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PENSION SCHEMES AND FIXED INCOME INVESTMENT

BY P. J. SWEETING

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ABSTRACT

The purpose of this paper is to investigate the role that fixed income securities should play in pension scheme investment. In this paper I look at the investment characteristics of the various bond asset classes, including the nature of the income streams produced. I also look at the relationships between the various asset classes and their stability over time. I then look at the usefulness of the asset classes in the context of a pensioner portfolio, considering both capital values and income streams. I look at skew and excess kurtosis in the distributions of asset returns and consider the effect of their existence on the decision making process. Given that most asset models are calibrated using historical data, I do not carry out any modelling and instead analyse past data. Finally, I discuss practical issues that need to be considered, particularly in a United Kingdom context.

KEYWORDS

Actuarial; Pensions; Investment; Bonds; Investment Grade; High Yield; Income; Capital; Risk

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1. BACKGROUND

1.1 *Introduction*

1.1.1 The purpose of this paper is to investigate the role that fixed income investment should play in occupational pension scheme investment and to discuss some of the issues that should be considered when investing to match liabilities.

1.1.2 Historically, bond investment for United Kingdom pension schemes meant Treasury bonds (that is, gilts). Now, though, investment grade debt is used extensively. The popularity of high yield (sub-investment grade) corporate debt, on the other hand, has generally been limited to the individual investors through pooled funds, although an increasing number of pension schemes are allocating funds to this asset class. On the supply side, the increase in the availability of all types of corporate debt, both from issuers and through pooled investment vehicles, comes at a time when its place in occupational pension scheme portfolios is being considered. This consideration has been at least partly driven by the development of market-based accounting requirements for pensions, such as Financial Reporting Standard (FRS) 17 (Accounting Standards Board, 2000). Also, the application of financial economic theory is resulting in moves away from equities and towards bonds, as in the case of the Boots pension scheme. This case is discussed in detail in Ralfe (2001), and the theory is discussed in more detail by, among others, Smith (1996), Jarvis *et al.* (2001) and Chapman *et al.* (2001).

1.2 *Proposed Approach*

1.2.1 In Section 2 I analyse the various bond asset classes in terms of the returns that they have produced. In Section 3 I extend this analysis to include the pension scheme liabilities. In Section 4 I look at the income produced by bond portfolios, and in Section 5 I extend the analysis to include the income required by a group of pensioners. In Section 6 I look at some other issues that should be considered, before giving my conclusions in Section 7.

1.2.2 In this paper, I use data from the United States market. Not only is this the largest single country debt market, with the longest history and the greatest amount of data, but also concentrating on a single market removes the need to allow for more than one currency and the differences in risk/return profiles that would occur if the country weights were different in each asset class. In concentrating on the U.S.A., I make an implicit assumption that relationships between sterling asset classes can be inferred from those between U.S. asset classes. This is particularly important for an asset class such as high yield corporate debt, where the U.K. history is negligible.

1.2.3 It is, though, worth bearing in mind that there are important differences between the U.K. and U.S. bond markets. Considering the corporate bond market, the U.S. market is a much more mature market than that of the U.K. There are also important differences between the bankruptcy laws in the U.S.A. and in Europe, which have an effect both on default rates, and on recovery rates in the event of default. It is reasonable to expect these differences to affect prices and thus influence returns.

1.2.4 This leads me to the asset classes that I consider. I look at the investment characteristics of the following debt asset classes:

— U.S. investment grade Treasury bonds (debt issued by central government, which can be taken to be free from the risk of default);
— U.S. investment grade corporate debt (high quality debt issued by companies); and
— U.S. high yield corporate debt (less secure company-issued debt).

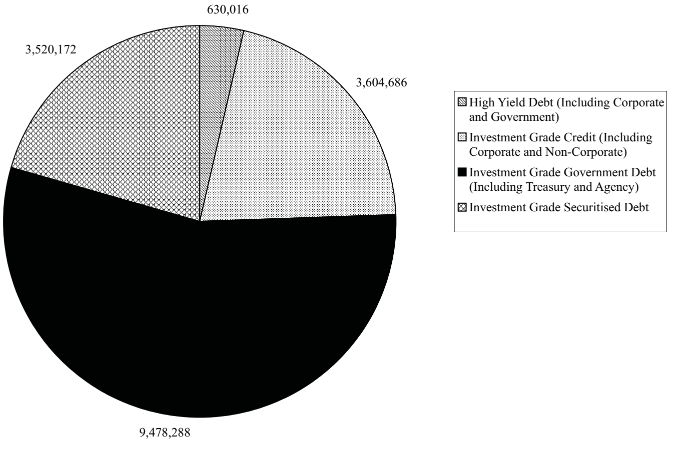

Figure 1.1. Comparison of global debt markets as at 31 December 2002 ($m)

1.2.5 I do not consider other categories such as collateralised debt, debt issued by supranational organisations or emerging market debt. However, I do include U.S. equities as a risk asset class. The choice of asset classes is driven by the country considerations above.

1.2.6 Throughout this paper I use the Lehman indices for bonds and the MSCI indices for equities.

1.2.7 Investment grade debt (both corporate and government) is debt with a rating of at least Baa3 from Moody's or BBB − from Standard & Poor's. Globally, the vast majority of debt is investment grade and thus deemed to have a relatively low risk of default. High yield debt (again, both corporate and government) is a broad term that refers to non-investment grade debt, that is, debt with a Moody's rating Ba1 or Standard & Poor's rating BB+ or lower. High yield debt, as its name suggests, offers a higher interest yield than investment grade debt. The yield is higher because there is a significant chance that the interest and/or the capital outstanding will be deferred, reduced, or will even remain unpaid. Even for the highest grade of high yield debt, the bonds are judged to have speculative elements; their future cannot be considered as well assured. More information on this asset class is given in Sweeting (2002).

1.2.8 The relative sizes of debt asset classes are shown in Figure 1.1. Also shown, in Figure 1.2, are the relative sizes of the U.S. asset classes that I use, with equities being included this time. Even in aggregate, the bond asset classes have a smaller market value than the equity market.

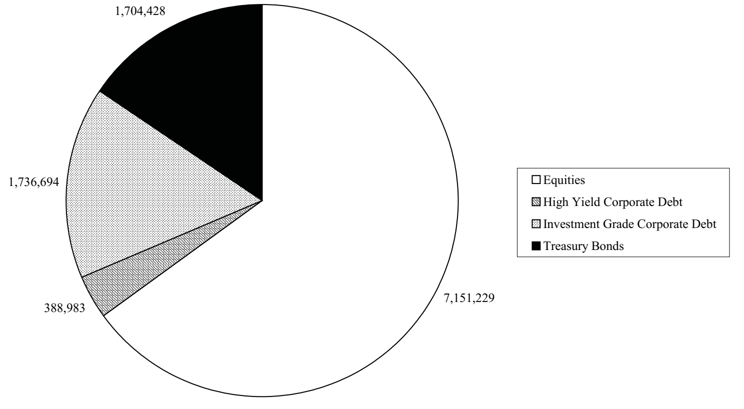

Figure 1.2. Comparison of U.S. markets as at 31 December 2002 ($m)

1.2.9 For a pension scheme there are three true matching asset classes: fixed income government bonds, inflation-linked government bonds (both of which are risk free in a developed market) and cash (or at least fixed-term deposits or zero-coupon bonds). These are effectively the only classes that can exactly match fixed pension payments, inflation-linked pension payments and cash lump sums respectively (if mortality is ignored).

1.2.10 However, it should be noted that even these matching classes have their limitations. Some liabilities, such as 5% LPI pension increases (increases in line with inflation subject to a ceiling of 5% p.a. and a floor of 0% p.a.) are difficult to hedge (although swaps to hedge these liabilities are becoming increasingly popular); salary inflation can only be hedged approximately; and even 'straightforward' liabilities can be difficult to match if they are particularly long in duration. I cover these issues later in the paper; however, for now I limit my analysis to 'straightforward' liabilities.

1.2.11 Other investment grade debt may be used in addition to government debt, as the low default rates make it an attractive substitute for part of the government bond portfolio, although it should be noted that it is not a true matching asset class, since there is a small, but genuine, risk of default. There is also the greater risk of downgrade. However, most important risk is valuation risk: if liabilities are valued using government bond yields, then an increase in the yield spreads of corporate over government bonds will adversely affect the ratio of assets to liabilities, or 'funding ratio', and government bond yields are appropriate for giving a true idea of the value of the liabilities. If liabilities are valued with reference to

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the yields on investment grade corporate debt, as is the case with U.S., U.K. and international accounting standards, then the volatility of the reported results (although not the underlying risk) is reduced through the use of investment grade corporate debt.

1.2.12 High yield corporate debt is not a matching asset class, as the higher default rates take returns even further away from government bond returns than investment grade corporate bonds. However, it is not clear how good a match high yield corporate debt would be for liabilities in terms of comparing the income stream from a portfolio of high yield bonds with a group of pensions in payment.

1.2.13 I restrict my calculations to historical data. Although it would be possible to carry out risk and return analysis using stochastic asset/liability models, I do not believe that these would give any additional information, since they would have been calibrated using past data. I believe this to be especially true since the dataset that I am using (1984 to 2002) contains a good range of different economic scenarios, although the steady reduction in long-term interest rates over the period has resulted in higher bond returns than could reasonably be expected in future.

1.2.14 There are several analyses that I carry out. The first is to compare the historical risk and return characteristics of U.S. high yield corporate debt, investment grade corporate debt, Treasury bonds and equities. In addition, because these measures look at each asset class in isolation, I consider correlations between these asset classes and measures of skew and excess kurtosis. Given that many of the risks considered by pension schemes are one sided (for example, the risk of a funding level — the ratio of assets to liabilities — falling below a certain level or the risk of contributions rising above a certain level), the shape of the distribution of asset returns is actually quite important — the mean and standard deviation do not necessarily provide sufficient information.

1.2.15 The risk and return characteristics of a market portfolio of the various U.S. asset classes (that is, one where each asset class is weighted according to its market capitalisation) are then used to calculate the beta for the various asset classes relative to the market portfolio. This shows whether the assets have been undervalued relative to the market.

1.2.16 I also consider the cash flow properties of the bond asset classes on an asset only basis by looking at the income produced by portfolios of each asset class.

1.2.17 So far all of this analysis is asset only. Whilst this is useful, it is important to look at the various bond asset classes in the context of a portfolio of liabilities. To this end I use mean/variance analysis on both assets and liabilities. I also extend the cash flow analysis to compare the income produced by debt portfolios with the benefits payable to a group of pensioners.

2. The Relative Efficiency of Bond Asset Classes

2.1 *Introduction*

In-depth work on the efficiency of credit bonds was carried out by ABN Amro (2000). This work was largely based around mean/variance analysis (that is, comparing the expected return and expected risk as measured by the variance of return) and included both historical and projected analysis. My analysis in this section builds on theirs, both in terms of scope and of data used, and efficiency here refers to mean/variance efficiency as well as beta calculation. As for all analysis in this paper, the bond data is taken from Lehman Brothers and the equity data from MSCI.

2.2 *Some Basic Risk and Return Measures*

2.2.1 The data that I use cover the period 1984 to 2002, since this is the longest whole-year period for which returns on U.S. high yield corporate debt (the asset class with the shortest history) are available. I generally use monthly data in my analysis (although I sometimes aggregate them to give annual figures) and rolling ten-year sub-periods (1 January of the starting years to 31 December of the ending years), as well as analysis of the whole period.

2.2.2 Figure 2.1 shows the annual returns for each asset class over the period 1984 to 2002. There are a number of interesting points to note about this figure. The first relates to the volatility of the asset classes. The returns on equities are clearly more volatile than those on other asset classes. It is also obvious that equities have performed poorly over the last three years. However, just as interesting is the fact that Treasury bonds and investment

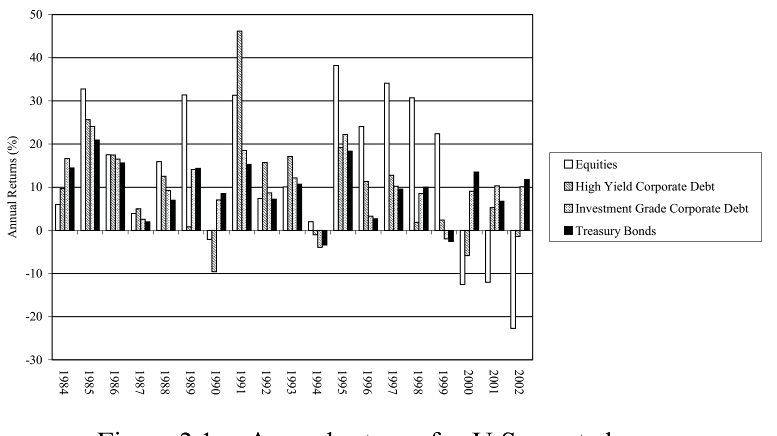

Figure 2.1. Annual returns for U.S. asset classes

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grade corporate bonds have both performed very well over the same period. This is particularly interesting, given that pension scheme liabilities generally move in the same direction as bond values — in other words, equities might have underperformed cash, but their performance relative to pension scheme liabilities will have been much worse.

2.2.3 In order to gain a clearer idea of the relative attractiveness of asset classes, it is necessary to calculate some more statistics.

2.2.4 Looking at the mean monthly returns and the standard deviations of monthly returns in Figure 2.2, it is clear that equities have had the highest average returns, but with the greatest volatility. This pattern of higher return for higher risk also holds for investment grade corporate debt and Treasury bonds, but for high yield corporate debt the higher volatility was not similarly rewarded for the period. Looking at the annual returns, it can be seen that recent strong performance by investment grade corporate debt is as big a factor in this as poor performance by high yield corporate debt.

2.2.5 This can be demonstrated by looking at rolling ten-year mean returns, in Figure 2.3. These show that it is only in the last two ten-year periods that ten-year returns on high yield corporate debt have fallen to levels comparable with or below those on investment grade corporate debt or Treasury bonds. It is also interesting to note that mean returns on all asset classes have generally decreased over time, albeit with mean equity returns going in the opposite direction for several periods as a result of the bubble in the late 1990s.

