Asset Allocation: An Evaluation of Investment Portfolios

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1.   Introduction

Asset allocation is the process of allocating your investments between different asset classes (equities, bonds, properties and cash); primarily to reduce the risk of capital losses and poor returns over time. We know from the history of financial markets that some asset class returns are quite volatile, inconsistent and unpredictable. Fortunately, not all asset classes move in the same direction all the time – for example, if one asset class disappoints over a specific period, another asset class will perform during that same period. Therefore, there should be value in diversifying your investment portfolio across various assets.

Asset allocation is probably one of your most important investment decisions. The classic research studies by Brinson, Beebower and others in the mid 80s and early 90s confirmed the importance of the asset allocation decision where they found that the variance in returns among managed institutional portfolios could be attributed mostly (over 90%) to the differences in asset allocations[1]. In all likelihood, the same rationale will apply for individual investors. Thus, which assets and how much I allocate to each will have a significant effect on my portfolio return and whether I will meet my investment objectives over time.

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[1] Brinson, G.P., Singer, B.D. & Beebower, G.L. 1991. "Determinants of Portfolio Performance II: An Update." Financial Analysts Journal, 47(3), 40-48.

The question arises whether there is a methodology an investor can follow to develop optimal asset allocation portfolios for different investment objectives and risk profiles. The good news there is, but the caveat is that a lot of common sense and investment knowledge (and dare I say luck!) are necessary to successfully apply asset allocation models. Therefore, many investors prefer to leave the asset allocation decision to professional advisors and money managers.

This article attempts to demystify the process of asset allocation by following a logical, "building block"- approach towards the asset allocation decision.

First, I will analyse the history of asset class returns and investigate the statistical correlations between the asset classes over various time periods. Second, I will build a static, optimised asset allocation model to derive at optimal portfolios for various risk profiles. Then I will evaluate these static portfolios with a simulation model that incorporates various economic scenarios, which will affect the asset class returns in different ways. Last, I will run a number of simulation tests to evaluate the consistency of the model portfolios in yielding its pre-designed target returns. From these I can make certain conclusions and recommendations regarding the suitability of the various asset allocation portfolios.

2.   Asset Class Returns: A Historical Perspective

Figures 1-4 and the corresponding tables 1-4 describe the relative performance of each major asset class – equities, bonds, listed commercial properties (property unit trusts) and cash – over different time intervals; ranging from the 1900s, thus more than 100 years of data[2], up to the annualised returns over the past decade.

Figures 5-7 depict the frequency distribution of annual returns for equities, bonds and commercial properties, thus enabling one to understand the potential range of returns possible and the likelihood that certain annual returns can occur over time.

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[2] The data from the 1900s is taken from a study done by Firer and Staunton, which was published in The Investment Analysts Journal (2002, Volume 56, pages 57-65), titled "102 Years of South African financial market history" and was made available to me in a spreadsheet format by the Advisory Services of Sanlam Personal Portfolios.
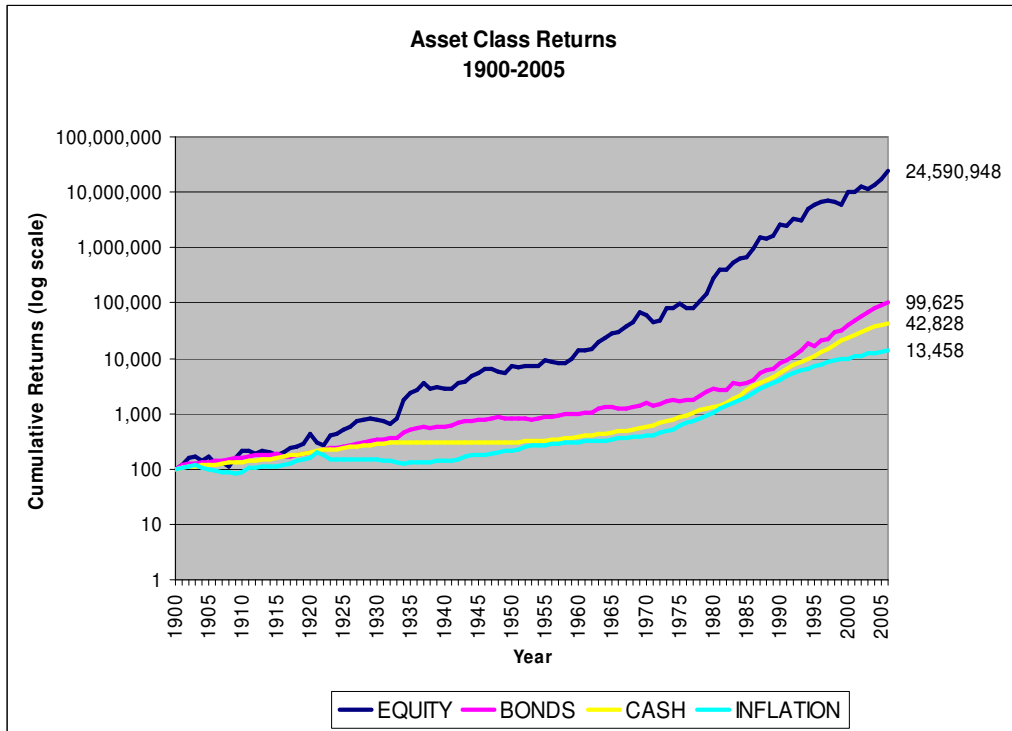
Asset Class Returns
1900-2005

Figure 1: The performance of the major asset classes from 1900-2005

Table 1: An analysis of asset class returns from 1900-2005

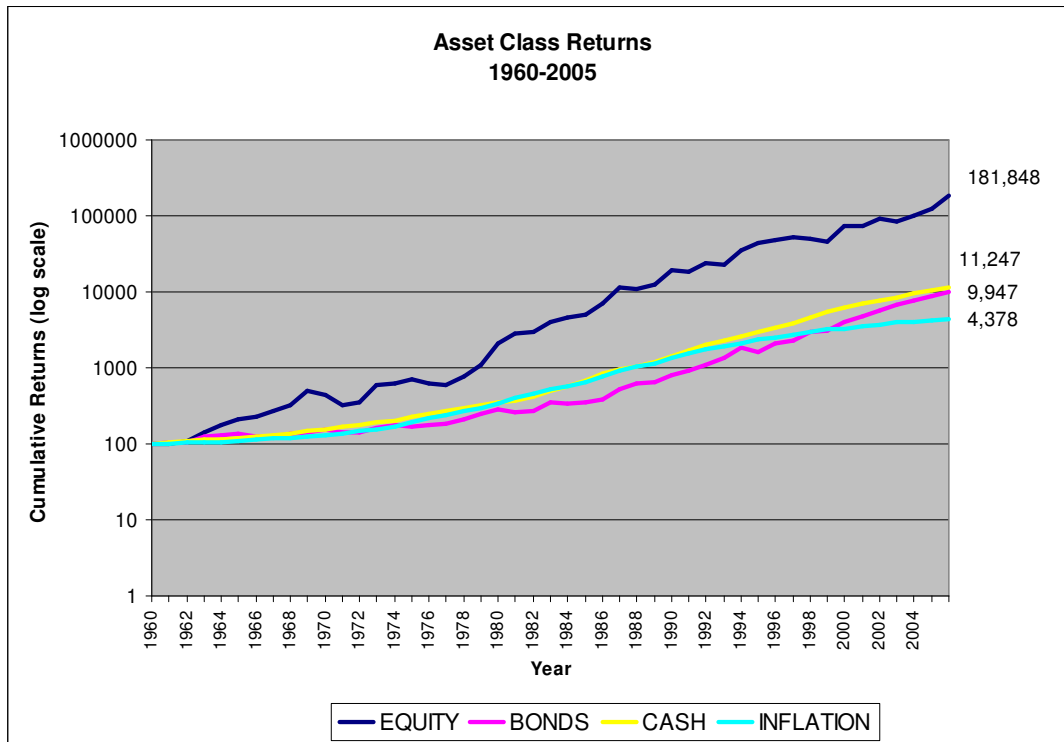| 1900-2005	EQUITY	BONDS	CASH	INFLATION
Periods	106	106	106	106
Negative	32%	17%	0%	0%
Positive	68%	83%	100%	100%
Above Inflation	61%	60%	58%	0%
Std Dev	23%	9%	6%	7%
Average	14.6%	7.1%	6.0%	4.9%
Median	10.6%	4.9%	3.6%	4.0%
Kurtosis	2.33	1.24	0.40	0.76
Skewness	1.11	1.16	1.14	0.00
FV of R1	245,909	996	428	135
Annualised Yield	12.4%	6.7%	5.9%	4.7%
Above Inflation	7.7%	2.0%	1.2%	0.0%

