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Risk Reduction and Diversification in UK Commercial Property Portfolios

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Abstract

The issue of diversification in direct real estate investment portfolios has been one of the most widely studied topics in academic and practitioner literature. Most work, however, has been done using mean returns and risks for broad market segments as inputs to asset allocation models, or in a few cases using data from small sets of individual properties. This paper reports results from a comprehensive testing of asset allocation modelling drawing on records of 10,000+ UK properties tracked by Investment Property Databank. It provides for the first time robust estimates of the diversification gains attainable given return, risk and cross-correlations across individual properties actually available to fund managers. The discussion of results covers implications for the number of assets and amount of money needed to construct "balanced" portfolios by direct investment, or via indirect specialist vehicles.

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1 Introduction

This paper investigates the potential for risk reduction and diversification in portfolios of direct investments in UK commercial property, drawing on Investment Property Databank (IPD) records of thousands of individual properties. Its primary objective is to establish the specific risk and tracking error of portfolios containing varying numbers of assets. In the course of that investigation, it provides full information on the return, risk and correlation characteristics of individual properties, and their variation across market segments. Standard analytical and simulation methods are applied to determine the variation in risk with number of assets for balanced funds seeking to track the overall market index, and also for specialist funds offering investors exposure to specific segments of the market.

There is an extensive literature on the issue of portfolio risk and the number of assets held in both equity investment and property investment. Previous work on property, however, has mostly been limited to exercises based on small samples of individual assets, or taking aggregate results for sub-segments of the market, to measure the potential risk reduction. The approach used here is the first, to our knowledge, which applies all the main available methods to the full dataset which is the best representation of the full universe of assets actually available to UK fund managers. It therefore gives the most realistic picture of the choices available to managers seeking to construct portfolios with a specific risk tolerance against index benchmarks.

Previous studies on UK property data have estimated the number of properties required to achieve a “diversified” portfolio anywhere between 20 (Jones Lang Wootton, 1986) and 2,000 (Young et al, 2006). Such wide spreads reflect differences in the definition of “diversified” as much as fundamental differences in the data sets and techniques used. There is a broad consensus among academics and practitioners that portfolios of 30 to 60 properties can diversify away a large part of the risk of individual assets, while a portfolio of around 200 properties achieves around 90% of the theoretical maximum diversification. Our results are broadly confirm the established consensus, but provide a more robust quantification of feasible risk reduction over a longer period of time, and for a wider range of investment objectives.

Following this introduction, Section 2 establishes the primary theoretical framework for the analysis, and reviews previous work on the subject in both equities and property markets,. Section 3 briefly describes the IPD data set used, and the details of the portfolio simulation methodology. Section 4 sets out the characteristics of property performance at the asset level, and out main results. Section 5 concludes with a discussion of practical implications of the work, and areas for further development.

2 Literature review

The standard measures of portfolio risk and diversification can be derived directly from the basic theories of Modern Portfolio Theory and the Capital Asset Pricing Model. This section first derives and defines these standard measures, and then reviews their application in previous work on both equities and property markets.

2.1 The measurement of risk and diversification

Following the finance literature, we apply two distinct measures of portfolio risk. The first is total portfolio risk – the standard deviation of a portfolio of n assets. The risk reduction available from portfolios of different sizes can be measured either by the extent to which an n asset portfolio reduces risk from the most risky portfolio – a single asset – or approaches that of the least risky portfolio – the market index. The second measure of risk is diversification – the closeness with which a portfolio of n assets tracks movements in a market Index year by year, or the extent to which the specific risk of individual assets has been diversified away, leaving only the systematic risk of the market index.

The basic principles of the risk reduction measure are familiar from the original formulations of Modern Portfolio Theory (Markowitz, 1952, 1959). In the standard form of presentation, the expected return on a portfolio is the capital weighted average returns on each asset:

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i) \qquad \textbf{Equation 1}$$

where $E(r_p)$ is the expected portfolio return

w_i is the proportion of funds invested in asset i

and $E(r_i)$ is the expected return from the individual asset i .

Expected portfolio risk is a function of both the weighted variance of the individual assets, and a double summation of the weights and covariances between individual assets:

$$\sigma_p^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} w_i w_j Cov_{ij} \qquad \textbf{Equation 2}$$

where σ_p^2 is the variance (risk) of portfolio returns

w_i is the proportion of funds invested in asset i

σ_i^2 is the variance of returns from asset i ,

w_j is the proportion of funds invested in asset j

Cov_{ij} is the covariance in the returns of assets i and j .