2.2.6 The picture for standard deviations, shown in Figure 2.4, is more consistent, with equities still at highest risk, Treasury bonds at lowest risk and the two corporate bond asset classes in the middle. Standard deviations of

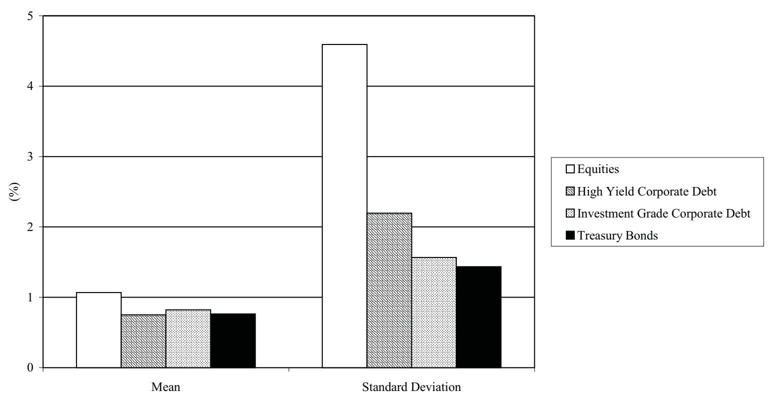

Figure 2.2. Mean and standard deviation of monthly returns, 1984 to 2002

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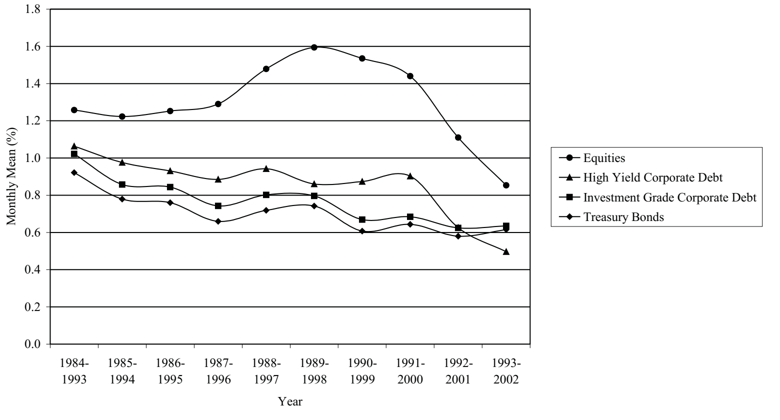

Figure 2.3. Mean monthly returns, rolling ten-year periods

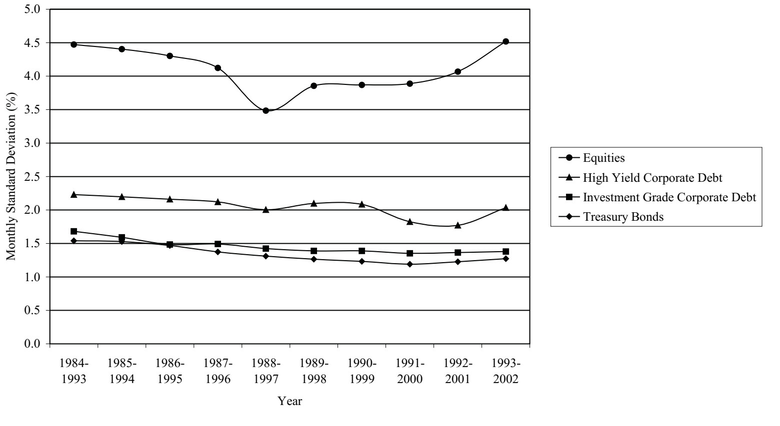

Figure 2.4. Standard deviation of monthly returns, rolling ten-year periods

returns were also decreasing over time for all asset classes until a couple of years ago, when volatility for equities and high yield corporate debt increased again.

2.2.7 The mean and standard deviation can be combined to give the traditional risk/reward chart, as shown in Figure 2.5, with risk measured as the standard deviation of monthly returns. As can be seen, the three bond asset classes move in broadly similar ways, very differently from

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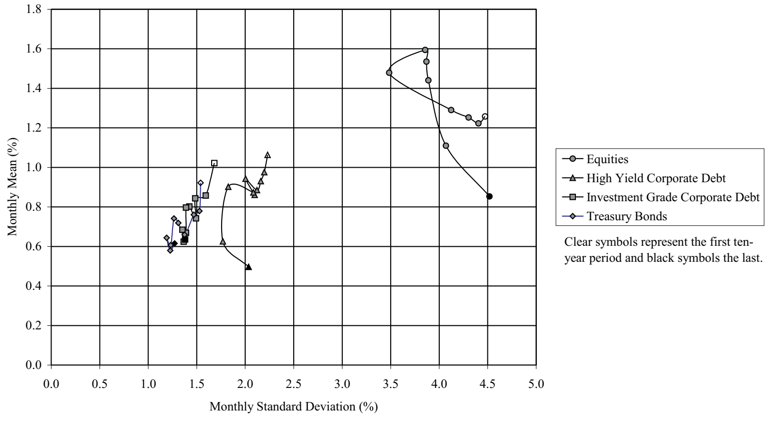

Figure 2.5. Mean/variance analysis, rolling ten-year periods, 1984 to 2002

equities. Looking more closely, it is clear that, whilst the risk differentials between high yield corporate debt and the other bond asset classes stay reasonably constant over the various periods, the return advantage of high yield corporate debt over the other bond asset classes has diminished recently, although even here the fall has not been as great as for equities.

2.2.8 Figure 2.6 shows the mean variance analysis for the whole period. It too shows that although the broad level of risk for high yield corporate debt is comparable to that of the other bond asset classes (albeit the highest of that group), it did provide the lowest returns over the period 1984 to 2002. Figure 2.6 also gives the efficient frontier, which I discuss in more detail later.

2.2.9 However, apart from high yield corporate debt, it is difficult to see which of the asset classes have relatively good or poor risk adjusted returns. One way of demonstrating the risk adjusted returns on the various asset classes is to look at the Sharpe ratio. This is calculated as the mean of the excess returns over the risk free asset divided by the standard deviation of the same excess returns. For the risk free asset class I use U.S. cash, so the risk free return is the U.S. discount rate. The Sharpe ratio over successive periods and for the four asset classes is given as Figure 2.7.

2.2.10 This shows that, for the period under investigation, on a risk adjusted basis, there is not much to choose between the various asset classes — the relative attractiveness of each changes over the rolling periods, although equities and high yield corporate debt have fared particularly badly over recent periods.

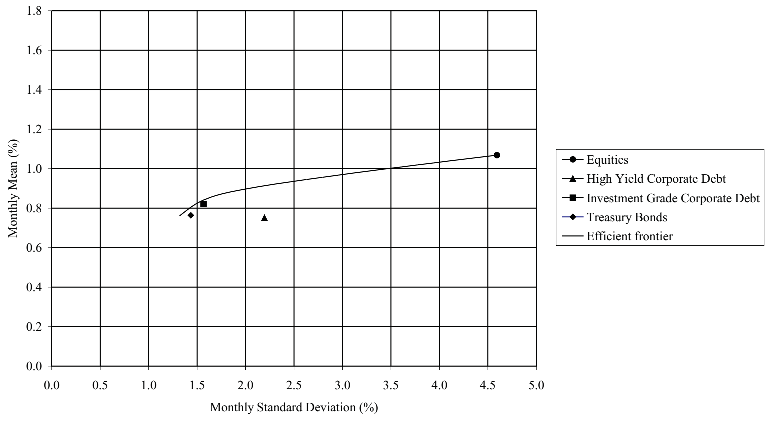

Figure 2.6. Mean/variance analysis, 1984 to 2002

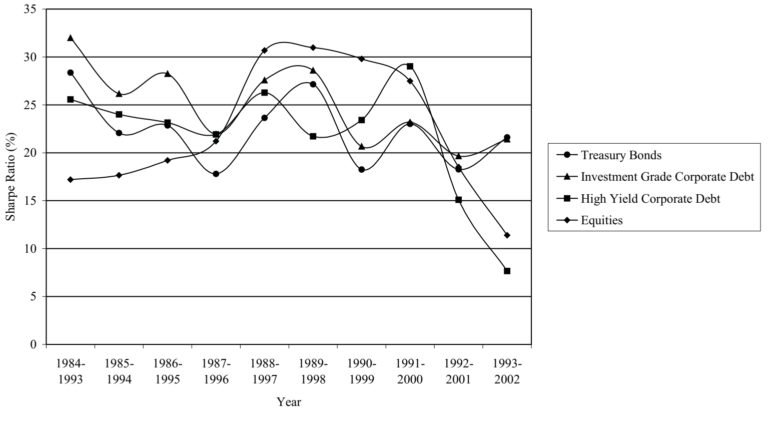

Figure 2.7. Sharpe ratios, rolling ten-year periods

2.2.11 Looking at the results for the whole period in Figure 2.8, the asset classes appear to fall into two distinct groups: Treasury and investment grade corporate bonds in one, and high yield corporate debt and equities in the other, with the former group giving significantly better risk adjusted returns from the latter. At first sight Figure 2.8 appears inconsistent with Figure 2.2: the standard deviation of monthly equity returns was more than twice that of high yield corporate debt returns,

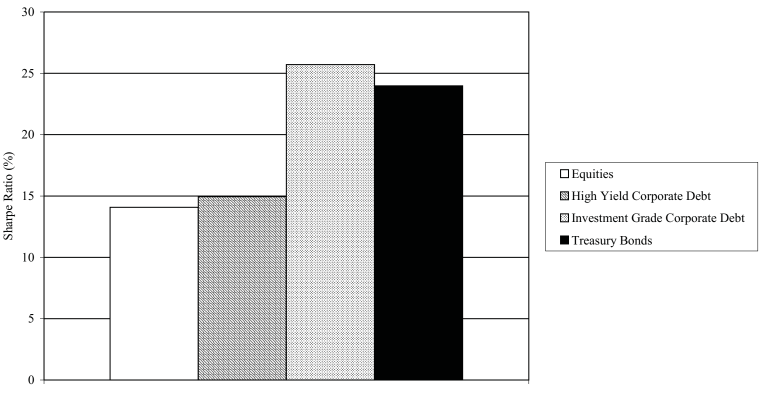

Figure 2.8. Sharpe ratios, 1984 to 2002

whereas mean equity returns were much less than twice mean high yield corporate debt returns; however, Sharpe ratios for the two asset classes are similar. This is because the returns used in the calculation of the Sharpe ratio are net of the risk free return, which will reduce mean returns (leading to a greater proportional difference between equities and high yield corporate debt), but not standard deviations of returns (since the risk free asset has a standard deviation of zero).

2.3 *Skew and Kurtosis*

2.3.1 Although mean/variance analysis gives an indication of the risk/return trade off, it does not always give the whole picture. For example, investors interested in a one-sided measure of risk, such as expected shortfall, should consider the shape of the return distributions, that is, skew and excess kurtosis, as shown in Figures 2.9 and 2.10.

2.3.2 The skew of a distribution measures how lop-sided the distribution is — positive skew indicates that the right tail of the distribution is longer than the left (and the mean is greater than the median, which is greater than the mode), whilst negative skew indicates the opposite. The normal distribution is symmetric, so the mean, median and mode are equal.

2.3.3 Excess kurtosis measures how fat the tails of the distribution are. The fatter the tails, the greater the chance of an extreme result relative to the probability implied by the normal distribution. Excess kurtosis is calculated as the kurtosis less three, since the standard normal distribution has a kurtosis of three. I always refer to excess kurtosis. A distribution with fat tails (positive excess kurtosis) is said to be leptokurtic, whilst one with thin tails (negative excess kurtosis) is said to be platykurtic.

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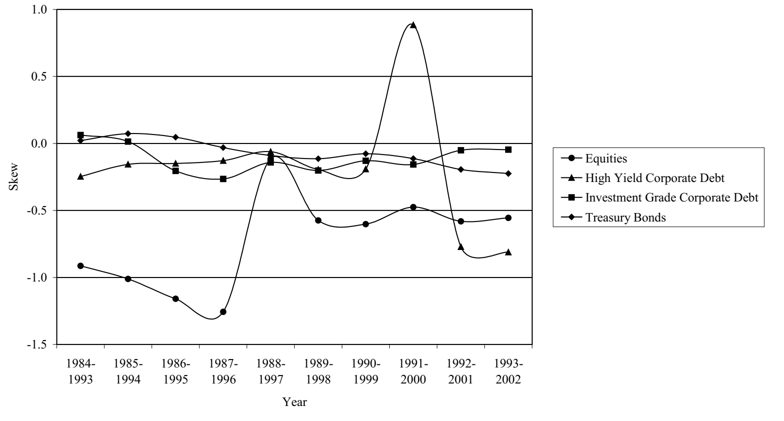

Figure 2.9. Skew of monthly returns, rolling ten-year periods

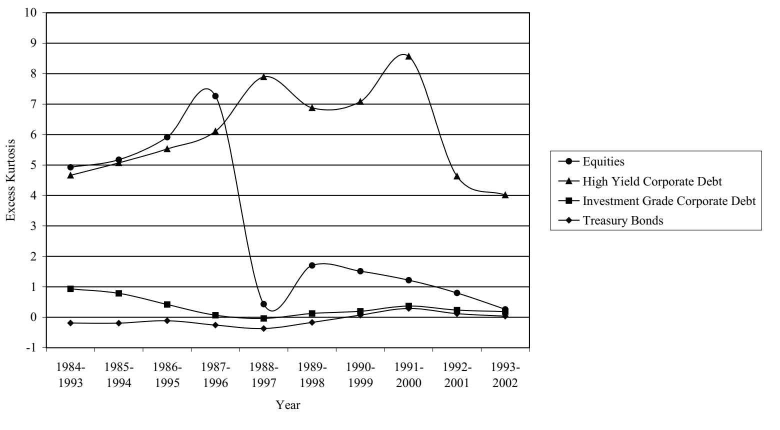

Figure 2.10. Excess kurtosis of monthly returns, rolling ten-year periods

2.3.4 An important point to make about these pictures is that the skew and the excess kurtosis can move a great deal, depending on the sample period — adding an additional year of data can have a large impact on the higher moments of the return distributions.