Asset Class Returns
1960-2005

Figure 2: The performance of the major asset classes from 1960-2005

Table 2: An analysis of asset class returns from 1960-2005

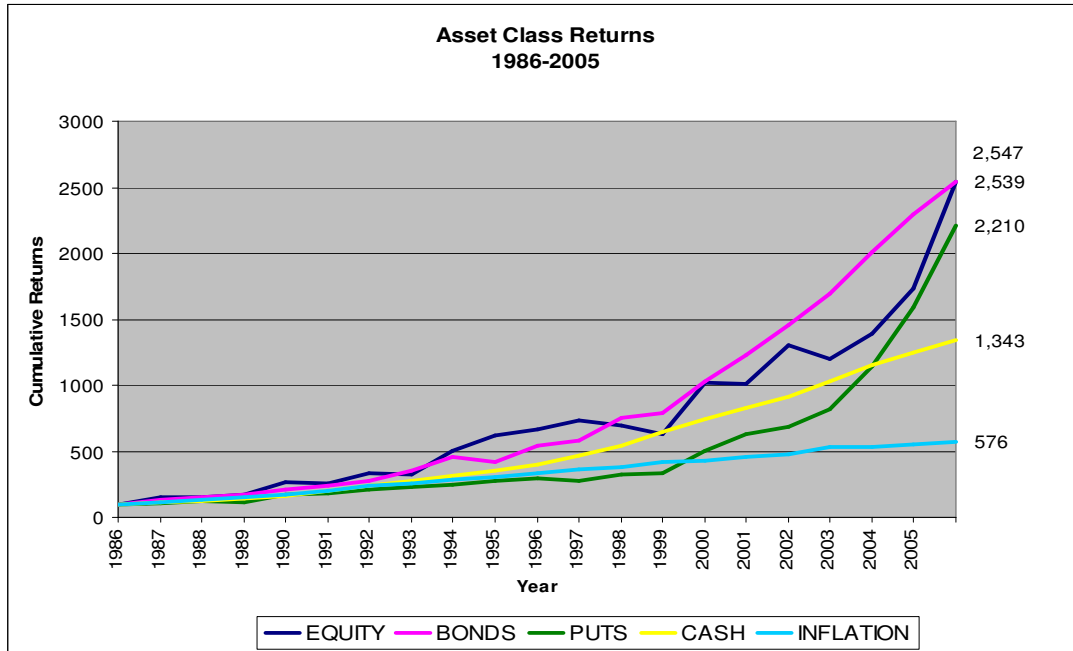| 1960-2005	EQUITY	BONDS	CASH	INFLATION
Periods	46	46	46	46
Negative	26%	15%	0%	0%
Positive	74%	85%	100%	100%
Above Inflation	65%	54%	72%	0%
Std Dev	25%	12%	5%	5%
Average	20.1%	11.1%	10.9%	8.7%
Median	15.3%	10.3%	10.8%	9.5%
Kurtosis	0.42	-0.65	-0.86	-1.20
Skewness	0.69	0.32	0.36	0.05
FV of R100	181,848	9,947	11,247	4,378
Annualised Yield	17.7%	10.5%	10.8%	8.6%
Above Inflation	9.1%	2.0%	2.2%	0.0%

**Asset Class Returns
1986-2005**

Figure 3: The performance of the major asset classes from 1986-2005

Table 3: An analysis of asset class returns from 1986-2005

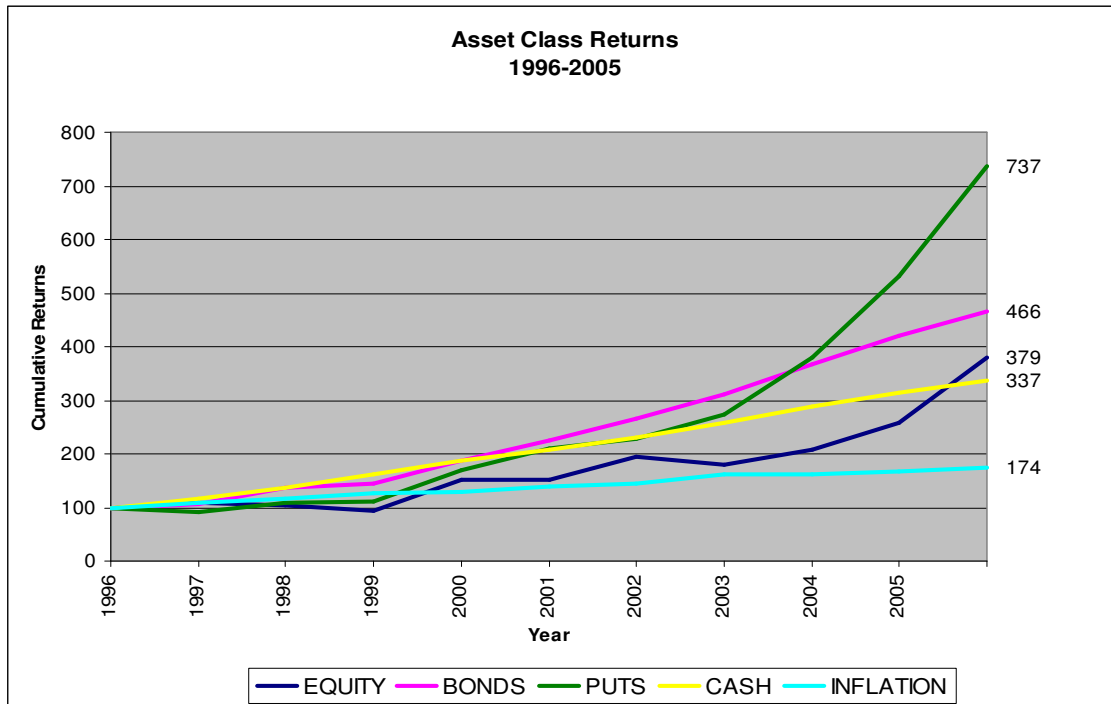| 1986-2005	EQUITY	BONDS	PUTS	CASH	INFLATION
Periods	20	20	20	20	20
Negative	35%	5%	10%	0%	0%
Positive	65%	95%	90%	100%	100%
Above Inflation	60%	75%	90%	85%	0%
Std Dev	24%	11%	18%	4%	5%
Average	19.8%	18.1%	18.0%	13.9%	9.3%
Median	15.3%	17.4%	11.6%	13.0%	9.5%
Kurtosis	-1.16	0.56	-0.41	-0.85	-0.93
Skewness	0.48	-0.50	0.64	0.14	0.01
FV of R100	2,539	2,547	2,210	1,343	576
Annualised Yield	17.6%	17.6%	16.7%	13.9%	9.1%
Above Inflation	8.4%	8.4%	7.6%	4.7%	0.0%

Figure 4: The performance of the major asset classes from 1996-2005

Table 4: An analysis of asset class returns from 1996-2005

1996-2005	EQUITY	BONDS	PUTS	CASH	INFLATION
Periods	10	10	10	10	10
Negative	40%	0%	10%	0%	0%
Positive	60%	100%	90%	100%	100%
Above Inflation	50%	80%	90%	90%	0%
Std Dev	24%	8%	19%	4%	4%
Average	16.4%	16.9%	23.6%	13.0%	5.8%
Median	12.5%	17.4%	22.8%	12.3%	5.1%
Kurtosis	-0.42	-0.52	-0.76	-1.34	-0.53
Skewness	0.73	0.26	-0.26	0.04	0.39
FV of R100	379	466	737	337	174
Annualised Yield	14.3%	16.6%	22.1%	12.9%	5.7%
Above Inflation	8.5%	10.9%	16.4%	7.2%	0.0%