While covariance between any pair of assets is found by:

$$Cov_{ij} = \rho_{ij} \sigma_i \sigma_j \qquad \textbf{Equation 3}$$

where ρ_{ij} is the correlation between the returns of assets i and j

σ_i is the standard deviation of the returns of asset i

σ_j is the standard deviation of the returns of asset j .

While it is not immediately obvious that there is a relationship between the portfolio risk and number of assets held, a general formula can be derived on the assumption that assets are equally weighted. If n assets each carry a weighting of 1/n, Equation 2 can be restated as:

$$\sigma_p^2 = \frac{1}{n} \overline{\sigma}^2 + \frac{n-1}{n} \overline{\mathrm{cov}_{ij}} \qquad \textbf{Equation 4}$$

where σ_p^2 is the variance (risk) of portfolio ret

n is the number of assets in the portfolio

$\overline{\sigma}^2$ is the average asset variance

$\overline{\mathrm{cov}_{ij}}$ is the average covariance between portfolio assets.

Clearly, for a given average variance of assets, as n increases, the first term of the total portfolio risk decreases, while the second term increases as a proportion of total risk. For small number of very risky assets, therefore, adding additional asset to the portfolio will always achieve a large measure of risk reduction. With a large number of assets, the impact on risk on adding further assets at the margin will depend primarily on the average level of covariance.

Equation 4 provides a specification of risk within a simple Mean Variance Portfolio framework, and the impact of number of assets on the expected spread of portfolio returns around a market average. It is an expression of *risk reduction* with increasing portfolio size. Risk reduction can be measured either as the standard deviation of expected portfolio return around the market average taken directly from Equation 4. If is often expressed as a percentage risk reduction, the percentage reduction in standard deviation around the market average produced by a portfolio of n properties against the standard deviation of a single property portfolio around that average. Thus if the standard deviation in returns for a single property about the market average is 10% and a 20 property portfolio reduces that standard deviation to 2%, an 80% risk reduction has been achieved.

Risk reduction measures only the standard deviation in returns for a portfolio against a market index in a single period, or a multi-period holding period. When applied over a holding period, it does not measure how closely, over several of years, a portfolio can be expected to move in line with the market average – the concept commonly known in performance measurement as tracking error.

The approach of the Capital Asset Pricing Model (CAPM) (Sharpe, 1963) splits overall risk into systematic risk, volatility caused by factors common to all assets, and specific risk, volatility caused by factors which affect only a single asset. Since systematic risk cannot be diversified away, a rigorous definition of diversification is the reduction of specific risk in a portfolio, and not the reduction in total risk.

In the standard CAPM formulation, the expected return on a single asset is:

$$r_i = \alpha_i + \beta_i r_m + \varepsilon_i \qquad \textbf{EQUATION 5}$$

where r_i is the return from individual asset i

r_m is the return on the market of all investible assets

α_i is a constant and β_i is the sensitivity of the returns of asset i to the market

and ε_i is a random error term.

By derivation, the risk on a single asset is:

$$\sigma_i^2 = \beta_i^2 \sigma_m^2 + \sigma_\varepsilon^2 \qquad \textbf{EQUATION 6}$$

where σ_i^2 is the total variance of returns from asset i

σ_m^2 is the variance of market returns

$\beta_i^2 \sigma_m^2$ (together) is the variability of asset i attributable to market (systematic) factors

σ_ε^2 represents the variability of asset i attributable to specific factors.

In Equation 6, the risk of an asset is a combination of systematic risk (the first term) and specific risk (the second term). For an individual asset, therefore, the proportion of total risk accounted for by systematic risk is:

$$R^2 = \frac{\beta_i^2 \sigma_m^2}{\sigma_i^2}$$ **EQUATION 7**

where R^2 is the ratio of systematic variance to total variance

A general relationship between portfolio risk and the number of assets held is not immediately apparent from Equation 7. However, Brown and Matysiak (2000: 338-339) derive the relationship shown in Equation 8, again on the assumption that all n assets are equally weighted, and that all assets share common characteristics in terms of specific risk and covariance. Using their notation:

$$R^2 = \frac{nA}{nA + B}$$ **EQUATION 8**

where *n* is the number of assets held
A represents systematic risk of a single asset
B is the specific risk of a single asset.