2.3.5 However, looking at the skew and excess kurtosis for the full period (Figure 2.11) marks out one asset class — high yield corporate debt

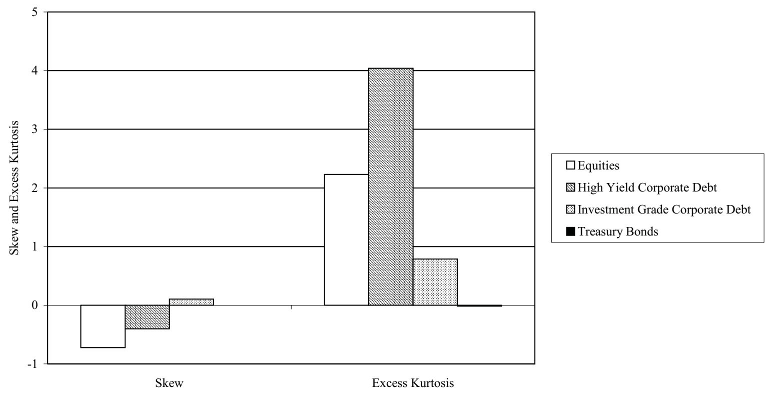

Figure 2.11. Skew and excess kurtosis of monthly returns, 1984 to 2002

— as apparently being less 'normal' than the others, by virtue of its high excess kurtosis ('fat tails').

2.3.6 There are few statistical tests available to determine the statistical significance of skew or excess kurtosis. Excess kurtosis in particular is difficult to test, since it is characterised by too many (or too few) observations in the tails of the distribution, so a large number of observations is needed to provide any certainty over the result. It is possible to determine whether the skew and kurtosis combined are statistically significant by carrying out a test for non-normality, such as the χ^2 test or the Bera-Jarque (1981) test.

2.3.7 The χ^2 test involves comparing the number of observed results in each range of returns with those that would be expected if the returns were normally distributed, using the sample mean and standard deviation. Looking at rolling ten-year periods for each asset class, there was no significant non-normality at the 5% level for any asset class other than for high yield corporate debt. This exhibited non-normality at the 10% level of significance in 1985 to 94, 1986 to 95, 1991 to 2000, 1992 to 2001 and 1993 to 2002; in all sub-periods from 1987 to 1996 until 1990 to 1999, it exhibited non-normality at the 5% level of significance. Unsurprisingly, it also exhibited non-normality at the 5% level of significance for the full period 1984 to 2002.

2.3.8 The Bera-Jarque test, rather than being a general 'goodness of fit' test, is calculated from the skew and excess kurtosis. It is calculated as:

$$\frac{\hat{\tau}^2}{6} + \frac{(\hat{\kappa} - 3)^2}{24}$$

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which is distributed χ^2_2, and where $\hat{\tau}$ is the sample coefficient of skew and $\hat{\kappa}$ is the sample coefficient of kurtosis (excess kurtosis being kurtosis in excess of three).

2.3.9 Under this test, the 'least normal' asset class appears to be high yield corporate debt over the period 1991 to 2000. However, even in this instance the Bera-Jarque statistic is not significant at even the 20% level (3.19 against a critical value of 3.22).

2.3.10 One characteristic of high yield corporate debt that leads to this non-normality is the fact that many issues are callable. This means that the issuer of the bond has an option to redeem it on pre-specified terms. This call option will be exercised if the redemption yield on the bond falls below a particular level, since it will then be better for the issuer to redeem the bond and issue another at a lower interest rate than to carry on paying the higher rate of interest. The callability of many high yield corporate debt issues means that there is an upper limit to the performance of these issues. Given that the lower limit to performance of a bond is that it will become worthless, the result is skewed returns.

2.3.11 There is, of course, an upper limit to the performance of investment grade corporate bonds (a spread over Treasury bonds of zero), and of Treasury bonds (a redemption yield of zero), but these are only theoretical, although Japanese government bonds have come close to this limit.

2.3.12 There is, therefore, no evidence for non-normality in the returns of Treasury bonds, investment grade corporate debt or equities. The results for high yield corporate debt, however, are inconclusive, and point potentially to both leptokurtosis and skew. However, there are signs of kurtosis and skew in other asset classes, albeit statistically insignificant at the 5% level. If negative skew is present, then, if returns are assumed to be normally distributed, they might not adequately allow for very bad results. Leptokurtosis is also potentially an issue, as it means that the probability of extreme results might be greater than expected if the asset model used assumes normally distributed returns.

2.3.13 Smith *et al.* (2001) give a brief overview of the models that consider fat tails, so the issue of leptokurtosis is being considered, the issue being ''returns might be more risky than you think they will be''. However, the potential for skewed returns is at least as important, since it means that a strategy chosen using a volatility-based measure could be different from that chosen using a downside risk measure. The asset allocations would be the same if the distributions of expected returns were symmetrical. This is important, given that for most financial entities downside risks are far more important than volatility.

2.4 *Correlation and Efficient Frontiers*

2.4.1 The information in the figures so far does not give a complete

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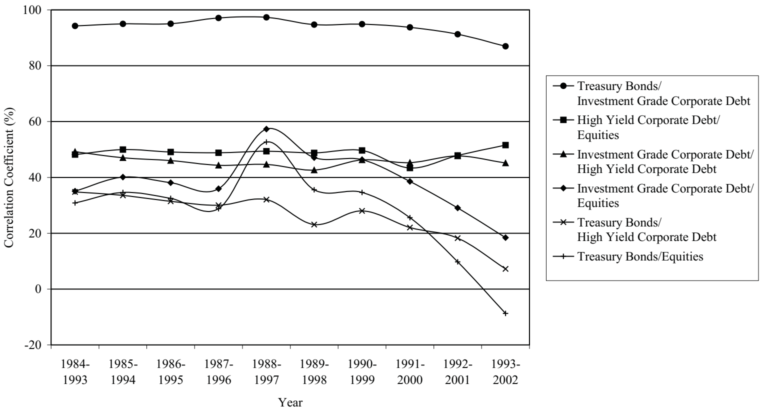

Figure 2.12. Correlation coefficients, rolling ten-year periods

story. Treasury bonds always offer the lowest risk (and return), and the reverse is true of equities; investment grade corporate debt has slightly higher risk and return than Treasury bonds; and high yield corporate debt has slightly higher risk than Treasury and investment grade bonds, and this risk has sometimes been rewarded with higher returns, although both risk and reward fall a long way short of equities.

2.4.2 However, what none of these figures show is the diversifying effect of combining various asset classes. Figure 2.12 shows that, apart from Treasury bonds and investment grade corporate debt, the correlations between the various asset classes are not high, particularly over the last couple of years, where strong Treasury and investment grade corporate debt returns have coincided with poor equity and mediocre high yield corporate debt returns. The correlations for the whole period 1984 to 2002 are given in Figure 2.13. Both of these figures indicate that high yield corporate debt has a potential role to play as a diversifier in low risk portfolios, and that equities come into play higher up the risk/return scale.

2.4.3 A way of combining the expected risk and return characteristics of the various asset classes that takes into account the correlations between them is to use efficient frontier analysis. The charts of the efficient frontiers themselves are not that interesting — all are upward sloping and end with the portfolio of 100% equities (which gives the maximum return). However, the charts showing the composition of the efficient frontier are more interesting. These are given for rolling ten-year periods in Figure 2.14 and for the full period 1984 to 2002 in Figure 2.15. The key for the asset classes in Figure 2.14 is the same as for Figure 2.15.

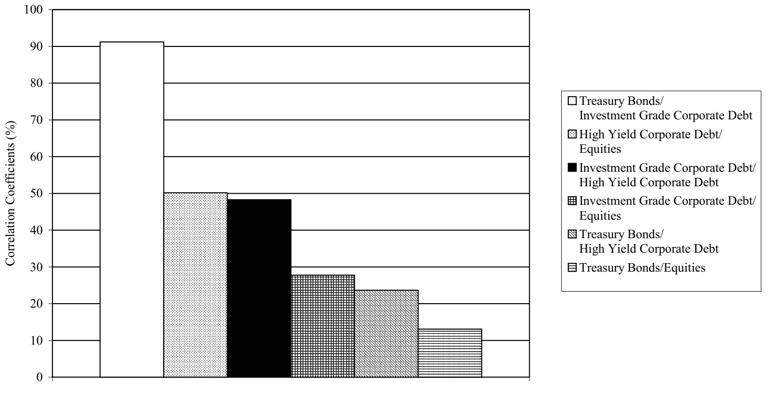

Figure 2.13. Correlation coefficients, 1984 to 2002

2.4.4 What each of these figures shows is the proportion of the various asset classes included in the efficient frontier over successive ten-year periods. The minimum risk and maximum return points on each chart are remarkably consistent: the minimum risk portfolio consists of around 80% Treasury bonds and 20% high yield corporate debt; the maximum return is always provided by a portfolio of 100% equities (at least it has been historically — there is no guarantee that this will be the case going forward). Between these points the proportion of the various asset classes varies considerably depending on the period under consideration.

2.4.5 Equities behave similarly in each period, increasing steadily from no appearance in the minimum risk portfolio to comprising the entire maximum return portfolio. High yield debt is similarly consistent, apart from in the final two rolling ten-year periods, where its importance declines significantly. The performance influencing the appearance of these periods is so poor as to limit its appearance in the figure for the period 1984 to 2002. Otherwise, though, its level in the efficient frontier remains reasonably level, only being excluded from the much higher risk portfolios.

2.4.6 The interaction between Treasury bonds and investment grade corporate debt is more interesting. Together, the two asset classes make up most of the lower-risk portfolios, decreasing steadily in favour of equities as risk increases. However, the balance between the asset classes varies greatly. In some instances the Treasury bonds remain dominant, with investment grade corporate debt not even appearing in the efficient frontier; however, in other instances Treasury bonds are displaced from relatively low risk portfolios by investment grade corporate debt. It is also interesting to note that investment grade corporate debt is not included in any of the minimum risk portfolios, because the additional return offered by investment grade

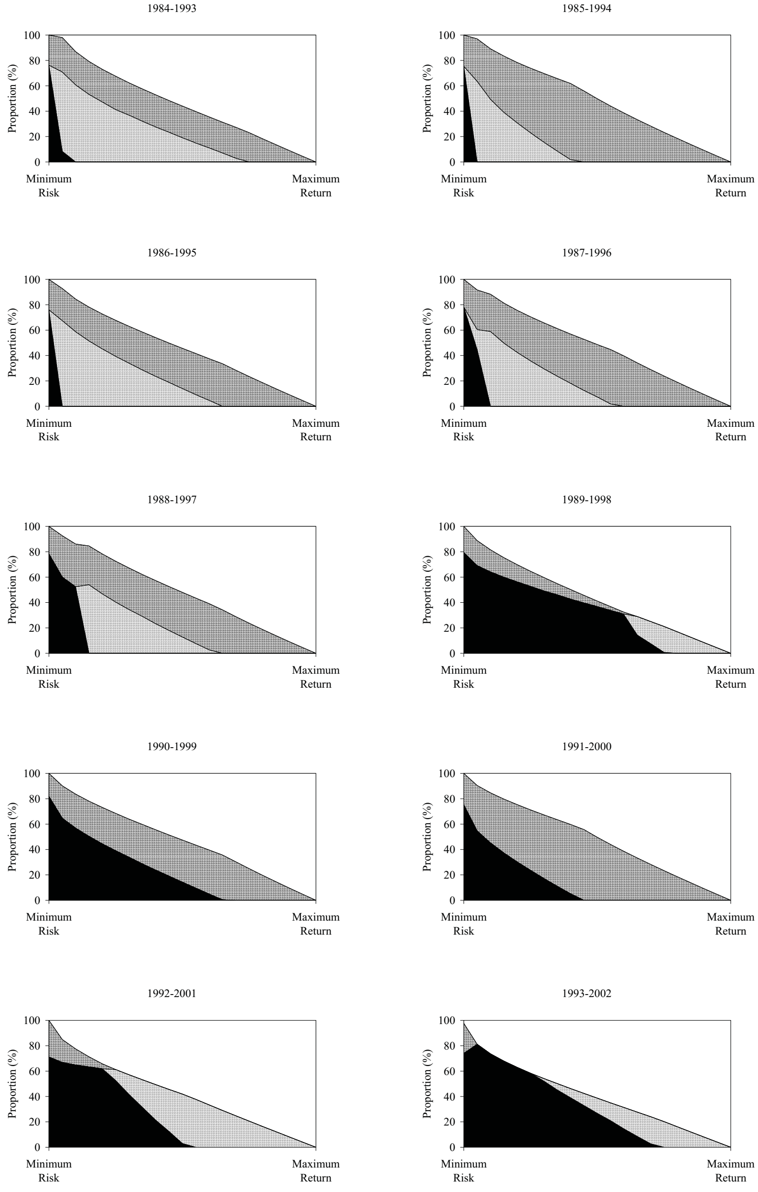

Figure 2.14. Proportion of assets in the efficient frontier, rolling ten-year periods

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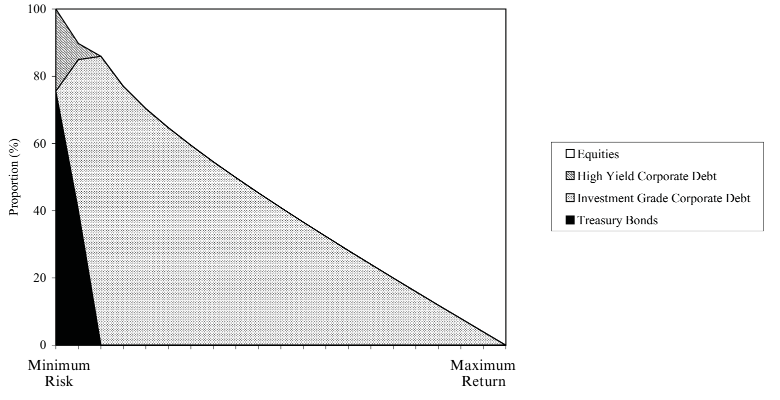

Figure 2.15. Proportion of assets in the efficient frontier, 1984 to 2002

corporate debt over Treasury bonds is not as attractive as the reduction in risk available from mixing high yield corporate debt and Treasury bonds.