Figure 5:   Distribution of equity returns

Histogram
Annual Equity Returns
1900-2005
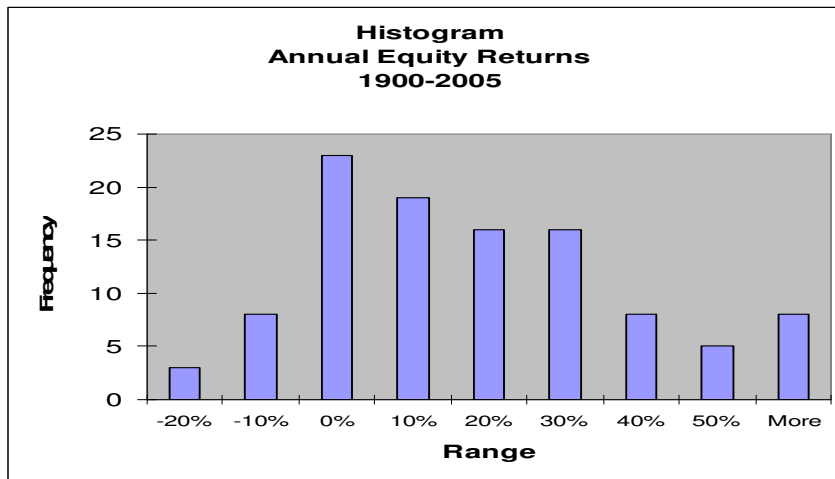
Figure 6:   Distribution of bond returns

Histogram
Annual Bond Returns
1900-2005
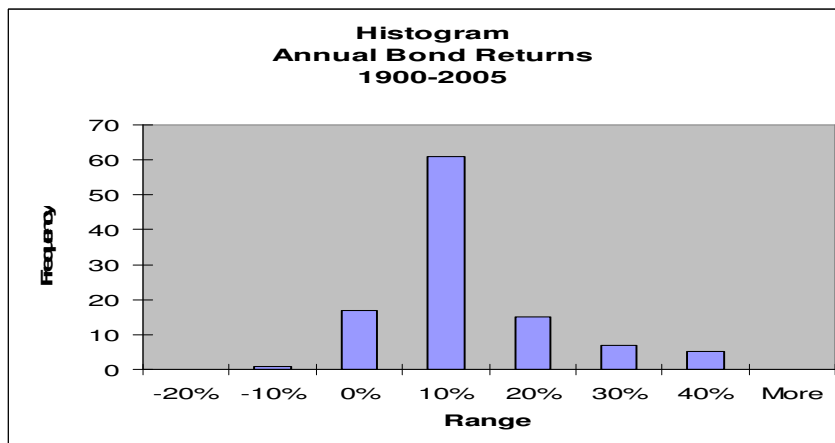
Figure 7: Distribution of commercial property returns

Histogram
Annual Property Returns
1986-2005
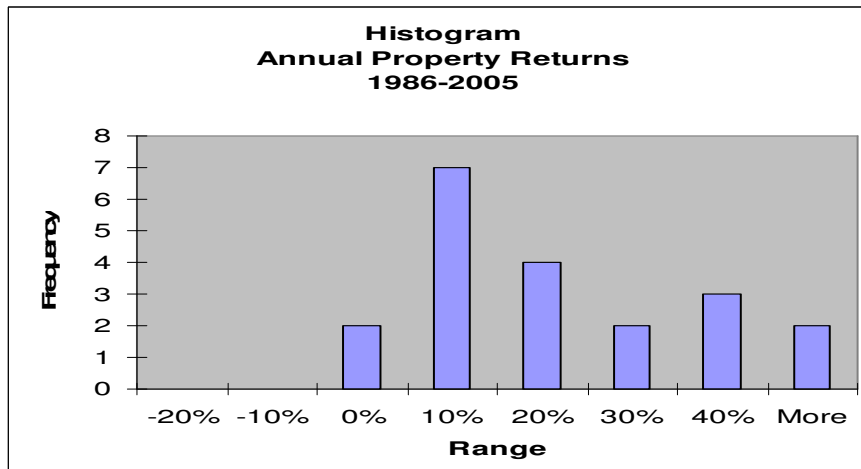
2.1   Equities

Over the long term equities have been a consistent real wealth creator. The long-term real return from equities varied between 7-9% per annum measured over all the holding periods. However, equities are by definition a risky asset class; on average more than 30% of the annual returns were in negative territory! Also, it had the worst success rate of consistently beating inflation (about 60% of the time) over all the holding periods.

But the key to equity investing is time and patience. A bad run of return will eventually be replaced by some good fortunes along the way and thus pushing up your average long-term yield to more than satisfactory levels.

2.2   Property Unit Trusts (PUTS)

Commercial properties have been the top-performing asset class over the past decade with an exceptional real return averaging more than 16% per annum!

But to assume these return levels going forward might be a costly mistake. This exceptional performance can be attributed to a dramatic drop in interest and capitalisation rates, especially over the past three years together with strong economic growth and consumer demand. The "unexpected" returns stemming from this phenomenon will be very unlikely repeated in the foreseeable future with interest rates at the low end of the cycle. Thus, some correction (reversion) in the average real return from properties is more than likely in the future.

Further, note that the return from properties is quite volatile (second highest standard deviation) and not such a "safe haven" as many investors and market commentators generally perceive it to be.

2.3   Bonds

Bonds have been one of the best investment classes over the past ten and twenty years. Bonds have benefited largely from a structural breakdown of the inflation phenomenon due to the high real interest rate policy followed by the Reserve Bank since the early 90s.

The re-assessment by the market of the long-term inflation outlook has created an "unexpected" windfall for bond investors over the last two decades – resulting in a real return averaging between 8-10% per annum. But again, as with properties, the immediate outlook for bonds is not that promising and a return to the long-term average of 2-3% real yield is on the cards.

2.4   Cash

The unusual real returns (more than 7% above inflation) achieved by cash holdings since 1996 is a clear indication of the high real interest rate policy followed by the monetary authorities to curb inflation expectations. To that extent it must be seen as a once-off event and unlikely to occur again in the foreseeable future.

Although cash is the safest asset class its wealth creating ability is limited in so far the return (interest) is fully taxable at the normal income tax scales. [The returns from PUTS and bonds include capital appreciation elements and are excluded for income tax purposes]. Due to the diluting effects of tax, one cannot expect real gains from cash over time and it must be seen as a diversification and tactical element in your investment plan, and not a strategic, wealth-creating element.

3.   Portfolio Diversification

3.1   Why Diversify?

An obvious answer to the above question is provided by the inconsistency of asset class performances over the past twenty years, as seen in table 5, where asset classes are ranked in terms of their relative annual performances.

Table 5: Ranking of Asset Class Returns (1986-2005)

YEAR	BEST	PERFORMANCE		WORST
1986	EQUITY	BONDS	CASH	PUTS
1987	BONDS	PUTS	CASH	EQUITY
1988	EQUITY	CASH	BONDS	PUTS
1989	EQUITY	PUTS	BONDS	CASH
1990	CASH	BONDS	PUTS	EQUITY
1991	EQUITY	CASH	PUTS	BONDS
1992	BONDS	CASH	PUTS	EQUITY
1993	EQUITY	BONDS	CASH	PUTS
1994	EQUITY	CASH	PUTS	BONDS
1995	BONDS	CASH	PUTS	EQUITY
1996	CASH	EQUITY	BONDS	PUTS
1997	BONDS	PUTS	CASH	EQUITY
1998	CASH	BONDS	PUTS	EQUITY
1999	EQUITY	PUTS	BONDS	CASH
2000	PUTS	BONDS	CASH	EQUITY
2001	EQUITY	BONDS	CASH	PUTS
2002	PUTS	BONDS	CASH	EQUITY
2003	PUTS	BONDS	EQUITY	CASH
2004	PUTS	EQUITY	BONDS	CASH
2005	EQUITY	PUTS	BONDS	CASH

For example, equities have been simultaneously the most "best" and "worst" asset class performer on an annual basis during this period. Therefore, any strategy that is purely focussed on the "equity play" (or any other asset class) is bound to disappoint periodically.