A can be computed as either the average covariance of all assets or as the variance of the market since, for the whole market, the average $\beta = 1$. *B* in turn can be found by subtracting the *A* from the average variance of all assets.

Hence, as *n* increases, systematic risk becomes a larger component of total risk and the R^2 ratio rises. This formula can be used to find the typical diversification of a portfolio of any size, or be rearranged to find the number of assets needed for a given level of risk reduction.

Under the CAPM formulation (Sharpe, 1964), in an efficient market, the expected return on an asset would reflect only the extent to which it varied with the market, since that was the motivation for its purchase. Its return would not reflect its specific risk, on the assumption that risk could be diversified away in a multi-asset portfolio. On this view, diversification is seen as the removal of risk for which the investor is not compensated and not simply as the reduction of overall risk.

From this theoretical basis, the analysis applies two separate measures of portfolio risk. First, the reduction in standard deviation in portfolio returns compared with the standard deviation in a market index over a period, is termed risk reduction, and can be calculated from Equation 4. Second, a full measure of the extent to which systematic risk has been reduced, and total portfolio risk approaches the systematic risk of the market index, termed diversification, can be calculated from Equation 8.

Both risk reduction and diversification can be estimated in two ways. Given averages of the standard deviations of individual assets, the correlation between individual assets (or intercorrelation), and the correlation between individual assets and a market index, they can be calculated by analytical methods – ie directly from summary statistics using Equations 4 and 8. These methods are, however, in their simple form restricted to an assumption of equal portfolio weights. The alternative is simulation methods, which construct hypothetical portfolios by sampling from a universe of individual assets. Simulation methods can assume either an equally weighted portfolio, or a value weighted portfolio in which each asset contributes to total return in proportion to its capital value.

2.2 Previous studies on equity and property portfolios

Work on the issue of diversification and portfolio size was originally conducted on equity markets. Here we briefly review those early foundations, and then consider in more detail the body of work on property markets.

For equity markets, Evans and Archer (1968) is the earliest empirical study usually cited, and it provides the basic methodology for subsequent work. They constructed portfolios of between 1 and 40 stocks through random selection from the S&P 500, repeating the selection for each portfolio size 60 times, and measuring average standard deviation from the 60 trials. The results suggested that most risk reduction was achieved with a portfolio of only 8 stocks and that the benefits of adding stocks beyond ten were not very great.

Elton and Gruber (1977) added analytical solutions to the risk reduction question – ie devising general formulae from the average variance and covariance of stocks quoted on the NYSE and ASE, rather than simulating portfolios from series of returns on individual stocks. Again, it was observed that most of the available risk reduction could be achieved with 10-20 stocks in the portfolio, although Elton and Gruber argued that very large portfolios could still achieve significant improvements in risk.

These early studies ignored variation in management and transactions costs with size of portfolio. Statman (1987) measured the gain from holding a large portfolio set against the increase in portfolio costs. He found that the benefits of holding a larger portfolio outweighed the added costs only for portfolios of up to 30-40 stocks.

Despite differences in emphasis resulting from the use of different time periods and methods, studies of equity markets have reached the same general conclusions; that most risk reduction and, also, a high degree of diversification can be achieved with a surprisingly small number of stocks.

In the real estate field, the development of research on this topic awaited the creation of large-scale data sets by firms of valuers in the 1980s. Using the basic simulation approach established by Evans and Archer (1968) and small sets of individual property records, Jones Lang Wootton (1986) concluded that a portfolio of 20 properties achieved most of the potential risk reduction. Barber (1991) put that threshold at 40-45 properties. These studies did not formally measure the extent of full diversification, or reduction in tracking error.

The first larger-scale and more rigorous exercise was conducted by Brown (1988). Taking base data on monthly returns for 135 properties, Brown applied analytical methods backed up by some simulations. He found that "market" returns represented by the average for the whole sample of properties explained, on average, only 10% of the variation in return on individual properties, compared to 30% in the case of UK equities. Given that high degree of specific risk, therefore, a large amount of risk reduction could be achieved with a portfolio of only 10 properties. But, due to the low inter-correlation between assets, an extremely large number of properties – 200 – would be needed for the market to explain more than 95% of the portfolio return.

Brown's analytical results were produced using an assumption of equal portfolio weights for each of the 135 individual assets. His accompanying simulation exercises, however, allowed this assumption to be relaxed, and suggested that the wide variations in lot sizes between property assets could have an important influence on the results.