2.4.7 What this shows is that the period from which data are taken has a significant impact on the relative attractiveness of certain asset classes, whereas the relationship between others remains broadly unaffected. For example, the relationship between equities and investment grade bonds (Treasury and corporate) is reasonably stable; however the relationship between the two investment grade bond asset classes is less so; and the role of high yield corporate debt — which suffers from being an immature, inefficient asset class — is also changeable. This suggests that stochastic asset modelling should be used to make the 'big' decisions (such as the risk/matching asset split), but that other decisions, such as the split between Treasury bonds and investment grade corporate debt, or the role of alternative asset classes such as high yield corporate debt, should be made more pragmatically. I do not analyse rolling periods in the remainder of this paper.

2.5 *Capital Market Line Analysis*

2.5.1 In this section I look at the returns in excess of the risk free rate when calculating the standard deviation of returns. Again, the risk free rate is taken as the U.S. discount rate.

2.5.2 This analysis introduces the idea of a market portfolio, being the portfolio containing all assets in proportion to their market weights. These weights are the ones given by the various indices used. The market portfolio therefore consists of:

— U.S. Treasury bonds;

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— U.S. investment grade corporate debt;
— U.S. high yield corporate debt; and
— U.S. equities.

2.5.3 In order to calculate the monthly return on the market portfolio, I multiply the monthly return on each asset class by the average market value of that asset class over the month (calculated as the start-of-month figure plus the end-of-month figure divided by two), sum over all asset classes and divide the result by the average market value of all asset classes over the month (calculated as before). Because the market values of the indices are required, the period 1987 to 2002 is used, since the market value of the U.S. high yield corporate debt is unavailable prior to 1987. Because the dataset is smaller, I do not look at rolling periods, only at the full sample period.

2.5.4 Since the risk free asset has zero standard deviation, all portfolios consisting of a combination of the market portfolio and the risk free asset fall on a linear risk/return line. If it is assumed that an investor can borrow at the risk free rate, then the risk/return line can be extended beyond the market portfolio to allow for gearing (leverage). This line is known as the capital market line.

2.5.5 At this point it is worth revisiting the concept of the efficient frontier. This is the line joining all portfolios for which, given a level of risk (in this case, standard deviation of returns), no better mean return can be achieved. As can be seen in Figure 2.16, each asset classes lies on or below the efficient frontier. However, Figure 2.16 also shows that, relative to the efficient frontier, the market portfolio appears to be inefficient, being placed some way below the frontier.

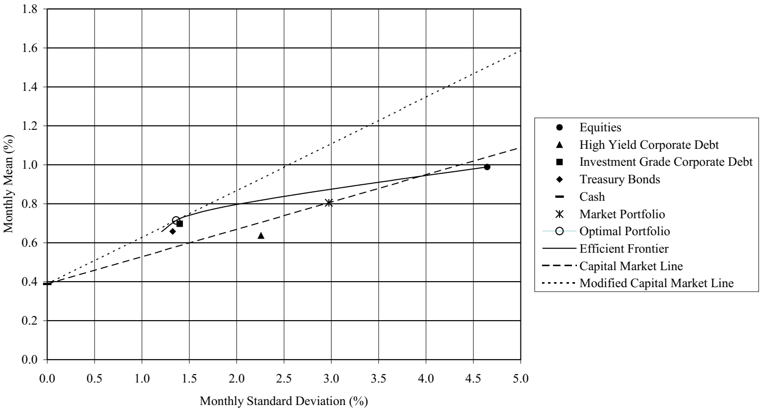

Figure 2.16. Capital market line analysis, 1987 to 2002

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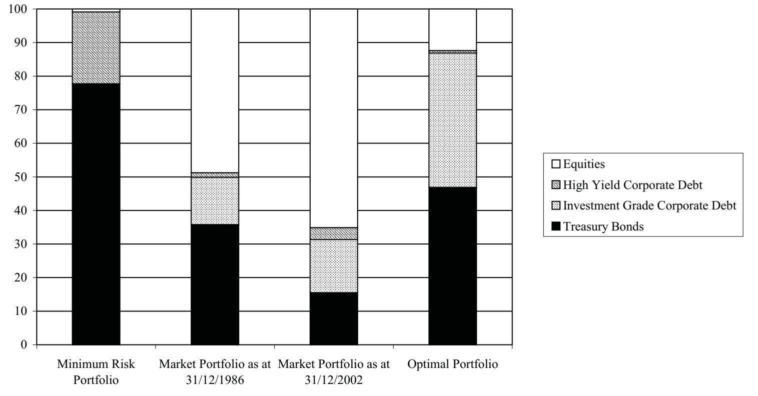

Figure 2.17. Minimum risk, market and optimal portfolio compositions, 1987 to 2002

2.5.6 This implies that there is a more efficient portfolio that can be combined with the risk free asset. Such a portfolio would be the point on the efficient frontier at which a line drawn from the risk free asset on the vertical axis would be tangential. I call this line the modified capital market line and the portfolio the optimal portfolio.

2.5.7 The asset mixes making up the optimal and market portfolios are shown in Figure 2.17. Since the composition of the market portfolio changes over time, I show the market portfolio's composition at the start and the end of the sample period. What this shows is that there are far higher proportions of both Treasury bonds and investment grade corporate debt in the optimal portfolio than in the market portfolio, and a much lower proportion of equities. High yield corporate debt remains a minority asset class in all cases (apart from the minimum risk portfolio).

2.6 *Beta Calculation*

2.6.1 Beta is a measure of the efficiency of an asset class. The beta for each asset class is calculated as the covariance of the asset's monthly return, with the market portfolio divided by the variance of the monthly returns on the market portfolio. The calculation can be done using either the actual returns or the returns in excess of the risk free asset.

2.6.2 According to the Capital Asset Pricing Model (CAPM), a security is undervalued if it falls above the security market line, a straight line plotting expected return against beta, starting with the risk free return on the vertical axis and passing through the market portfolio (which has a beta of

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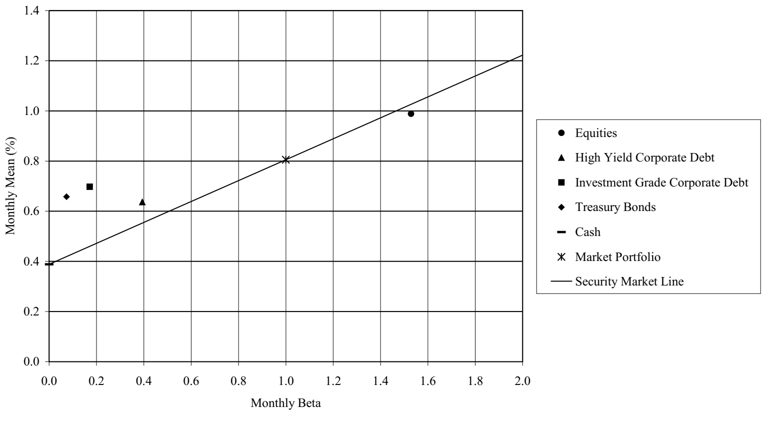

Figure 2.18. Security market line analysis, 1987 to 2002

one). As can be seen in Figure 2.18, bond asset classes appear to be undervalued (and equities slightly overvalued) according to this approach, if historical mean returns are taken to be a good indicator of the expected returns. If regressions are run of each bond asset class against the market portfolio (all net of the risk free rate of return), then *t*-statistics for the intercept term are given as 2.503, 2.499 and 0.596 for Treasury bonds, investment grade corporate bonds and high yield corporate bonds respectively. In other words, the degree of undervaluation is significant at the 95% level of confidence for Treasury bonds and investment grade corporate bonds.

2.6.3 Another interpretation of the apparent undervaluation of the bond asset classes is based on the CAPM estimation of expected return. This is given as:

$$ER_S = RF + \beta(ER_M - RF)$$

where ER_S is the expected return on the stock or asset class; RF is the return on the risk free asset; β is the beta of the stock or asset class relative to the market portfolio; and ER_M is the expected return of the market portfolio. The second interpretation is that the expected return of the bond asset classes is a better estimate than the historical mean return, and that bonds are not going to perform as well going forward as they did between 1987 and 2002 — an argument that is plausible, given the fall in inflation and, likewise, interest rates in the 1990s.

3. Asset/Liability Value Analysis

3.1 *Introduction*

3.1.1 The mean/variance analysis above can be extended from an asset/only to an asset/liability basis. In this case, the return measure that I use is the average (mean) increase in surplus (assets less liabilities). The cash flows used in calculating these liabilities are explored in more detail in Section 5. I consider two risk measures here: the volatility in the increase in surplus; and the volatility of the increase in funding level. The difference between these is that for the former, low risk portfolios are those where the change in the cash amount of surplus is minimised, but for the latter, the lowest risks occur when the variability of the surplus in relation to the liabilities is lessened.

3.1.2 I have not used any downside measures of risk. Since the statistical analysis above does not strongly suggest skew, the results would not add any insight to the analysis. This is not to say that downside risk measures should not be used in practice — they are the best way to allow for any non-normality in the return distributions produced by asset models. A commonly used measure of downside risk is expected shortfall. This is calculated as:

$$ES = {}^{1}/_{T} \sum_{t=1}^{T} Max[0, (R_H - R_t)]$$

where ES is the expected shortfall, R_t is the return in period t, and R_H is the hurdle rate of return.

3.1.3 There are a number of possible approaches that can be used in deriving an interest rate to value the liabilities. The theoretically correct approach to valuing the liabilities should involve some sort of option pricing that takes into account the degree to which the liabilities are securitised (that is, the funding level) and the various options available to stakeholders in the pension scheme (for example, the employer's option to default). An approximation to this value of liabilities is obtained by using the risk free rate to value the securitised liabilities, and the company's cost of borrowing to value any liabilities not backed by assets (that is, a deficit), the higher cost of borrowing, taking into account the fact that the employer might not be able to cover the deficit.

3.1.4 Because the funding level changes in each time period, so does the effective interest rate that applies, at least when there is a deficit. I therefore use the risk free rate to value all liabilities. This gives more conservative results than the method outlined above, but only when there is a deficit present.

3.1.5 The risk free rate that I use in this context is the long-dated U.S. Treasury bond yield. Mortality is assumed to be in line with U.S. mortality tables RP-2000.

3.1.6 I only look at pensioner portfolios in the analysis. Looking at a scheme with pre-retirement members could give very different results.

3.2 *Open Pensioner Portfolio*

3.2.1 In the first set of calculations I carry out, I assume that there are sufficient additional retirements to maintain a stationary population — in other words, I assume that there is exactly the number of retirements from an active population each quarter to keep the number of pensioners constant, and that the increase in assets to cover these new retirements is calculated on the same basis as the existing liabilities. I assume that the retirement age is 65 and that there are no increases to pensions in payment. However, wages (and thus initial pensions) are assumed to increase in line with U.S. pay (private industry workers, wages and salaries only). I assume that no contributions are made in respect of any surplus or deficit (other than deficits created by retirements) and that the funding level is measured at the end of each quarter.

3.2.2 As before, the figure for the efficient frontier itself is not that interesting — it is upward sloping and ends with the portfolio of 100% equities (which gives the maximum return) — so, I again give the composition of the efficient frontier in Figures 3.1 to 3.6. Because the funding level will partly determine the most appropriate solution, there are, in fact, three figures for each risk measure: one for an 80% funding level; one for 100%; and one for 120%. The title for each figure gives the funding level, and whether the measure used is the volatility of increase in surplus or of funding level.

3.2.3 As with portfolios optimised only in relation to assets, the proportion of equities in the portfolio steadily increases with the risk of the portfolio with the highest risk (and return) portfolio being 100% equity. However, there are a number of differences between the figures. Let us look first at volatility of surplus scenarios.

3.2.4 For a fully funded scheme, the minimum risk will be provided by the assets that most closely match the liabilities. These are mainly Treasury bonds with a small amount of equities. Increasing the level of risk, the asset allocation changes very quickly from Treasury bonds to investment grade corporate bonds, although the variability of the asset only scenarios should be borne in mind.

3.2.5 For an over-funded scheme, the minimum risk portfolio for the excess can effectively be thought of as being the minimum risk portfolio in the asset only scenario in Section 2.5. Therefore, the minimum risk portfolio for the over-funded increase-in-surplus scenario contains a significant proportion of high yield corporate debt.

3.2.6 For the under-funded scenario, the same opportunity does not exist: the alternative would be to find an asset class that moved in the same

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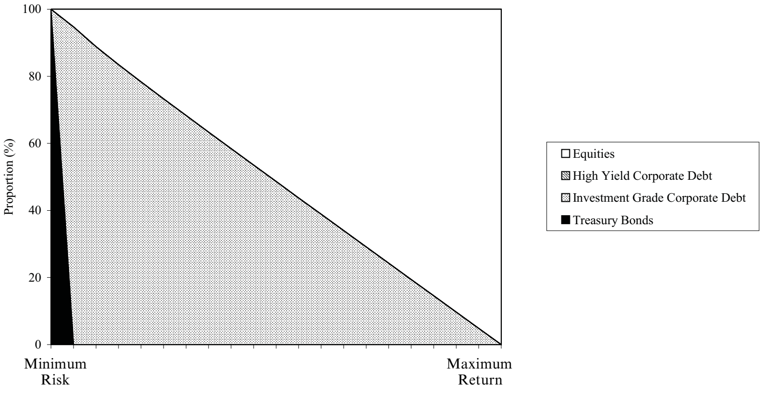

Figure 3.1. Efficient frontier composition, 80%, surplus, 1984 to 2002

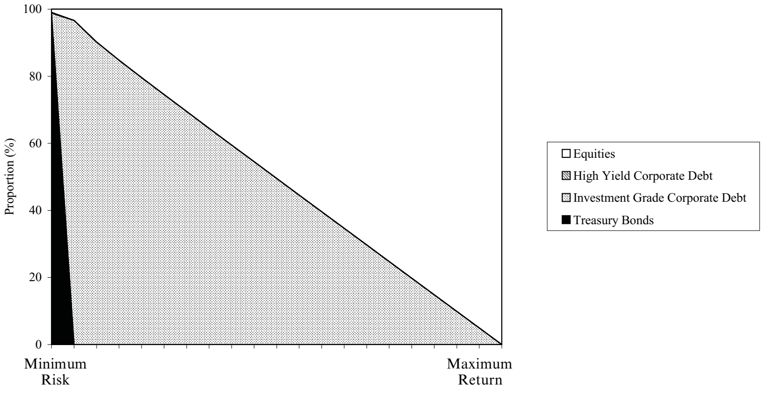

Figure 3.2. Efficient frontier composition, 100%, surplus, 1984 to 2002

direction as the liabilities, but by a greater amount, to the extent that the volatility of the deficit was minimised. The minimum risk portfolio here contains only Treasury bonds, suggesting that the small amount of equity in the fully-funded scenario reduced volatility.