In this regard it is important to remember the golden rule of investing: "Never lose money!" Any one year that you might experience a severe negative return has a profound adverse effect on the long-term outcome of your investment plan. Thus, do not rely heavily on one asset class only to create wealth; it is rather about how you employ the asset classes in your investment plan.

And just to make sure that no one misses the diversification argument: forget that anyone (whether amateur or professional) can consistently predict which asset class is going to be the top performer year after year; thereby changing portfolio weights accordingly. Market timing is nothing else than a loser's game!

3.2   The Principles of Portfolio Diversification (Asset Allocation)

Although it is fairly easy to build a solid argument for diversification, it is less obvious how to formulate a diversification policy, in other words how your portfolio should be invested among the four different asset classes.

The primary objective of diversification is to reduce one's portfolio risk, thus to make one's investment less subject to huge up– and downswings over time. Ideally, one would want to include in the portfolio mix those investments that are negatively correlated with each other, meaning that if one investment fails, another should perform under the same market circumstances.

However, to find such negative correlation relationships is not always possible, but at best then to include those investments that at least have a low correlation with each other. By combining such assets in a portfolio, the overall volatility of the portfolio (portfolio risk measured by the standard deviation) will be lower than the volatilities of the individual assets.

A second important objective in portfolio diversification is to maximise the expected return for a given level of portfolio risk. Harry Markowitz, "father" of Modern Portfolio Theory, developed the mean-variance optimising method, which aims to provide that set of efficient portfolios (asset allocations) with the lowest risk (variance) for different expected portfolio return levels – the so-called "Efficient Frontier". Alternatively stated: to maximise the returns for a given level of portfolio risk.

Without elaborating into much further detail and theory it is suffice to say that a good starting point in building such an efficient asset allocation model is to establish the "interconnectedness" of asset classes. In other words, to what extent was the performance of one asset class related to the performance of another asset class?

Table 6 and 7 describe the correlations of the main asset classes over various time spans, and specifically during three different inflation environments, namely low inflation (1946-1972), high inflation with negative real interest rates (1973-1988), and high inflation with positive real interest rates (1989-2002).

Table 6: Asset class correlations over different time spans and economic situations

Correlation (1900-2005)	Equities	Bonds	Cash	Inflation
Equities	1			
Bonds	0.42	1		
Cash	0.12	0.46	1	
Inflation	0.09	0.16	0.57	1

The Low Inflation Years

Correlation (1946-1972)	Equities	Bonds	Cash	Inflation
Equities	1			
Bonds	0.50	1		
Cash	0.26	0.12	1	
Inflation	-0.10	-0.28	-0.00	1

The High Inflation Years (Negative Real Interest Rates)

Correlation (1973-1988)	Equities	Bonds	Cash	Inflation
Equities	1			
Bonds	0.43	1		
Cash	-0.10	0.11	1	
Inflation	0.44	0.27	0.31	1

The High Inflation Years (Positive Real Interest Rates)

Correlation (1989-2002)	Equities	Bonds	PUTS	Cash	Inflation
Equities	1				
Bonds	0.25	1			
PUTS	0.59	0.38	1		
Cash	-0.08	0.04	0.05	1	
Inflation	-0.08	-0.29	-0.06	0.51	1

Table 7: Correlation between asset classes over recent periods

The Past Twenty Years

Correlation (1986-2005)	Equities	Bonds	PUTS	Cash	Inflation
Equities	1				
Bonds	0.30	1			
PUTS	0.48	0.23	1		
Cash	-0.16	0.12	-0.17	1	
Inflation	-0.03	-0.01	-0.39	0.38	1

The Past Ten Years

Correlation (1996-2005)	Equities	Bonds	PUTS	Cash	Inflation
Equities	1				
Bonds	0.27	1			
PUTS	0.62	0.55	1		
Cash	-0.39	0.07	-0.46	1	
Inflation	-0.70	-0.39	-0.68	0.34	1

The following observations are made from tables 6 and 7:

- As expected cash had a high positive correlation with inflation during the positive real interest rate regime, but less so during the other periods.
- Cash and equities (and PUTS) were negatively correlated during the past two decades.
- A low correlation is found between cash and bonds. Some explanation therefore can be put forward insofar that higher inflation is positive for cash returns, but negative for bond returns, especially when a real interest rate policy is being followed.
- Whereas the yields of bonds and PUTS are quite often compared, it is found that the latter had a higher positive correlation with equities than with bonds. Thus, if this relationship holds into the future it can be argued that the inclusion of PUTS in an equity portfolio, and *vice versa*, is not necessarily effective diversification.
- Note the relative strong negative correlation between PUTS and inflation. It seems that PUTS will do well in lower inflation regimes, but less so if inflation is trending upwards.
- A mild negative correlation is found between equities and inflation over the past twenty years.
- The correlation between bonds and equities declined substantially since the economy moved into a real interest rate environment. Thereby, bonds became more effective in the diversification of an investment portfolio.

3.3   Finding the Efficient Frontier (Optimal Asset Allocations)

Following the "Markowitz methodology" a range of efficient asset allocations can be determined for different expected portfolio return levels.

Table 8 summarizes the input assumptions used to formulate a set of optimal portfolios, which are illustrated in figure 8 and table 9.

Table 8: Expected return, volatilities and correlation coefficients of different asset
classes

Asset Class	Equities	Properties (PUT)	Bonds	Cash
Expected Return	14.00%	11.00%	9.00%	7.00%
Standard Deviation	18.00%	16.00%	8.00%	2.00%

Correlation	Equities	Properties (PUT)	Bonds	Cash
Equities	1.000	0.500	0.300	-0.200
Properties	0.500	1.000	0.300	-0.250
Bonds	0.300	0.300	1.000	0.100
Cash	-0.200	-0.250	0.100	1.000

The correlation assumptions in table 8 are based on historical evidence with emphasis on the most recent periods where monetary authorities have kept a tight lid on inflation expectations, a policy which in all likelihood will continue in the future.

The expected return for the different asset classes relates to the expected above-inflation returns over the long term. For example, if the long-term inflation outlook (CPI) is expected to be 6%, cash will yield a one percent real return, whereas equities will deliver 8% real return. Note that tax consequences are excluded.

The target return levels are expressed in terms of the risk premium. If one assumes that cash is risk-free and yields one percent real, a portfolio with no risk premium is equivalent to a portfolio with a target return of inflation plus one percent. Similarly, a portfolio with a target risk premium of 4% is equivalent to an expected return of inflation plus 5%.
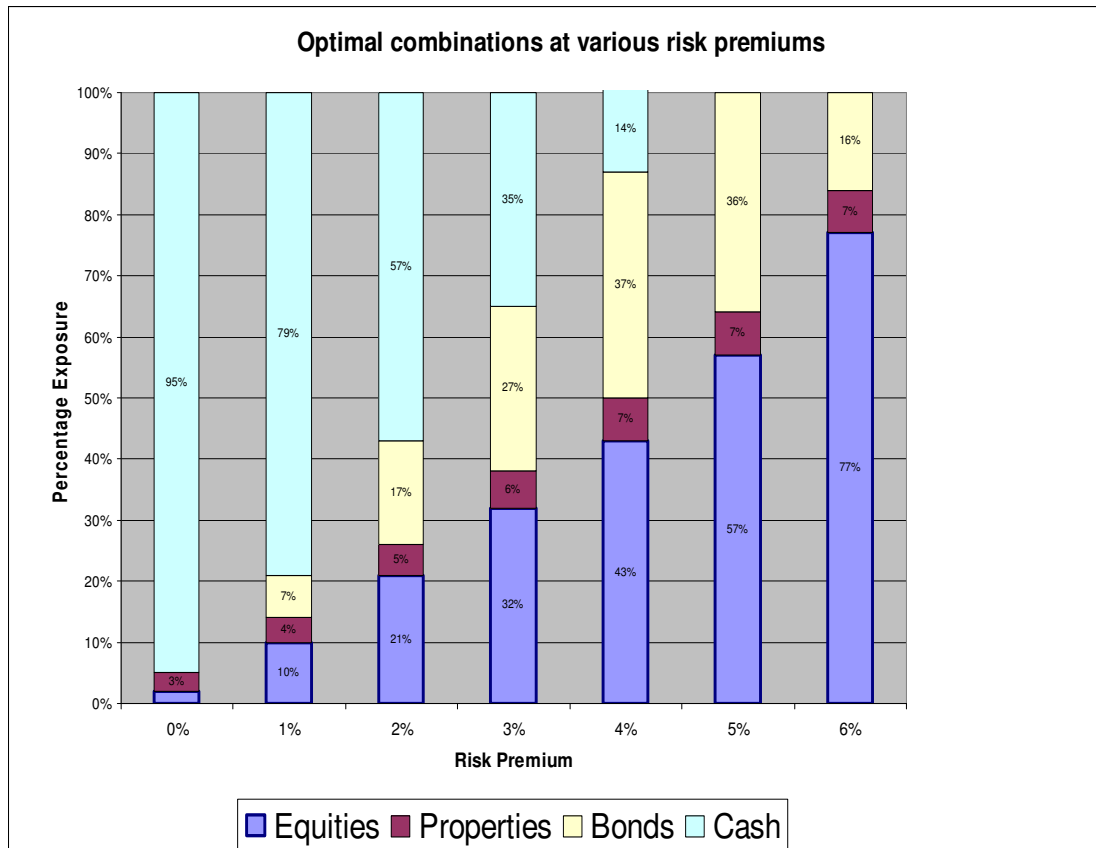