As Brown (1988:146) noted, his results mean that it is very difficult for all but the very largest property portfolios to track a market index such as IPD, and that two medium sized funds which are similar in structure may perform very differently. Brown and Schuck (1996) suggest that this barrier to diversification is one of the factors that explains why property investors generally hold much lower weights than indicated by portfolio optimisation models.

The implications of value weighting of property assets were taken further by Morrell (1993), who stressed that equal weighting is not a realistic choice for investors constructing a balanced portfolio including (say) low value industrial units and high value shopping centres. To give a fuller account of the inevitable impact of value weighting on risk, Morrell used full cash flow data on 562 assets held from 1984 to 1987 to construct portfolios of 2 to 50 properties, on both equal weighting and value weighting assumptions. Estimates of risk for were taken from 100 sampling trials for each portfolio size. The results showed that the dispersion of returns for the value weighted portfolios was significantly greater than that for the equally weighted portfolios of the same total value, because individual assets with large lot sizes can dominate the portfolio return. Thus, Morrell concluded, previous estimates of risk reduction with portfolio size underestimated the number of properties required to achieve a given level of diversification.

In a discussion of these results, Schuck and Brown (1997) observed that the relationships between number of assets, their specific and systematic risk, and uneven lot sizes are complex. While uneven lot sizes might, on average, increase the risk found in value weighted portfolios, the precise impact depends on an interplay between individual asset risks, the spread in lot sizes and the correlations between assets. In some cases, value weighted portfolios could show lower risk than equally weighted portfolios. Overall, Schuck and Brown suggested that value weighted portfolios were more likely to show increased risk when inter-asset correlations are low, as in UK commercial property.

A further development in Morrell (1997) noted that, because property assets are indivisible, property portfolios contain unique sets of assets, unlike equity portfolios of varying size which will be largely constructed from shares in the same companies. This adds a further level of variance between actual property portfolios and an index, on top of the low level of correlation between assets. Morrell considered that, as a substitute for the ability to cross-invest in different properties, property fund managers attempt to identify market segments with greater homogeneity which can then be used to structure portfolios. The key question for such managers then becomes how many assets in each segment are required to provide a reasonable approximation of their risk and return characteristics.

The construction of portfolios using market segments has been investigated in most detail by Byrne and Lee (2000). They applied both analytical and simulation methods to a dataset of returns for different UK local authority districts, split by sector, covering the period 1981 to 1996. These data points were then aggregated into 4 regions and portfolios were constructed selecting from the whole dataset and from particular sector/region combinations. The authors observed that previous studies which reported only the average results from many trial sets of portfolios were misleading. While increasing portfolio size may reduce significantly reduce average risk by the time portfolios rise to (say) 20 properties, the individual outcomes of the trials may still show a wide dispersion. In other words, some of the randomly selected portfolios still show high levels of specific risk. Byrne and Lee found that, adding this further dimension, it took another step up on portfolio size, to 60-80 assets, to produce sets of portfolios with a reasonable degree of confidence that the average level of risk reduction would be achieved by all individual portfolios.

The most recent investigation of the issue using individual property data is reported in Brown and Matysiak (2000), which revisited the work of Brown (1988). This used IPD monthly returns for 100 properties over the period 1987 to 1997, split into two five-year sub-periods, and annual returns for 750 properties over the period 1987 to 1996. Overall, on the monthly figures the analysis found risk reduction results very similar to those in Brown's 1988 study (also based on monthly returns). The results also suggested that market states may impact on risk reduction, with rather higher inter-correlations between properties and therefore less potential risk reduction in the highly volatile boom and bust market from 1987 to 1992.

Brown and Matysiak's results based on the annual returns, however, were significantly different, finding a much higher average correlation between assets (0.4) than on the monthly figures (0.10). This suggests that the frequency at which returns are measured may imply very different diversification characteristics. At a monthly frequency, correlations may be biased downward by the large proportion of properties – around 60% - for which capital values remain unchanged in any one month. Given the length of time necessary to adjust portfolio structures, measurement at an annual frequency might well be considered more appropriate. In that case, the potential for risk reduction may be lower than suggested by many papers based on higher frequency results.

