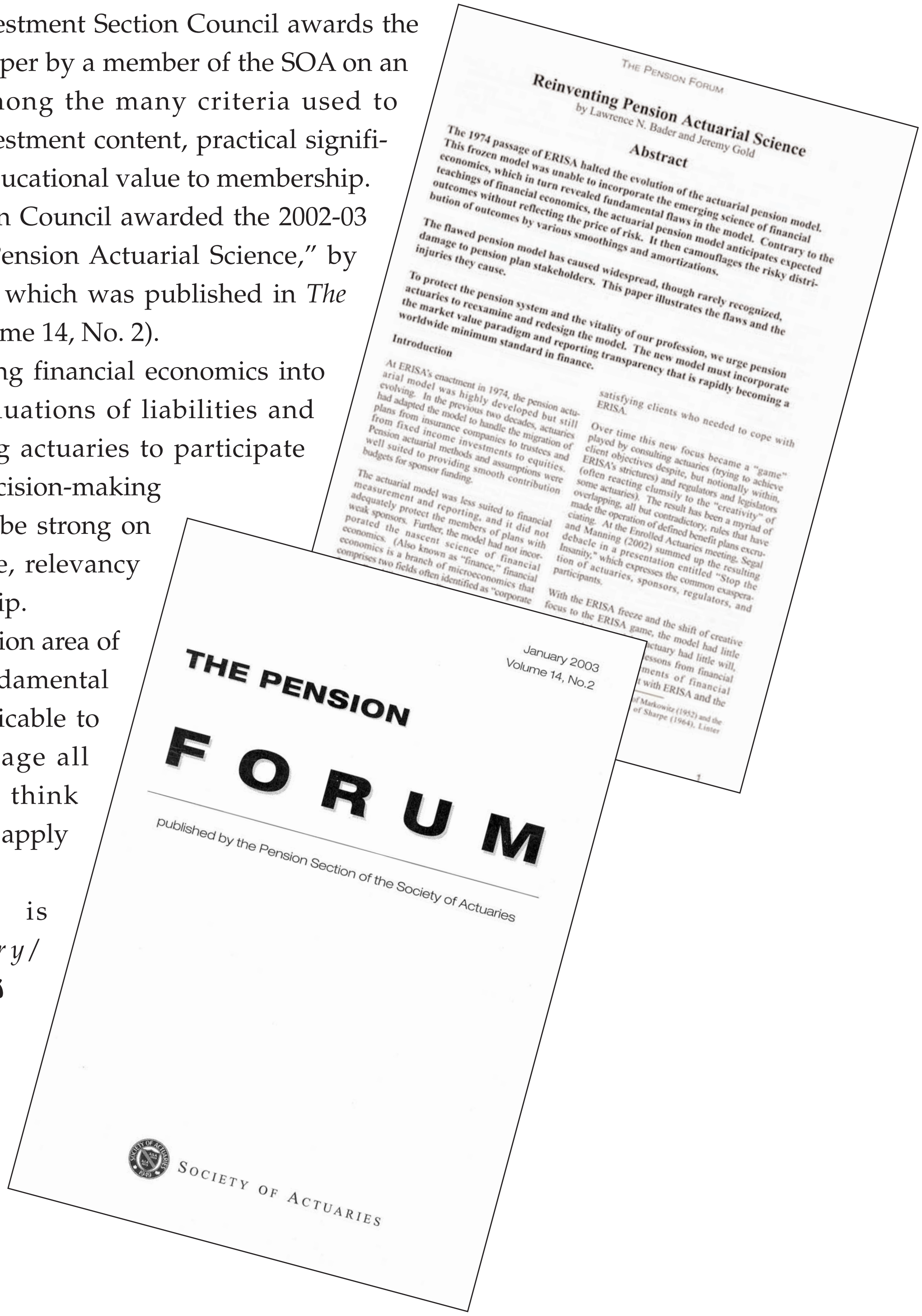
Lo, A.W., Mamaysky, H. & Wang, J. (2000)
Foundations of Technical Analysis: Computational Algorithms, Statistical Inference, and Empirical Implementation. Journal of Finance, Vol. 55, Issue 4, pp.1705-1770, August 2000.

Meese, R.A. & Rogoff, K. (1983)
Empirical Exchange Rate Models: Do They Fit Out of Sample? Journal of International Economics, Vol. 14, pp. 3-24.

Redington Prize Announcement

Every two years the Investment Section Council awards the Redington Prize to a paper by a member of the SOA on an investment topic. Among the many criteria used to choose a paper are investment content, practical significance, relevancy and educational value to membership.

This year the Investment Section Council awarded the 2002-03 Redington Prize to "Reinventing Pension Actuarial Science," by Lawrence Bader and Jeremy Gold, which was published in *The Pension Forum* in January 2003 (Volume 14, No. 2).



This paper's focus on integrating financial economics into actuarial science would bring valuations of liabilities and assets onto equal footing, enabling actuaries to participate and add value to the investment decision-making process. This paper was judged to be strong on the criteria of practical significance, relevancy and educational value to membership.

This paper's focus is on the pension area of the practice. Nevertheless, the fundamental points made in the paper are applicable to any area of practice. We encourage all members to read this paper and think about how the fundamental points apply to their own area of practice.

The URL for the paper is *http://library.soa.org/library/sectionnews/pension/PFN0301.pdf.*

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