Figure 8: Optimal asset allocations for different target return levels

Table 9: Optimal asset class exposure for different target return levels

Risk Premium	Equivalent Portfolio	Expected Return	Std Deviation	Equities	Properties	Bonds	Cash
0%	CPI + 1%	7.3%	1.9%	2%	3%	0%	95%
1%	CPI + 2%	8.0%	2.6%	10%	4%	7%	79%
2%	CPI + 3%	9.0%	4.8%	21%	5%	17%	57%
3%	CPI + 4%	10.0%	7.2%	32%	6%	27%	35%
4%	CPI + 5%	11.0%	9.6%	43%	7%	37%	14%
5%	CPI + 6%	12.0%	12.1%	57%	7%	36%	0%
6%	CPI + 7%	13.0%	14.9%	77%	7%	16%	0%

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From figure 8 and table 9 it is obvious the higher the target returns, the more risky assets should be included in the portfolio mix.

For example, the optimal asset allocation for the *CPI + 5%* portfolio would consist of 43% equities, 7% properties, 37% bonds and 14% cash with an expected volatility of 9.6% around the expected return of 11%. The *CPI + 7%* portfolio will have 77% equities, 7% properties, 16% bonds and no cash holdings with an expected return of 13%, but with a 14.9% standard deviation.

Since equities and properties (PUTS) have a high positive correlation – thus less efficient diversification – the exposure of properties relative to equities will be limited in the optimal portfolios. However, the model's answer is subject to the core assumptions used in the optimising process. If one believes that properties will yield a higher return than equities over time, the optimising model would have given properties a dominant position in the asset allocation mix for riskier portfolios.

The optimising process described above is an important benchmark (guideline) for the asset allocation decision-making. Yet, it cannot be utilised as-is since it have some serious shortcomings, which will be discussed in the next section.

4.   Portfolio Evaluation

4.1   Building a Simulation Tool

The "mean-variance" optimising method has some serious deficiencies. Two important issues stand out. One, it is static in nature as if the inter-relationships (correlations) between the various asset classes and return levels will not change over time. We know, as we have seen from this study, it is not. Second, it assumes that all asset classes are fairly priced, which we know is not a valid argument, especially for certain asset classes today.

Therefore, an alternative, less rigid, quantitative method might be more appropriate to evaluate the suitability of the different optimal portfolios. For this purposes I have developed a simulation model which incorporates three different economic scenarios, each with its own expected return levels for the various asset classes, but the actual return levels and correlation coefficients are not constant and will fluctuate from year to year.

Table 10 describes the core assumptions used to build the simulation model of which a brief explanation will follow thereafter.

Table 10: Economic and asset class return assumptions

Economic Outlook	Inflation Expectations	Probability	Expected Return Equities	Expected Return Properties	Expected Return Bonds	Expected Return Cash
Good	4%	25%	20%	16%	12%	5%
Neutral	6%	50%	14%	10%	9%	7%
Poor	8%	25%	8%	8%	6%	9%

First, the model has to select the economic outlook for a specific year (good, neutral, poor). Certain probabilities are attached to each economic scenario (25%, 50% and 25% respectively). When the outlook for the economy in a particular year is good, one can expect, for example, equities to perform above average (20% versus 14%). Yet, a lot of other factors are at play which will determine the actual return of equities in a particular year. Therefore, I allow the model to randomly pick a return level (mean return of 20% with a standard deviation of 18%). In similar fashion, when the economic outlook is poor, the expected mean return for equities is 8% with 18% standard deviation. This process is repeated for all the other asset classes, year after year.

Second, once the asset class return for a specific year is known, the model computes the overall return for the different portfolios, each with their own set of asset allocations.

The results of one such simulation are shown in table 11. In this example I have selected three optimal portfolios, namely *CPI +3%*, *CPI + 5%* and *CPI + 7%*, plus an additional two portfolios, namely an equal-weighted portfolio (*Equal*) and a "rule-of-thumb" portfolio (*Heuristic*), which consists of 50% equities, 10% properties, 20% bonds and 20% cash holdings. The annual portfolio returns are displayed over a 20-year period. The different portfolios are compared then over different holding periods (5-year, 10-year, 15-year and 20-year periods), both on a lump sum and recurring investing basis.

A graphical illustration of the 10-year cumulative portfolio returns are shown in figures 9 and 10. In this case the most aggressive portfolio (*CPI + 7%*) have outperformed all the other portfolios in both lump sum and recurring investments.