3.2.7 Looking next at the volatility of funding level, it is clear that there is much less variation between these three figures than between those showing volatility of surplus, which is to be expected, given that the surplus

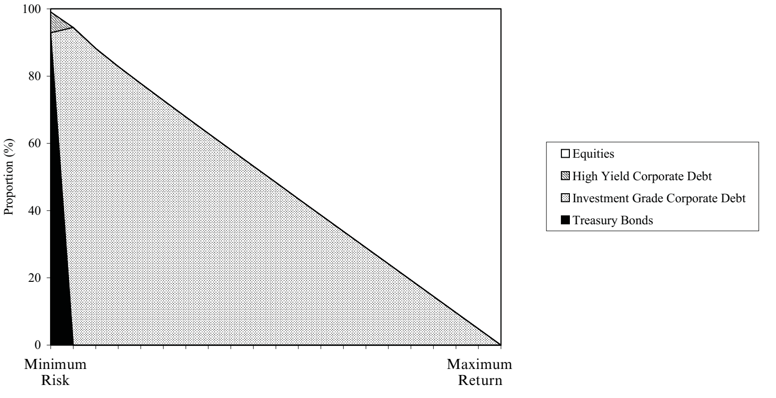

Figure 3.3. Efficient frontier composition, 120%, surplus, 1984 to 2002

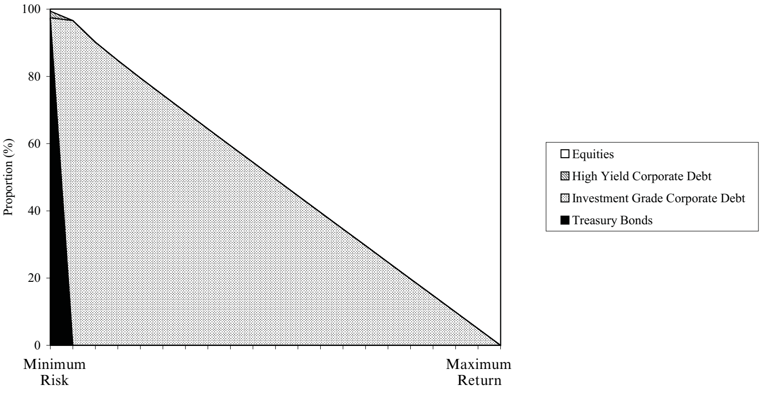

Figure 3.4. Efficient frontier composition, 80%, funding level, 1984 to 2002

or deficit measured in liability terms is more closely related than that measured in cash terms to the liabilities as a whole.

3.2.8 The asset allocations for a fully-funded scheme under this risk measure are very similar to those shown for the volatility of funding level. Furthermore, the efficient portfolios for the over-funded increase-in-funding-level scenario are very similar to the fully-funded ones. This is because the

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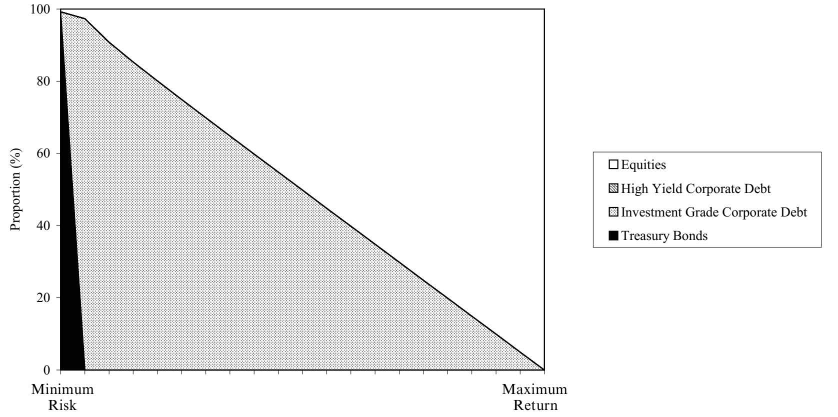

Figure 3.5. Efficient frontier composition, 100%, funding level, 1984 to 2002

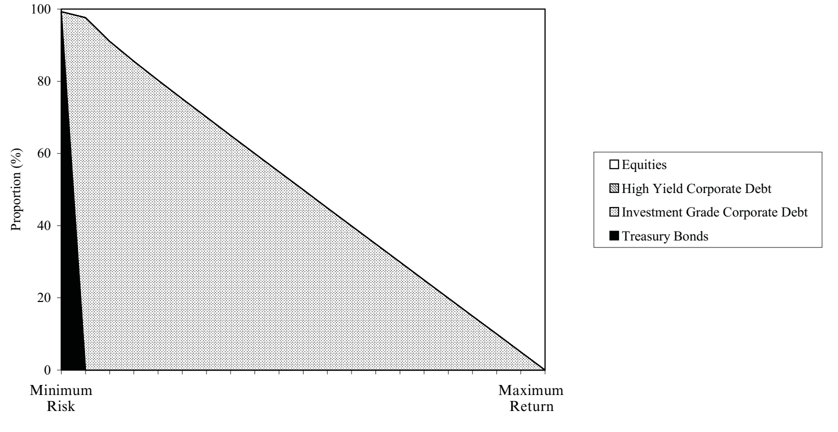

Figure 3.6. Efficient frontier composition, 120%, funding level, 1984 to 2002

surplus is required to move in the same direction as the assets backing the liabilities, although ideally they would not move by quite as much.

3.2.9 However, the under-funded scenario is different. The fund here needs to be even more volatile than the equivalent under-funded scenario, where the risk measure is the volatility of the increase in surplus, since the deficit that is being tracked is more volatile. The solution appears to be for equities to be replaced with high yield corporate debt rather than with more Treasury bonds.

3.3 *Closed Pensioner Portfolio*

3.3.1 It is perhaps more important to consider the situation in a closed fund, that is a fund where there are no new retirements and, therefore (for the purpose of this modelling), no additional contributions being made. It is worth noting that in a 'real life' situation it might be expected that the duration of the assets would be reduced in response to the falling duration of the liabilities. This is not done here — the duration of the assets is not deliberately altered — so the results should be treated with some caution.

3.3.2 Again, compositions of efficient frontiers are shown in Figures 3.7 to 3.12, and there are three figures for each risk measure, being for the 80%, 100% and 120% initial funding levels.

3.3.3 The two fully-funded figures are similar to each other and to the fully funded figures in the open portfolio scenarios, but with slightly more high yield corporate debt; if anything, they are more like the over-funded charts from the earlier scenarios. This can be explained by the fact that under the open scheme scenarios, the additional contributions paid in respect of new retirements effectively pull the funding level back to 100%. Therefore, with no additional retirements, there is no such reversionary force, and since Treasury bonds have given the lowest returns, investments in any other asset classes will result in surpluses (based on this historical data). This also explains why the minimum risk allocations for over-funded charts in the

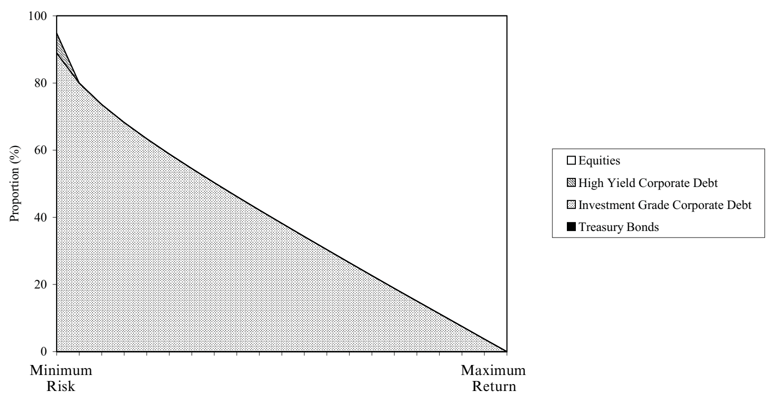

Figure 3.7. Efficient frontier composition, 80%, surplus, 1984 to 2002

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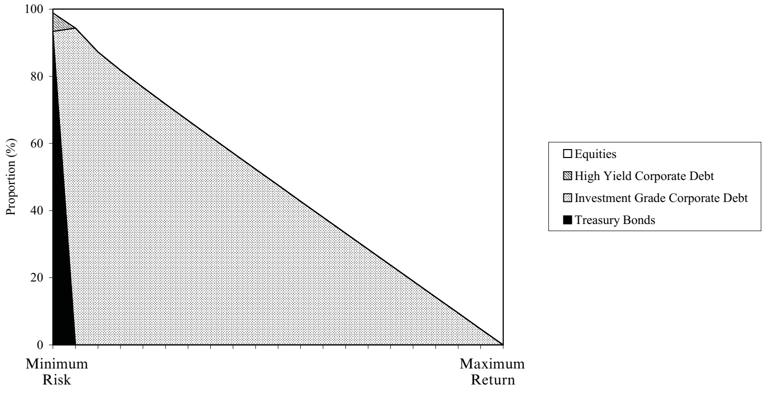

Figure 3.8. Efficient frontier composition, 100%, surplus, 1984 to 2002

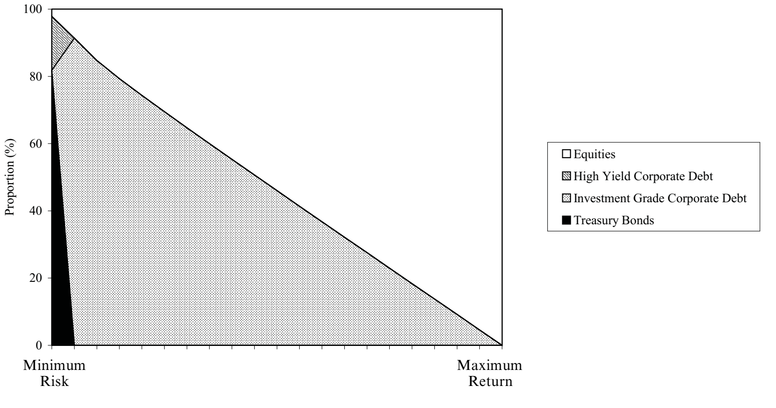

Figure 3.9. Efficient frontier composition, 120%, surplus, 1984 to 2002

closed portfolio scenarios have even more high yield corporate debt than those in the open portfolio scenarios.

3.3.4 However, the under-funded scenarios are different — the Treasury bonds are replaced with investment grade corporate debt, some equities and, in the increase in surplus example, some high yield corporate debt.

3.3.5 This can be explained by the very large increase in volatility required by the assets in the face of a growing deficit. The deficit increases in the under-funded closed portfolio, and the volatility needed in the assets to

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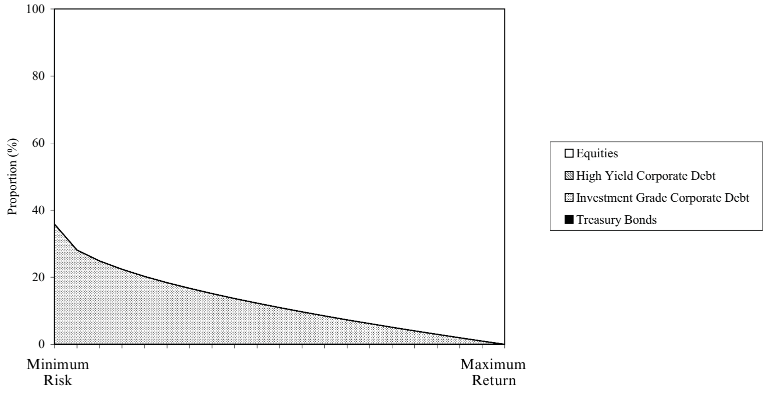

Figure 3.10. Efficient frontier composition, 80%, funding level, 1984 to 2002

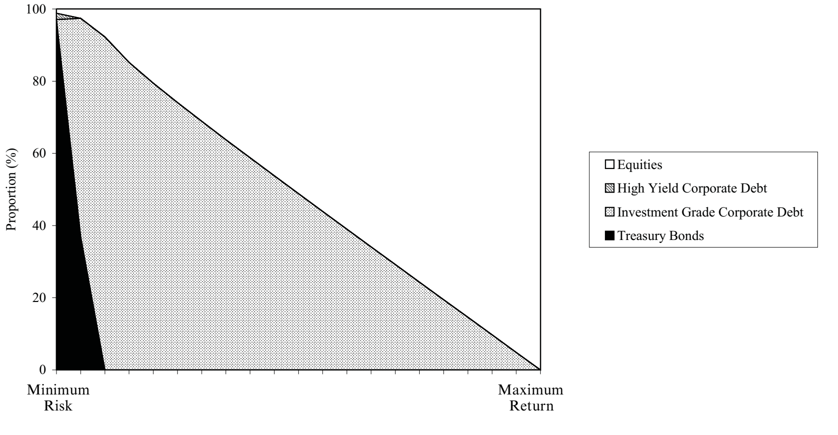

Figure 3.11. Efficient frontier composition, 100%, funding level, 1984 to 2002

try to reduce risk in the minimum risk portfolio is far more than can be provided by Treasury bonds, so investment grade corporate bonds feature heavily instead. For the increase-in-surplus scenario, this substitution is adequate to reduce the volatility, since it is the absolute volatility of the surplus that is targeted. However, for the increase-in-funding-level scenario, the minimum risk portfolio is the one that minimised a volatile liability-based

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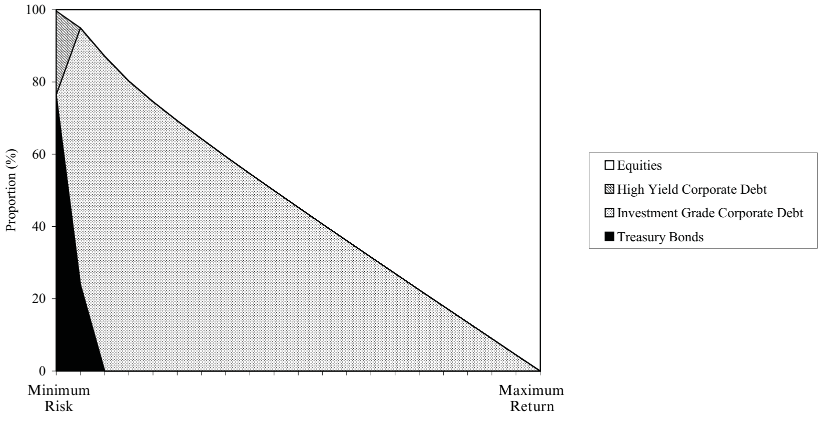

Figure 3.12. Efficient frontier composition, 120%, funding level, 1984 to 2002

measure of deficit, so much greater asset volatility is needed and this is provided by equities.