Table 11: Simulation output

| Year	Predicted Economy	Predicted Inflation	CPI + 3% Total	CPI + 5% Total	CPI + 7% Total	Equal Total	Heuristic Total
1	Poor	8.0%	8.8%	4.5%	4.6%	6.3%	5.9%
2	Neutral	6.0%	7.9%	7.9%	5.4%	10.9%	7.3%
3	Poor	8.0%	8.2%	9.1%	17.4%	-0.2%	10.9%
4	Neutral	6.0%	12.8%	15.8%	19.6%	13.1%	16.3%
5	Good	4.0%	12.2%	19.5%	26.0%	18.1%	20.5%
6	Good	4.0%	10.9%	15.2%	16.7%	14.7%	14.8%
7	Neutral	6.0%	13.3%	22.7%	32.8%	14.2%	23.5%
8	Good	4.0%	3.5%	-1.3%	-11.0%	9.5%	-2.5%
9	Neutral	6.0%	9.2%	13.5%	20.0%	10.5%	14.9%
10	Good	4.0%	20.3%	34.3%	52.8%	26.8%	38.0%
11	Neutral	6.0%	7.8%	4.4%	6.2%	2.3%	5.7%
12	Poor	8.0%	5.6%	7.5%	10.9%	4.4%	8.0%
13	Poor	8.0%	9.9%	9.2%	14.5%	8.2%	11.6%
14	Good	4.0%	8.3%	13.8%	16.6%	10.9%	13.2%
15	Neutral	6.0%	6.8%	4.6%	-0.3%	0.5%	2.1%
16	Neutral	6.0%	10.8%	17.5%	29.0%	7.0%	19.2%
17	Poor	8.0%	-1.2%	-12.3%	-25.8%	-7.8%	-15.0%
18	Neutral	6.0%	11.9%	17.1%	21.1%	14.4%	17.2%
19	Poor	8.0%	9.9%	9.5%	10.0%	2.2%	8.4%
20	Good	4.0%	7.0%	10.9%	20.4%	12.0%	14.6%
Portfolio Composition							
Equities			21%	43%	77%	25%	50%
Properties			5%	7%	7%	25%	10%
Bonds			17%	36%	16%	25%	20%
Cash			57%	14%	0%	25%	20%
			100%	100%	100%	100%	100%
Portfolio Return (Annualised)							
Lump sum investment period		5	9.96%	11.24%	14.31%	9.45%	12.07%
Lump sum investment period		10	10.63%	13.74%	17.31%	12.18%	14.50%
Lump sum investment period		15	9.63%	11.74%	14.61%	9.79%	12.30%
Lump sum investment period		20	9.11%	10.77%	13.17%	8.64%	11.23%
Portfolio Return (Annualised)							
Recurring investment period		5	10.64%	13.47%	17.63%	10.92%	14.29%
Recurring investment period		10	11.24%	15.57%	19.82%	13.82%	16.36%
Recurring investment period		15	9.52%	11.96%	15.02%	9.67%	12.46%
Recurring investment period		20	9.56%	10.55%	12.96%	8.08%	10.93%
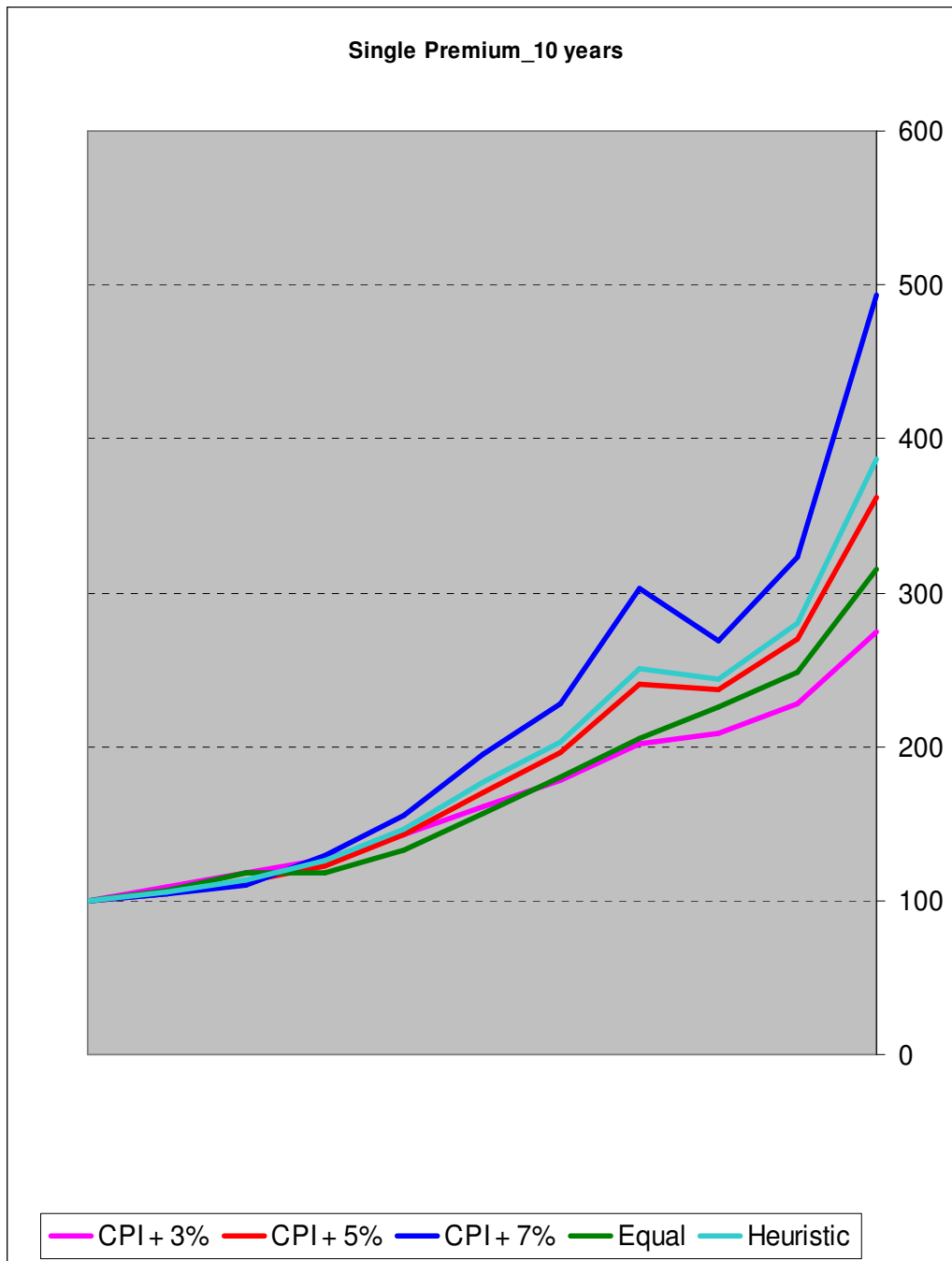
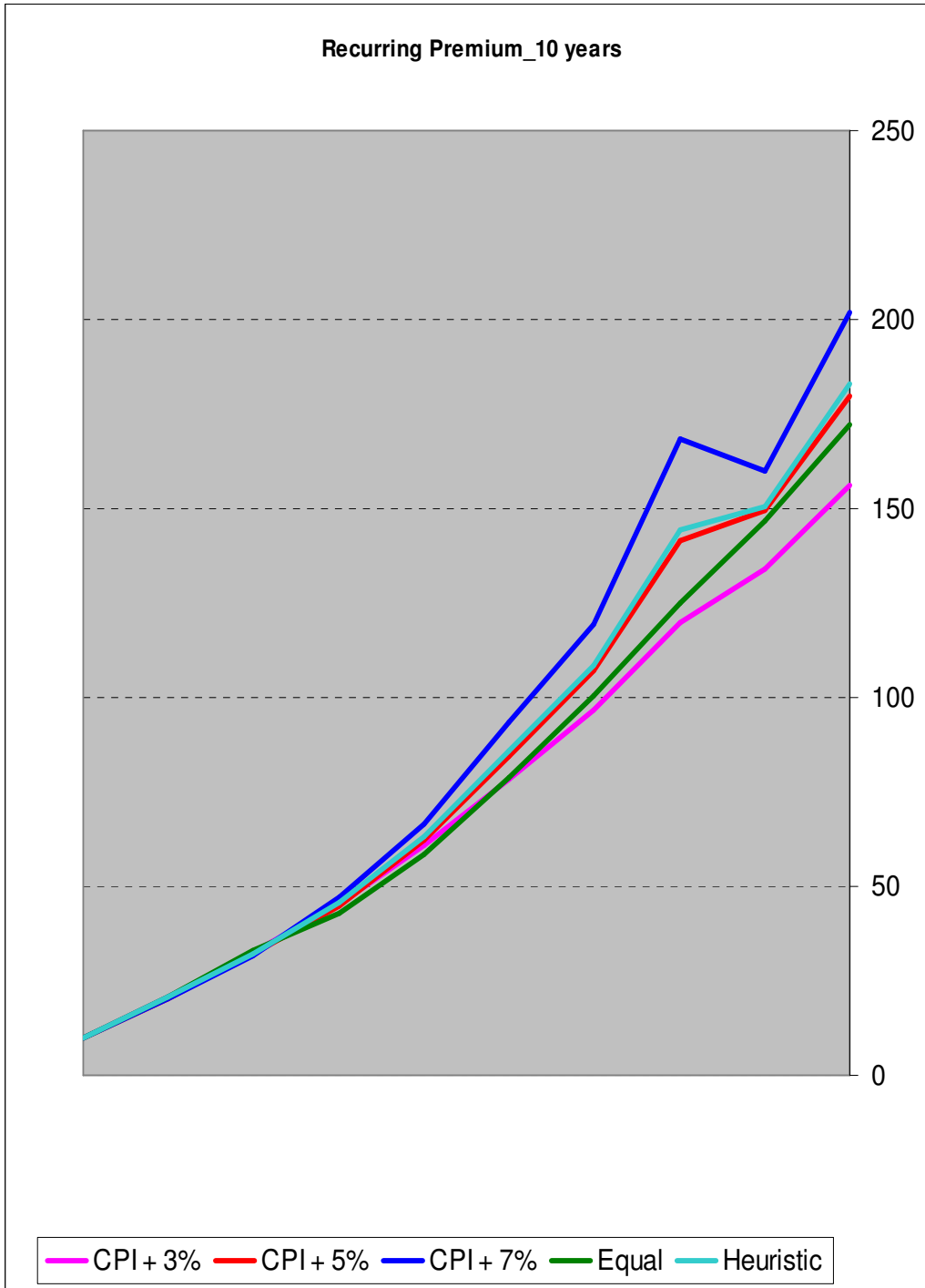Figure 9: Simulated returns for various investment portfolios (lump sum investment)

Figure 10: Simulated returns for various investment portfolios (recurring investment)

4.2   Evaluating the Persistency of Portfolio Performances

In the above example the most aggressive investment portfolio has outperformed all the other portfolios over various holding periods. But we know equity-dominated portfolios are quite volatile, thus if such a portfolio outperformed the less aggressive portfolios in one period, how likely is the out-performance to be repeated in another period or when a different set of economic conditions will apply?

Consequently, I did 100 consecutive simulations. From this I constructed a table of probabilities that a specific portfolio would have been the best or worst strategy, and the likelihood that it would beat inflation and inflation plus 3% benchmarks over a 5-year, 10-year and 20-year period.

Tables 12 and 13 show the outcome of this analysis. Figures 11 and 12 depict the range of confidence intervals in which the respective portfolios would have outperformed an inflation benchmark in a lump sum and a recurring investment scenario.

Table 12: Persistence of investment portfolios (lump sum investment)

Best Strategy

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	8%	19%	7%	0%	66%
10	7%	15%	8%	0%	70%
20	3%	14%	3%	0%	80%

Worst Strategy

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	53%	26%	1%	0%	20%
10	68%	14%	4%	0%	14%
20	82%	6%	2%	0%	10%

Beating Inflation

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	97%	90%	90%	90%	82%
10	96%	94%	93%	91%	87%
20	100%	99%	99%	100%	95%

Beating Inflation + 3%

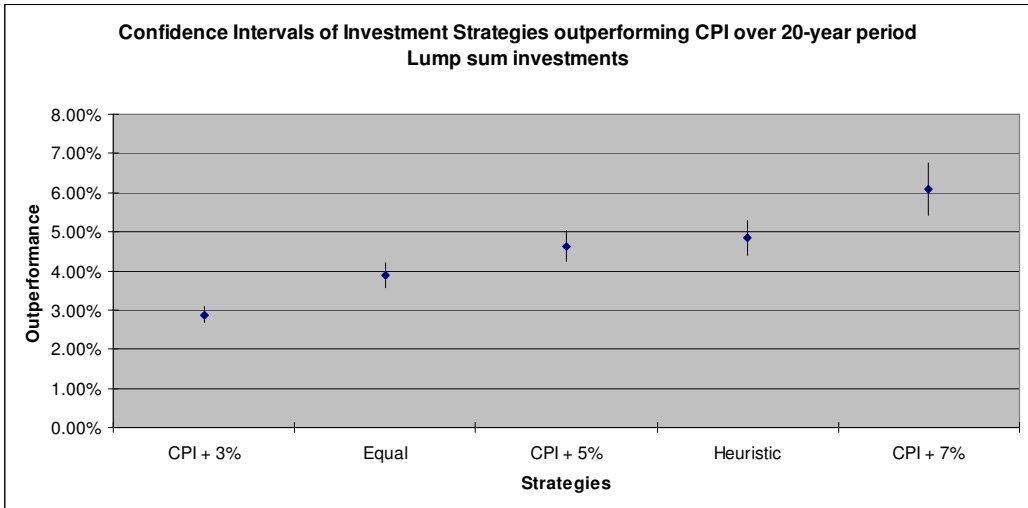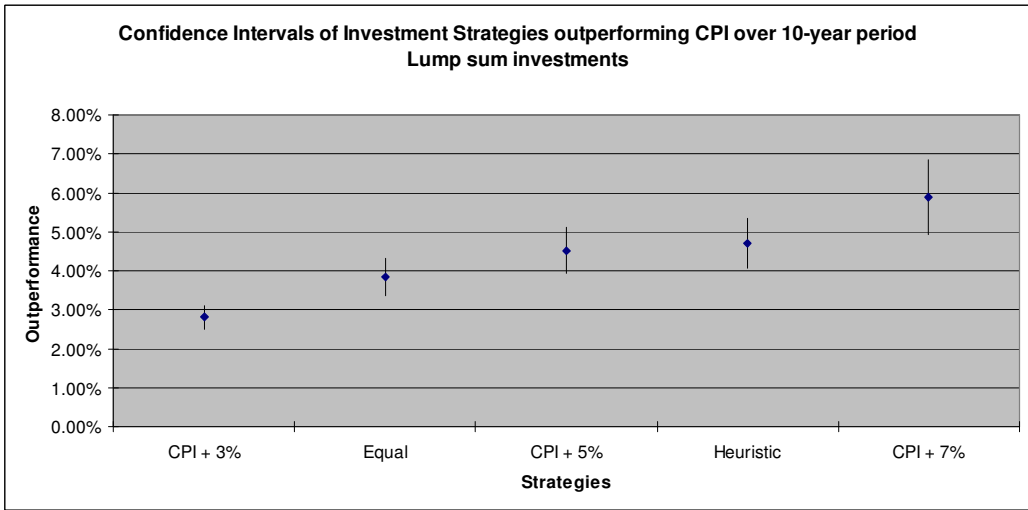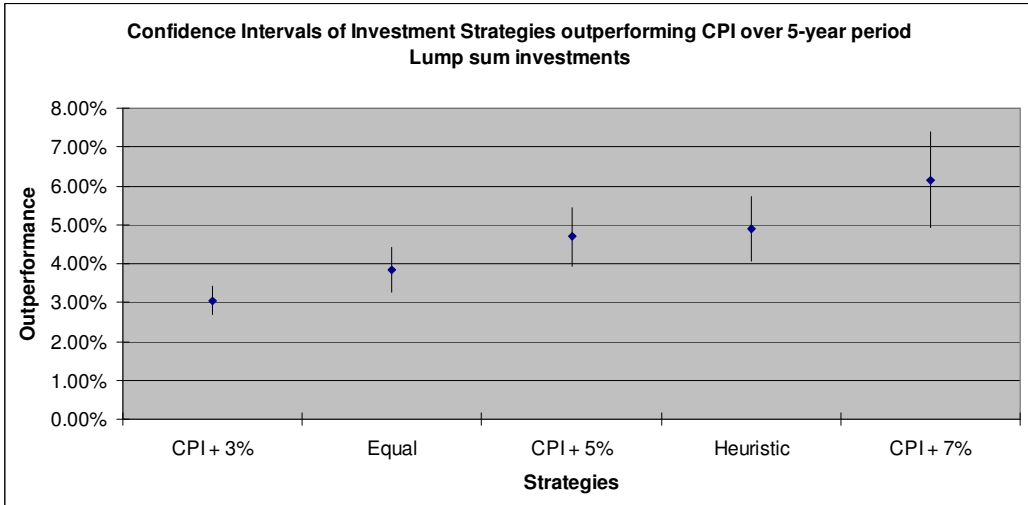| Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	55%	61%	69%	69%	68%
10	45%	60%	71%	70%	71%
20	49%	70%	76%	77%	80%

Figure 11: Confidence intervals of investment strategies outperforming inflation
   (lump sum)

Table 13: Persistence of investment portfolios (recurring investments)

Best Strategy

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	8%	16%	9%	0%	67%
10	4%	28%	4%	0%	64%
20	8%	16%	2%	0%	74%

Worst Strategy

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	66%	15%	3%	0%	16%
10	67%	11%	2%	0%	20%
20	62%	17%	8%	0%	13%

Beating Inflation

Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	93%	91%	86%	86%	85%
10	98%	97%	94%	93%	87%
20	100%	98%	97%	97%	97%