4. Income Analysis of Debt Asset Classes

4.1 *Introduction*

4.1.1 The preceding work concentrates on the values of the assets and the liabilities. However, another indication of the usefulness of each bond asset class to pension schemes might be to consider the income that a portfolio of each would produce. There are two broad analyses that can be carried out here: the first is to look only at the income produced by the portfolio and to consider the level and stability of that income; the second is to consider the development of a portfolio of assets and liabilities over time.

4.1.2 In these analyses it would be preferable to look at the actual coupon income produced by assets. However, the Lehman Brothers indices only give accrued interest. This means that using monthly data would be misleading, particularly for Treasury bonds, which tend to be issued in February, August and November. Treasury bond coupons are paid half-yearly, so, with the issue months a quarter of a year apart, considering the income received quarterly would resolve much of the distortion. Also, a three-month period helps to remove any distortion existing in investment grade or high yield corporate debt coupon payments, although there should be less of an issue with these asset classes. I therefore use quarterly periods in my analyses. The income shown allows for defaults.

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4.2 *Long-Term Results*

4.2.1 There are two ways in which the income producing potential of high yield corporate debt can be analysed. The first (and crudest) method is to consider the running yield of various bond asset classes. The quarterly running yields are constructed from monthly data in the Lehman Brothers series.

4.2.2 The calculation method is straightforward. First, the index returns are split into price and coupon returns (both are given as data items in the Lehman Brothers' series). I then assume income to be paid out and not reinvested. Starting with an initial fund value of $100, the price of the fund at the end of each month is calculated as the price at the end of the previous month multiplied by the index price return. The income produced each month is calculated as the index coupon return multiplied by the fund price at the end of the previous month. The quarterly running yield is then calculated as the income received each quarter divided by the fund price at the end of the previous quarter.

4.2.3 It is important to note that this approach assumes that the index portfolio is sold at the end of each period and that the proceeds are reinvested in the new index portfolio. In practice this would be prohibitively expensive, as bid/offer spreads on high yield corporate debt are high.

4.2.4 The quarterly running yield is shown for different asset classes in Figure 4.1. These data are only available for high yield corporate debt from 1 January 1987, so I use this as my start date for all bond asset classes. The chart shows that the running yield on high yield corporate debt is,

Figure 4.1. Quarterly running yield of bond asset classes, 1987 to 2002

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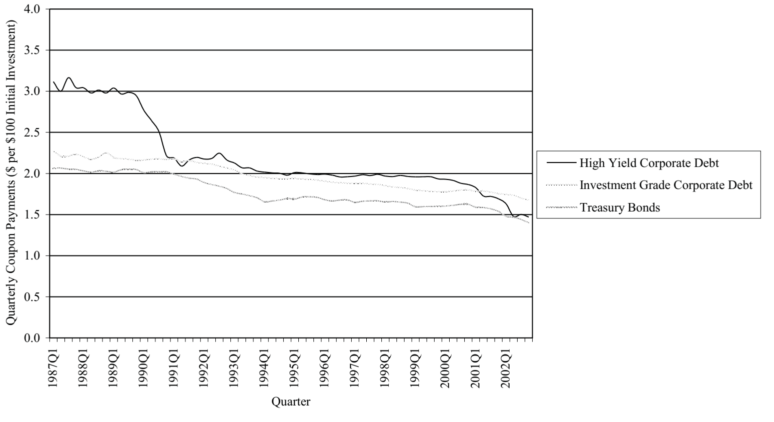

Figure 4.2. Quarterly coupon payments of bond asset classes, 1987 to 2002

unsurprisingly, the highest of the three. However, it also shows differences in running yields to be reasonably steady over time, particularly after around 1991. In other words, a sophisticated asset projection model would probably show Treasury bonds to have a significant influence on high yield corporate debt returns.

4.2.5 An alternative asset-only approach is to consider what income would be produced from a portfolio of each asset class. Here the same calculations are carried out as before, but I take the quarterly income itself rather than dividing it by the previous end-of-month fund value.

4.2.6 The results are shown in Figure 4.2. As can be seen, the income produced by the portfolio of high yield corporate debt is higher than that produced by either of the two asset classes, apart from a short period in 1990/91 where it fell below the other asset classes, and also in 2001. It is also a relatively stable income after around 1990. Investment grade corporate debt, though, has maintained its income advantage over Treasury bonds for the whole period.

4.2.7 Looking at the market value of these portfolios (still assuming that coupons are paid out rather than being reinvested) for the same period is also informative. Figure 4.3 shows that, for someone investing in 1987, the loss in capital value for a high yield corporate debt portfolio between 1989 and 1991 relative to the other portfolios was never regained (although there was partial compensation in the form of higher income).

4.2.8 Figure 4.3 also helps to explain the differences between Figures 4.1 and 4.2. For example, the running yield of high yield corporate debt falls sharply relative to other asset classes in 1991. However, income from high

Figure 4.3. Market values of bond asset classes, 1987 to 2002

yield corporate debt portfolios started falling in 1989 and fell by much more than the running yield, because the market value of the high yield corporate debt portfolio had also been falling.

4.3 *Short-Term Results*

What happens, then, if we consider a 'modern' investor in high yield corporate debt who avoided the capital loss of the early 1990s? For this

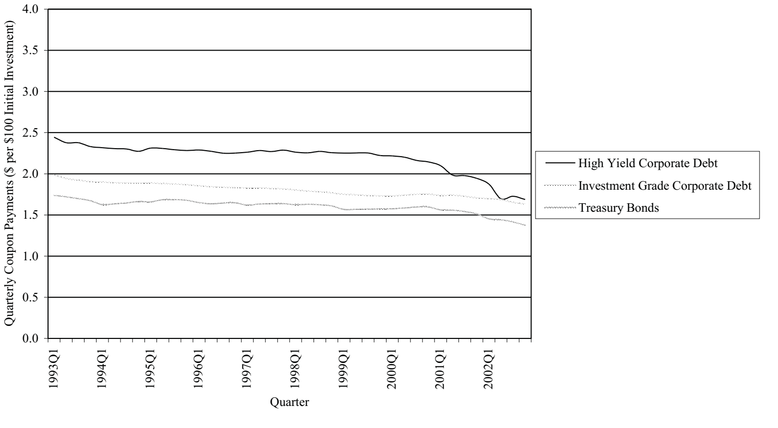

Figure 4.4. Quarterly coupon payments of bond asset classes, 1993 to 2002

purpose I look at what would happen if an investor were to start with the three portfolios on the (admittedly arbitrary) date of 1 January 1993. The purpose of this is to exclude from the analysis a period during which it could be argued that, because the market was immature, the returns on high yield corporate debt might not be consistent with those after the period. The period excluded is after the crisis and subsequent recovery of the early 1990s, and the results are shown in Figure 4.4. As can be seen before, high yield corporate debt provides a smooth — and high — level of income, although the level of income from a portfolio commencing in 1993 would now be below that of an investment grade corporate debt portfolio commencing at the same time.

5. Asset/Liability Income Analysis

5.1 *Introduction*

Although relative to the other debt asset classes high yield corporate debt appears to be an attractive asset class in asset-only income analysis, Treasury bonds and investment grade corporate debt fare better in the efficient frontier analysis when liabilities are taken into account. In this section, however, I look at the income produced by bond portfolios and the income required by pension schemes. I only look at pensioner portfolios in the analysis, and I consider open and closed portfolios.

5.2 *Open Pensioner Portfolio*

5.2.1 For this work I use the same assumptions as I did in Section 3, that is: a stationary population; a retirement age of 65; no increases to pensions in payment; wage increases in line with U.S. pay; and no contributions in respect of any surplus or deficit. Initial liabilities are assumed to be equal to \$10,000 and initial assets are assumed to be \$8,000, £10,000 or \$12,000 respectively. The pensions payable and income receivable are both calculated quarterly. Pensions are assumed to be payable quarterly in advance. If the coupon income exceeds the pension payments, then the excess is reinvested. However, if there is a shortfall, then it is assumed that the amount required is obtained by disinvestment. The net cash flow for each asset class is the quarterly income less the quarterly pension payment.

5.2.2 Before looking at the net cash flows, it is worth considering the various payments into and out of the fund. The payments out of the fund will grow steadily, but only in respect of salary increases for the newly retired members — the fact that the open scheme is modelled as a stable population means that the number of pensioners remains unchanged. The payments into the fund also increase in line with salaries. However, they are also linked

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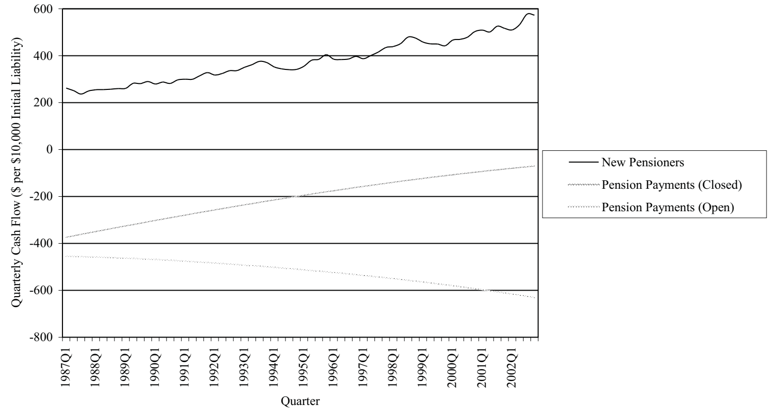

Figure 5.1. Cash flow relating to pensions paid and new pensioners

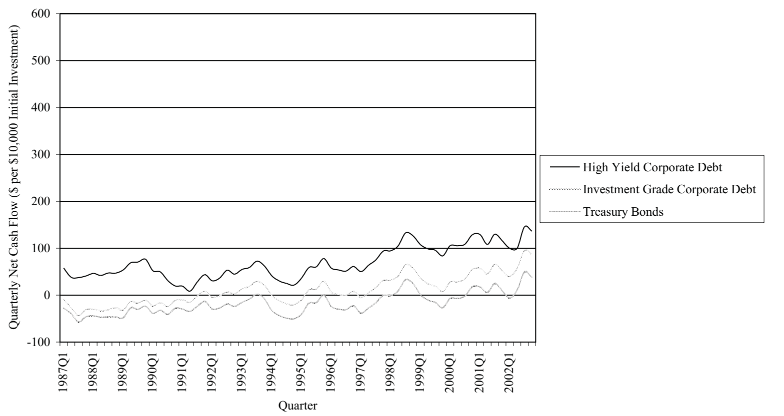

Figure 5.2. Net cash flow, open pensioner portfolio, 80% funding level

to the long Treasury bond yield. As this has generally fallen over time, the payment into the fund in respect of new retirements has increased by even more (although the initial higher cash flow in will ultimately be offset by lower interest receivable from the assets bought). Both of these cash flows are shown in Figure 5.1.

5.2.3 The net cash flows, in Figures 5.2 to 5.4, show that, even allowing for the early and recent poor performance of high yield corporate debt, this

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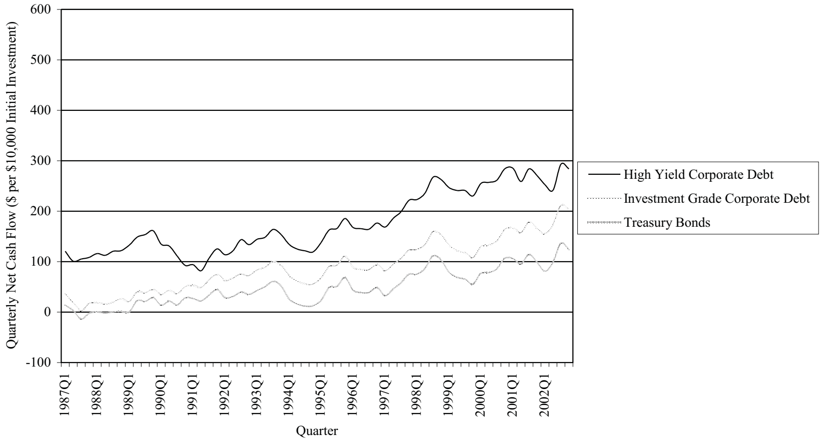

Figure 5.3. Net cash flow, open pensioner portfolio, 100% funding level

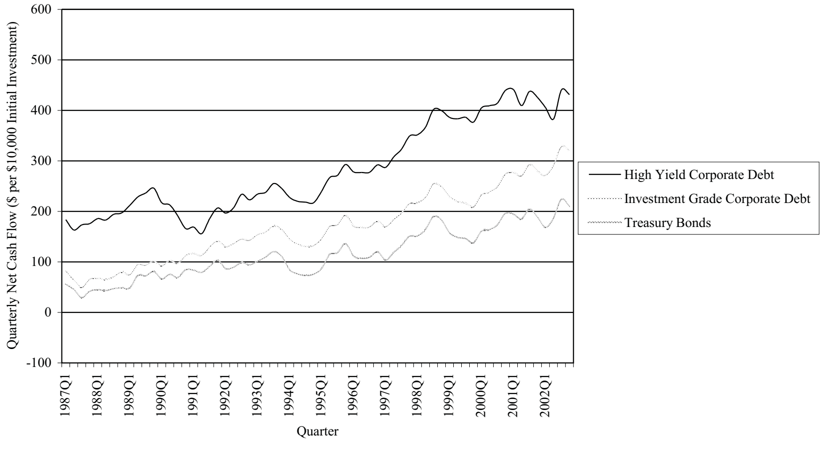

Figure 5.4. Net cash flow, open pensioner portfolio, 120% funding level

asset class provides a consistently higher level of net income than investment grade corporate debt or Treasury bonds. It is also worth noting that investment grade corporate debt outperforms Treasury bonds in this respect.