Beating Inflation + 3%

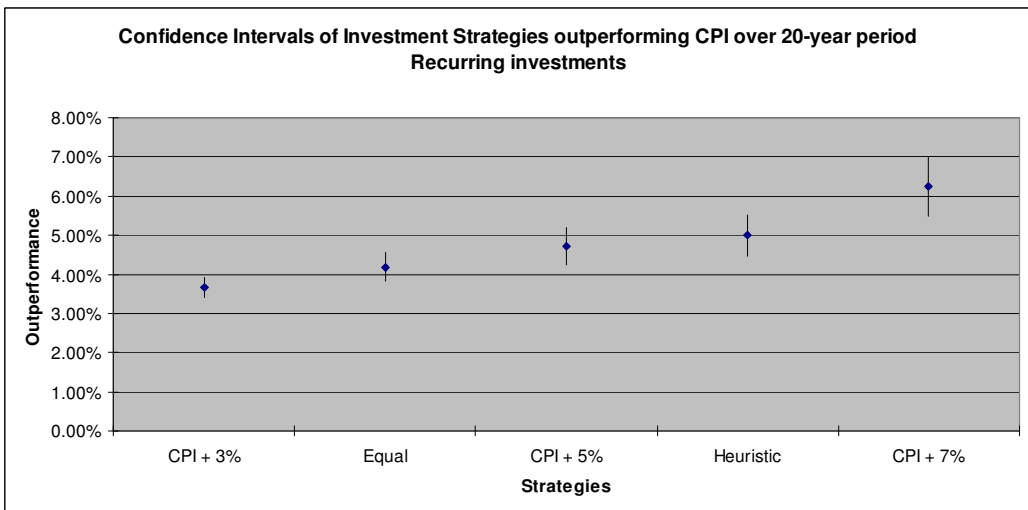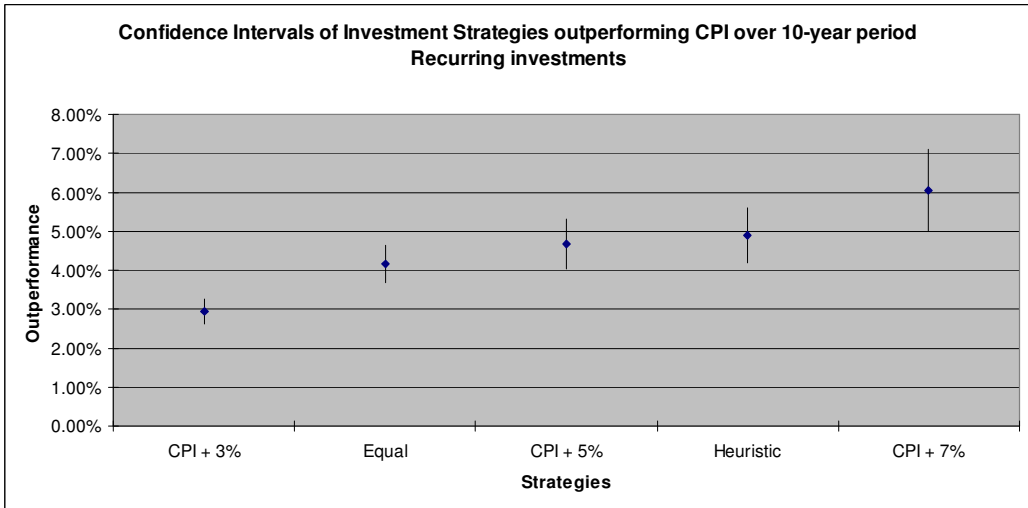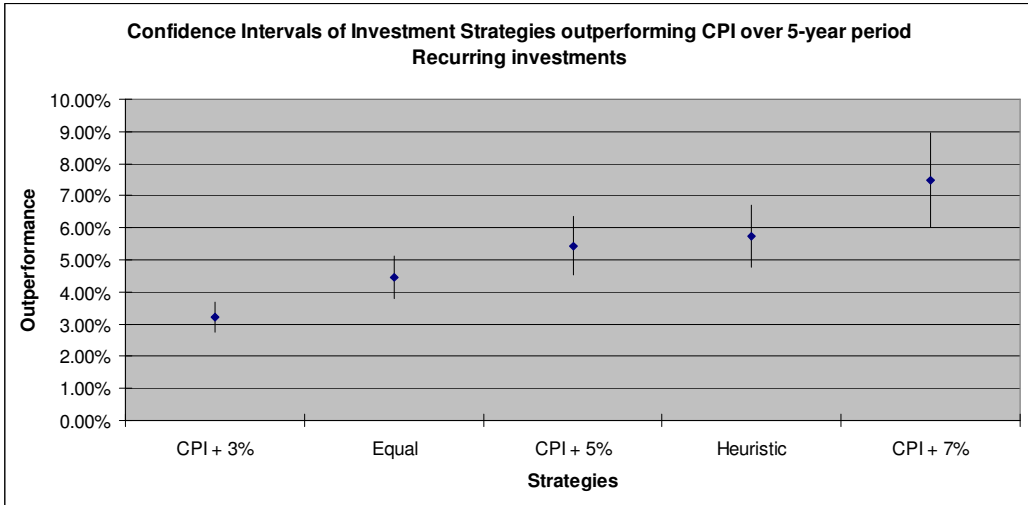| Period (years)	CPI + 3%	Equal	CPI + 5%	Heuristic	CPI + 7%
5	53%	67%	71%	74%	75%
10	49%	70%	67%	67%	67%
20	63%	75%	73%	75%	79%

Figure 12: Confidence intervals of investment strategies outperforming inflation
(recurring)

A brief discussion of table 12 and figure 11 follows below:

Most often the *CPI + 7%* would have been the best performing portfolio over the various holding periods. Surprisingly, the *Equal* portfolio would have yielded the second highest success rate. Note that the *Heuristic* portfolio never came out tops, while the *CPI + 3%* and *CPI + 5%* had low to moderate success.

But look now at the flipside of the coin – the *CPI + 3%* would have been most often the worst portfolio selection over the various holding periods, especially over the longer term periods. Furthermore, the *Equal* and *CPI + 7%* portfolios have had a relative high failure rate, especially over the shorter holding periods; strengthening the belief that shorter term investment horizons should have a more conservative character (less risky assets). Interestingly, note that the *Heuristic* portfolio never became the worst portfolio selection during any holding period.

Inflation is the long-term investor's biggest enemy since it destroys the purchasing value of money. Therefore, it is imperative that any well-designed portfolio should beat the inflation benchmark over a reasonable period. Somewhat of a contra-dictionary, but not surprising result is evident from this analysis. The surest way of beating inflation is by following a conservative approach (*CPI + 3%*), but when the stakes are put up a notch higher – inflation + 3% benchmark – it had the worst success rate. In fact, the *CPI + 5%*, *CPI + 7%* and *Heuristic* portfolios had the best success outstripping the inflation + 3% benchmark.

Figure 11 shows the confidence intervals (indicated by the vertical lines on the graph) where one should find 95% of the time the average above-inflation performance. In general, note that all "*CPI +*" portfolios conveniently outstripped inflation, but not necessarily by the intended margins. For example, the *CPI + 7%* portfolio is unlikely to produce a 7% real return, especially over longer holding periods.

5. Conclusion

By no means is the simulation model used in this analysis exhaustive, but it provides some educational value in ascertaining the appropriateness of different investment portfolios in satisfying their investment objectives.

On balance, weighing up the simulation results as illustrated in the previous section, it seems that the *CPI +5%* and *Heuristic* portfolios delivered the most persistent results, despite seldom being the best performing strategy over various holding periods. At the same time, these strategies rarely became the worst performers!

The *CPI + 7%* portfolio is by no means a bad long-term investment strategy, but follows a much more uncertain route where the actual outcome might not justify the extra risks being taken. The *CPI + 3%* portfolio seems to be more suited for a shorter term investment horizon (5 years and shorter). The *Equal* portfolio, despite its average 4% real return, does not seem as persistent as the two preferred portfolios (*CPI + 5%* and *Heuristic*) and thus not likely to be recommended.