5.2.4 Unlike the funding level calculations, there are no real differences in the results for the different initial funding levels — 80%, 100% and 120% initial funding levels provide much the same results.

5.3 *Closed Pensioner Portfolio*

5.3.1 It is worth considering what happens in a closed pensioner portfolio where there are no additional retirements. There are no new retirements here, so there is no cash inflow from any other source than the investments. Also, as a closed portfolio, the number of pensioners will fall. As can be seen in Figure 5.1, the pension paid falls from the start. The net cash flow charts for these scenarios (again assuming 80%, 100% and 120% initial funding levels) are given as Figures 5.5 to 5.7.

5.3.2 These charts are similar to those in Figures 5.2 to 5.4, although there are differences. The first difference is that the net cash flows are smoother for the closed portfolio than for the open one. Also, the initial funding level has a significant difference on the relative attractiveness of the different bond asset classes; the higher the initial funding level, the more attractive high yield corporate debt becomes (although investment grade corporate debt is always more attractive than Treasury bonds). Indeed, in the under-funded scenario, there was no advantage at all to holding high yield corporate debt, but there was a significant advantage in the other scenarios.

5.3.3. These differences between the open and closed portfolios are due to the fact that new pensioners in the open pensioner portfolio bring new funds. This has two effects. First, since the additional funds are related to

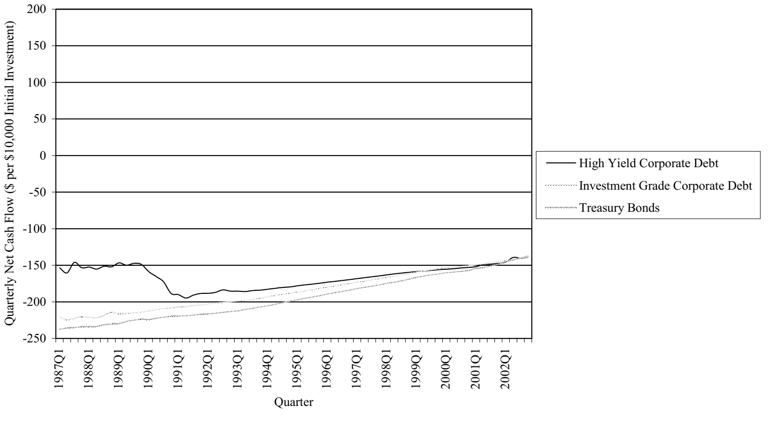

Figure 5.5. Net cash flow, closed pensioner portfolio, 80% funding level

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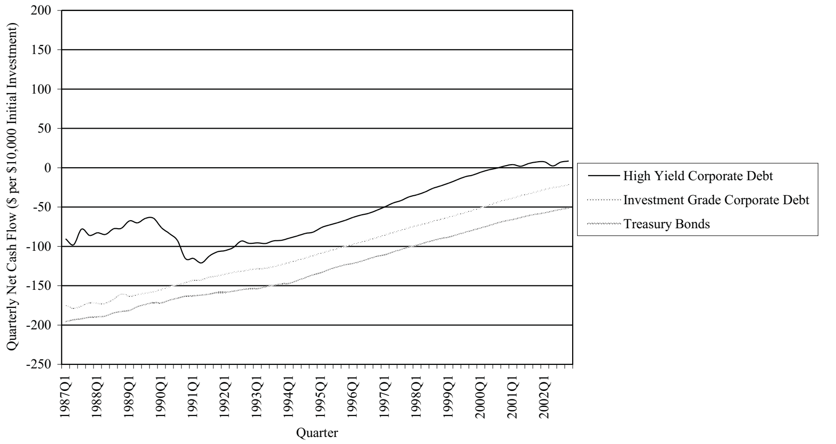

Figure 5.6. Net cash flow, closed pensioner portfolio, 100% funding level

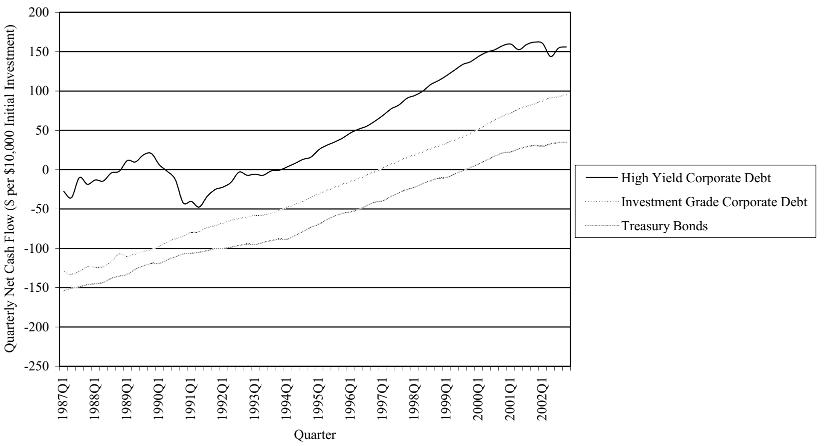

Figure 5.7. Net cash flow, closed pensioner portfolio, 120% funding level

Treasury bonds, the running yields of which vary, the additional funds add volatility to the cash flows. Also, the constant supply of new funds from retiring members pushes the funding level towards 100% in the open portfolio scenario, causing the scenarios to be similar. In the closed fund, on the other hand, any surplus or deficit will ultimately be magnified as either the assets or the liabilities will eventually reach zero. This means that, for example, any unusually large reduction in income from high yield corporate debt would result in disinvestment being required that would make it harder for that asset class to recover in the future.

6. Additional Considerations

6.1 *Stochastic Projections*

6.1.1 As mentioned in Section 1, I restrict my calculations to historical data, since I believe that the calibration of models using historical data means that they would be unlikely to yield additional information.

6.1.2 There are also practical limitations of using stochastic asset models. Some asset classes appear to have reasonably stable relationships with each other, for example investment grade bonds and equities. However, some others appear to be much less stable over time, such as investment grade corporate debt and Treasury bonds, or high yield corporate debt and any other asset class. This means that calibrating asset models using historical data could be unreliable. It is even arguable that it is pointless, and that stochastic modelling should only be used for the 'big' decisions, such as the split between matching and non-matching assets, with a more pragmatic approach being used for subdivisions within these classes.

6.1.3 A further practical issue is finding models which actually deal with all of the asset classes on a consistent basis. A number of models do exist that attempt to ensure consistency between price inflation, government bond returns and equity returns, such as the Wilkie model and its many successors, but the range of asset classes included is often limited.

6.1.4 There is also a wide range of corporate bond models, at least on the investment grade level, as described by Exley & Smith (2002). However, these have not in general been developed in conjunction with models for other asset classes. This is particularly true for high yield corporate debt, which is more than just a version of investment grade corporate debt with high spreads.

6.1.5 However, on the life insurance side more comprehensive asset models are being developed in response to the Financial Services Authority Consultation Paper (CP) 195 (Financial Services Authority, 2003), which considers provisioning for liabilities and capital requirements.

6.2 *Adjustments to Index Data*

6.2.1 The work in this paper has been carried out using index data. Whilst this is convenient, it ignores a number of factors that might change the conclusions of this paper.

6.2.2 Costs (including bid/offer spreads, commissions, dealing costs and management fees) are significantly different for the various asset classes.

Generally, the lower the risk of the asset class, the lower the associated costs, so analysis will be weighted towards lower-risk asset classes. This is particularly relevant when looking at Treasury bonds and investment grade corporate debt; if dealing costs were taken into account, then a traded corporate bond portfolio would be much less attractive than a traded Treasury bond portfolio for a reasonably low risk portfolio. The case in which this would be less of an issue is the one where a portfolio of bonds is bought and held for a reasonably long time (so that the initial effect of the bid/offer spread difference is mitigated).

6.2.3 Another issue is that of the indices used. Some indices, particularly those for high yield corporate debt, are difficult to match. In this case, the reason is the price at which some stocks enter the index. If a stock is downgraded to high yield status from investment grade, then funds only allowed to hold investment grade stocks will need to sell the bond immediately, whatever the price. This leads to the price of the bond being artificially — and temporarily — depressed. The stock price will then revert to a more realistic price, but only after having been excluded from the relevant index. Because high yield corporate debt issues are generally small, it is impossible for the majority of managers to participate in the relative out-performance enjoyed by this bond, so it is difficult for many managers to even match the index. A similar, but opposite, effect occurs in the investment grade corporate bond index. Indices that are intended to represent the universe of an asset class (such as equities or Treasury bonds) rather than a subset (such as investment grade and high yield corporate debt) are less susceptible, although instances do occur in other indices. An example is when there is a merger that involves two companies listed on different exchanges. These are really only issues for index tracking managers, and rarely result in performance differentials of more than a few basis points in a year.

6.2.4 The durations of the various indices change over time. These changes will be driven partly by changes in redemption yields (as this falls, the duration lengthens), which, for investment grade bonds, will similarly affect the liabilities. However, changes in the coupon and the term of new bonds will also affect duration (an increase in either of these will lengthen duration), and these changes are independent of the liabilities.

6.2.5 The effect of active management is also ignored. This is justifiable on the grounds that, on average, active managers will perform in line with (or slightly below, allowing for fees) the index against which they are benchmarked. It could be argued that there are some asset classes where consistent out-performance is possible — currency is an oft used example — but none of the asset classes in my analysis really falls into this category. However, the additional volatility caused by active management is worth mentioning. The effect of active management on the overall volatility of funding level or surplus might not even be significant — if relative performance against an index is taken to be independent from the absolute performance of that index, then the combined volatility of an asset class and its active management (each measured by standard deviation) is the square root of the summed squared volatilities. If the degree of active management is small and the volatility of the asset class is high, then active management will not have a significant effect on the overall level of risk. This principle can be carried through to asset/liability analysis — active management only has a significant effect on risk if a pension scheme is well matched, otherwise the tracking error is likely to swamp the effect of active management on volatility.

6.3 *U.S., European and U.K. Markets*

6.3.1 For the reasons given in Section 1, I concentrate on U.S. asset classes. What about European (particularly U.K.) markets? The European investment grade corporate debt market is now reasonably mature. Indeed, in the U.K. the sterling corporate bond market has overtaken the gilt market. Treasury bond markets are also well developed globally.

6.3.2 However, the European high yield corporate debt is still young. Does this mean that it will exhibit the same volatility that the U.S. market did a decade ago, or will globalisation cause returns to be linked to U.S. returns, reducing the risk?

6.3.3 The European high yield corporate debt market is, though, maturing quickly. As recently as 31 January 2001 (the date on which Lehman Brothers started recording sector information for the European high yield corporate debt index), communications companies formed more than 50% of the index by value; that number had fallen to less than 10% at 31 December 2002. In other words, the European market is becoming rapidly more diversified. However, the comparatively mature U.S. market has diversified still further over the period, with the proportion of its index consisting of communications companies halving, from almost 30% to just over 15%. All of this information is shown in Figure 6.1, the data being taken from Lehman Brothers. There are a number of reasons for this increased diversification, but the most important are that telecom bonds have performed very badly compared to bonds in other sectors (reflecting what has happened in equity markets), and that bonds from other sectors have been downgraded from investment grade to high yield. In fact, the number of stocks in the European high yield corporate debt index has risen from 141 to 173 over the period 31 January 2001 to 31 December 2002, despite the number of communication stocks falling from 71 to 28, whereas in the U.S.A. the number of stocks rose from 1,135 to 1,400, whilst the number of communication stocks fell from 362 to 240.

6.3.4 It is, though, worth bearing in mind the structural differences between the U.K. and European bond markets (bankruptcy laws, for example), as these will remain regardless of the relative maturity of each market.

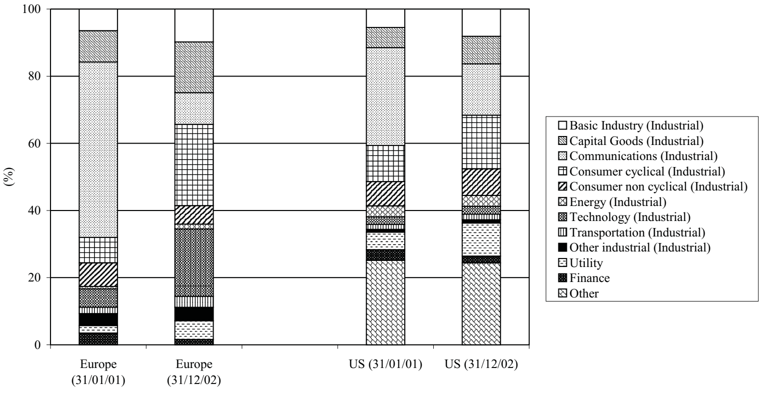

Figure 6.1. Composition of regional high yield corporate debt indices

6.3.5 The short history of European high yield corporate debt also means that there are limited data available for analysis. However, there is an argument that an asset class should not be ignored simply because it does not have a long time series to enable quantitative modelling. As Myners (2001) points out, if poorly researched markets with limited data are likely to offer the best opportunities for higher risk adjusted returns, it is precisely those asset classes that are not susceptible to quantitative modelling which may be most worth pursuing. However, as I note before, pragmatism is needed when deciding on the allocation to such asset classes.

6.4 *Duration*

6.4.1 Another important issue is that of the duration of the bonds. This has already been mentioned as an issue with the index data, but it is worth expanding on, particularly in relation to the liabilities. In the examples before the pensioner liabilities are valued using long-dated Treasury bond yields, but the assets held are all 'all stock' portfolios. This means that there is already a mismatch between the assets and the liabilities, in that the interest rate of the assets will differ from that of the liabilities. However, more important, potentially, is the duration of the liabilities relative to the duration of the bond portfolios. The duration of the pensioner portfolios starts at around nine years; the duration of the all Treasury bond portfolio rarely exceeds six years (although the duration of the long-dated Treasury bond portfolio occasionally exceeds 11 years). The effect of investing in the all Treasury bond portfolio is that the minimum risk portfolio still leaves in funding level volatility, given by a standard deviation of 2.6% p.a. for the fully funded pension scenario using the full dataset. The residual volatility increases to 18.3% for the over-funded scenario and 7.6% for the under-funded one.

6.4.2 However, in the real world most schemes do not consist solely of pensioners, and the issue of duration becomes more important the less mature the pension scheme is. This means that, for many schemes of even medium maturity, the duration mismatch leaves the scheme with risk comparable to investing in non-matching asset classes, such as equities. As an example, if a pension scheme were invested in assets with an overall duration of ten years less than that of the liabilities, then a 1% fall in interest rates could result in the funding level falling by more than 10%.

6.4.3 There are ways of dealing with the duration issue. The easiest is to invest in particular long-dated bonds with durations comparable to those of the liabilities. This is also a low cost option in that no management is needed, apart from to reinvest coupons in the same bonds, and each year to review the bonds held (although the smaller the scheme gets, the more significant custody costs become).

6.4.4 A second way to deal with the issue is to use interest rate swaps. The interest rate swap curve stretches out to 50 years, far longer than any bond. This means that swaps can be used either with cash or overlaid onto a bond portfolio to arrive at the appropriate duration. However, this approach will not generally be available to smaller schemes, for example those with less than £50m of assets.

6.5 *Inflation-Linked Pensions*

6.5.1 All of the asset/liability work before assumes an absence of pension increases. In the U.K. liabilities for active members are generally linked to inflation, in that they are linked to members' salaries. A significant proportion of benefits will also be linked to inflation through the 5% Limited Price Indexation (price inflation to an annual maximum of 5% and minimum of 0%, or 5% LPI) applied to pensions in payment accrued after 5 April 1997. This will have an impact on the assets that are appropriate for the minimum risk portfolio, that is, they should include a significant proportion of index-linked Treasury bonds. The exact proportion will generally be determined by the assumptions on the level and volatility of future price inflation. These items will impact in different ways.

6.5.2 Looking first at salary increases, high price inflation will generally lead to high salary increases, which are not, in the main, capped, so, if a large proportion of benefits is in respect of active members, then this will lead to a higher than average exposure to high price inflation; if price inflation is low or negative, then so might salary inflation be to the extent that the definition of salary includes bonus (likely) and to the extent that basic salary will be reduced (less likely). Therefore, the greater the proportion of benefits in respect of active members, the greater the proportion of assets that should be in index-linked bonds.

6.5.3 Deferred pensioner liabilities are similarly affected pre-retirement, in that the only cap or collar that applies is over the period of deferment rather than on a year-by-year basis.

6.5.4 Deflation will lead to nil pension increases being paid under 5% LPI and for fully index-linked pensions, since pensions are not permitted to decrease, so if deflation is thought to be likely either on average or through volatile inflation going forward, and there is significant exposure to 5% LPI or index-linked pension increases, then a significant proportion of fixed income bonds should be held to hedge the risk of deflation.

6.5.5 High inflation is less of a risk under 5% LPI, since the pension increase is capped at 5%. Having said this, if high inflation is thought to be a risk, then holding index-linked bonds will give protection for inflation up to 5% and will be a source of surplus if inflation does exceed this level, although, if high inflation is anticipated by the market, then holding index-linked bonds unnecessarily is an expensive choice. (Of course, high inflation is also a risk if guaranteed index-linked pensions are provided, but such increases are rarely guaranteed in the private sector.)

6.5.6 Given that 5% LPI increases are common, the inflation/deflation scenarios before lead to a dilemma — index-linked bonds are more appropriate in inflationary environments (or, more accurately, when inflation is positive), whereas fixed income bonds are more appropriate if deflation occurs. If a higher probability of deflation is coupled with a higher probability of high inflation (that is, any volatility will not be one-sided), then it could be said that, if the main exposure to inflation is through 5% LPI pension increases, then the more volatile inflation was expected to be, the higher the proportion of assets that should be in fixed income bonds — this would provide deflation protection, and only the difference between current inflation estimates and the 5% level would be at risk. Also, the higher the proportion of non-pensioner members (regardless of the expectations of inflation), the higher the proportion that should be held in index-linked bonds.

6.5.7 The index-linked market in the U.K. suffers from the same duration problem as the fixed income market — the bonds that it contains are often of shorter duration than the liabilities. However, the same solutions can be employed here as before, that is, to either pick a portfolio of very-long-dated index-linked bonds, or to use an inflation swap overlay together with the interest rate swap.

6.5.8 A problem that the U.K. index-linked bond market has that the fixed income market does not is the lack of issuer choice. For an investor exposed to U.K. inflation, there are U.K. index-linked government bonds. There are also index-linked government bonds issued by a number of other countries, but it is more difficult to hedge overseas inflation as well as interest rates, which is what would be needed if the asset class were intended to be a true match for sterling liabilities. However, the main difference between the fixed income and index-linked market is the limited amount of corporate issuance in the latter.

6.5.9 There are several reasons why an issuer might want to issue index-linked corporate debt, which are discussed in van Bezooyen *et al.* (2001). The first is that, if the issuer has inflation-linked income, as many utility companies do, then it might want to borrow on similar terms. Index-linked corporate bonds are also beneficial in cash flow terms, the payments in early years being lower than for an equivalent fixed income bond. Index-linked issuance might also be more attractive if it can be obtained more cheaply than fixed income issuance — this is a market timing issue.

6.5.10 However, the index-linked corporate bond market in the U.K. remains relatively small. There are several potential reasons for this. The first is to do with tax. The part of the redemption payment paid in respect of price inflation, which in part compensates for the low initial coupon, does not attract tax relief when paid. This means that, unless a company is loss making, there is a tax penalty for issuing index-linked rather than fixed income debt.

6.5.11 There is also a 'Catch-22' situation here, in that there is little demand for index-linked corporate debt, because the low level of issuance makes it difficult to construct diversified portfolios; however, corporate index-linked issuance is actually low, because there is insufficient demand to make issue attractive relative to fixed income issuance.

6.5.12 It is possible to construct synthetic index-linked corporate bonds using either index-linked Treasury bonds and credit default swaps, fixed income corporate bonds and inflation swaps, cash, interest swaps, inflation swaps and credit default swaps, or some other permutation of the above instruments. It can be argued that index-linked gilts should not be used, as there is a liquidity premium in the price, and pension schemes do not need this liquidity. It can also be argued that credit default swaps should be used, since they allow greater diversification than corporate bonds, since a global credit default swap portfolio can be created without the exposure to overseas government bond yields. This potentially leads to a more diversified portfolio than could easily be achieved using sterling corporate bonds. However, there is the issue that credit default swaps are generally only of a short duration.

6.6 *A Suggested Approach for Bond Investment*

6.6.1 The following is an approach that might be suitable for larger schemes that wish, above all, to ensure that their bond (or bond-like) investments do what they are supposed to, namely reduce risk:

— Decide whether active or passive duration management is required.

— If passive management is all that is needed, then invest the assets in a portfolio of long-dated AAA-rated bonds (thus requiring little adjustment in respect of duration) or an AAA-rated cash fund (thus removing the problem of reinvestment of coupons and ultimately principals). Hedged overseas AAA-rated bonds might also be used.

— If active management is required, give your manager an all-bond benchmark as far as duration is concerned — this will give the manager the widest range of opportunities to add value. The breadth of opportunity might extend to overseas bonds and currency decisions, with fully hedged issues being included in the benchmark.
— Decide whether credit exposure is required. If so, the bond portfolio can be widened from AAA to investment grade, or exposure can be obtained through credit default swaps. Active credit management can also be added here if required.
— Use interest and inflation swaps to move from the duration and inflation exposures of the assets (the benchmark duration, if the assets are being actively managed) to the duration and inflation exposures of the liabilities.

6.6.2 The above process does not consider any of the corporate governance issues involved in setting investment strategies. In practice, a negotiation between the trustees and the sponsoring employer would be expected.

6.6.3 There are many instances where the approach outlined here will not be exactly appropriate. For example, if long-dated AAA-rated bonds appear to be expensive relative to swaps, then it might be preferable to invest in shorter-dated bonds and obtain more of the duration exposure through the swap market.

6.6.4 There should also be steps taken to ensure that smaller schemes are able to take properly duration and inflation match. One way in which this can be done is to make available pooled funds that match appropriate durations rather than bond indices and that allow schemes to mix and match to arrive at an inflation and duration profile consistent with the scheme's liabilities.

6.6.5 There is also an argument for going one step further than the scenarios outlined before. The freedom to employ active duration, currency and credit management to attempt to achieve out-performance relative to the bond benchmark is mentioned. However, if out-performance is to be sought, it makes more sense to use more than three potential sources. Therefore, various other 'absolute return' strategies could be used to diversify the sources of active management.

6.6.6 Having said this, in many cases there is a strong argument from the sponsoring employer's point of view that, if the employer is financially strong, then the pension scheme should be fully funded and adopt the minimum risk position, and that the sponsoring employer should control its risk appetite by taking actions that affect the company directly rather than using the pension scheme. However, a weaker sponsoring employer may well want to run a deficit in the pension scheme to take advantage of the cheap debt funding that the pension scheme is effectively supplying to the company, and a seriously distressed company might want to have pension scheme assets invested in very risky assets, on the grounds that things could not get much worse, but if the investment gamble paid off then the company's finances would be strengthened. The trustees could take the opposite view, that they would be less willing to have a risky investment strategy the weaker the sponsoring employer. However, given that their primary role is to ensure that benefits are paid, not to generate surplus for discretionary benefits, there is an argument that the trustees should prefer the minimum risk position whatever the strength of the sponsoring employer.

6.6.7 Of course, the Pension Protection Fund could change things again, giving some trustees an incentive to take more risk, as a degree of insurance now exists.

7. Conclusion

7.1 *Asset Only Value Analysis*

7.1.1 Looking at the risk and reward characteristics of the asset classes in isolation offers inconclusive evidence as to the relative merits of the different bond asset classes. However, when the correlations between the asset classes are taken into account, the fact that the returns on U.S. high yield corporate debt have a low correlation with the other U.S. bond asset classes means that it is a good diversifying asset class when included in lower-risk portfolios, whereas the good risk adjusted returns on investment grade corporate debt means that it features strongly in higher risk portfolios.

7.1.2 The beta analysis produces some interesting results. Firstly, the market portfolio lies below the efficient frontier. This situation arises because equities make up a large proportion of the market portfolio, but are not as strongly represented in the efficient frontier. The analysis also shows that, if historical mean returns are taken as a good indicator of future returns, then bond asset classes are undervalued. However, the degree of undervaluation is not statistically significant at any reasonable level.

7.1.3 Looking at risk and reward over rolling time periods shows that some relationships are more stable than others — the broad equity/bond split is reasonably stable over time, whereas, for example, the split between investment grade corporate debt and Treasury bonds is not. This suggests that the degree to which stochastic asset models are used should be considered and tempered with pragmatism.

7.1.4 Skew and excess kurtosis are not generally an issue, except for high yield corporate debt. This suggests that, if modelling is carried out, attention should be paid to the shape of the returns distribution as well as to the mean and variance.

7.2 *Asset/Liability Value Analysis*

When liabilities are taken into account the picture changes, to the extent that Treasury bonds are intuitively the best match liabilities, and the asset allocation changes away from this depending on the risk measure used and the level of funding. The differences are much more pronounced for the closed pensioner portfolio, where investment grade corporate debt appears in some of the minimum risk scenarios.

7.3 *Asset Only Income Analysis*

7.3.1 From an asset only point of view, the further down the credit scale an investor goes the more that investor is rewarded with a higher level of income. This is unsurprising. However, what is surprising is that undue volatility in the income is a rare occurrence, although the last couple of years have seen income adversely affected.

7.3.2 A fund investing in high yield corporate debt before 1991 would have suffered a sharp fall in income (and capital values) that would not have been recovered (although the level of income would still have remained above that of other bond asset classes after 1991). However, if this early period in the development of the high yield corporate debt market is avoided, then income going forward is high and stable, although it has fallen off in recent years.

7.3.3 On the strength of this, provided that a diversified portfolio is held, high yield corporate debt is a very attractive proposition for an investor requiring income.

7.4 *Asset/Liability Income Analysis*

When liabilities are taken into account, the position again depends on the initial funding level. However, in this case Treasury bonds get progressively less attractive relative to corporate bonds as the funding level increases. Poorer credit quality becomes an issue when liabilities are taken into account, because falls in coupon income require disinvestment, probably at a depressed price, and the effect of this disinvestment is amplified when funding levels are low.

7.5 *Overall Conclusion*

7.5.1 Overall, I believe that this study shows that, on a value basis, the types of debt asset class that are most appropriate for pension portfolios depend on a number of factors relating to the pension fund and also the risk appetite of the trustees and plan sponsor. Having said this, there is often a strong argument from the sponsoring employer's point of view that pension schemes should adopt the minimum risk position and that the sponsoring employer should control its risk appetite by taking actions that affect the company directly rather than using the pension scheme. There is also an argument that, rather than trying to best match pension scheme liabilities using only traditional investments, derivatives should be more widely used to allow appropriately for duration, currency, inflation and solvency.

7.5.2 However, if market values can be ignored, then there is an argument for using corporate debt (investment grade and high yield) to provide an income that is higher but no less stable than that available from Treasury bonds.

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