There have been few attempts to match up the results predicted from analytical methods or simulations based on small samples to the range of returns and risks achieved by actual investment funds. Funds covered by IPD, as reported in Cullen (1991), do not appear to show a systematic relationship between portfolio size and risk. Indeed, some very small portfolios record very low levels of risk against theoretical predictions based on the number of properties held. While there may be several explanations for this counter-intuitive result, Byrne and Lee (2003) consider it may be due to the attribution of fund risk to systematic and specific factors. In particular, both total volatility as measured by the simple variance on total returns, and diversification as measured on the CAPM model, may rise with the size of portfolios. Thus large funds are more likely to track the market, and therefore pick more systematic risk, while at the same time reducing specific risk through their wider access to the full range of market segments and lot sizes.

Smaller portfolios, by contrast, may show low overall variance due to fortuitous combinations of assets, but their returns are much more weakly linked to the market index. To take hypothetical extreme cases, a two-property portfolio of assets which are negatively correlated with each other but weakly correlated with the market index would show very low risk coupled with very poor diversification measured by its ability to track the market. At the other extreme, two properties highly correlated with each other and with the market index would show a high level of risk, but high diversification, tracking close to the market.

Previous work, in summary, provides a well-established theoretical base. Studies based on analytical methods or simulations run on small sets of individual property data show a large measure of consistency, in that increasing the number of properties in a portfolio at the low end of the size range – up to 30 to 50 properties - produces rapid reductions in risk due to the combination of high asset specific risk and low asset inter-correlations. Very high levels of diversification, removing say 90% of specific risk from portfolios, can be achieved only with very large holdings of 200 or more assets. There remains a question mark, however, on how these theoretical predictions marry up with observed performance of real portfolios. And no previous research has used complete individual property histories taken from IPD's largest available record of investible properties. Bridging these gaps sets the agenda for the present study.

3 Objectives, data and methods

Following from previous work, this study has used the full range of established methods – the analytical approach and the simulation approach – and the largest available data set of individual property records, where possible over 24 years from 1981 to 2004. It therefore aims to clearly up some of the uncertainty surrounding the results of earlier studies associated with limited sample sizes and specific time periods.

Furthermore, access to a large set of individual properties enables us to undertake more disaggregation of the characteristics of returns and portfolios. Previous work has been almost exclusively concerned with the all-property level – in other words with diversification issues relevant to the construction of balanced funds benchmarked against an All Property index. With a larger data set, we can also investigate relationships between portfolio size and diversification for specialist funds with a one-segment focus (such as London offices or shopping centres) which seek to replicate segment-specific returns. This type of fund has, in recent years, become one of the most favoured indirect investment vehicles.

Finally, histories of return for all the actual investment funds tracked by IPD can be generated from the same data set used in the theoretical analysis. This means it is possible to cast more light on the linkages between the predictions about portfolio performance generated by theory to the empirical results achieved in practice. The wide coverage of the IPD system, again, makes it possible to separate out portfolios with specific characteristics – such as balanced funds – from the overall sample.

The individual property data that are the foundation of the analysis are taken from IPD's annual databank. At the end of 2004, the databank covered around 11,000 properties with a total value close to £120 billion. IPD estimates this is equivalent to approximately 50% of all commercial property held by large-scale professional investors, and a much higher fraction of that held by the largest domestic institutional investors, listed property companies and investment funds. IPD data, and the principles of its construction, are widely used and understood in both industry and academia. Details on the databank and the underlying principles of measurement are available from www.ipdglobal.com.

The theoretical analysis cuts into the individual property data in two ways: annual cross-sectional samples from 1981 to 2004, and longitudinal time series samples from 1994 to 2004. In both cases, the properties selected are "standing investments" as defined by IPD – ie properties held between two year-end valuation dates, and thus excluding all properties transacted or under development in the course of the year. Meanwhile, the comparison indices for the market and for different market segments were also obtained from the IPD databank.

The cross-sectional analysis draws on the full set of properties available each year, to measure the dispersion of individual properties returns around the all-property and segment averages. This is the basis for analytical methods to determine the diversification impacts of different portfolio sizes in any one year, and also for parallel simulation methods constructing randomly selected portfolios with varying numbers of properties. The sample sizes available for this part of the research were at a minimum of 11,000 in 2004, and up to 15,000 in earlier years.

Our longitudinal analysis replicates the construction of portfolios over the period 1994 to 2004. To bring this as close as possible to a realistic representation of portfolios actually available to medium-long term investors, the time series analysis was based only on properties continuously held by investors covered by IPD throughout the assumed holding period. This restriction cuts the available sample size to 1,720 properties for the ten year period. Again, this sample served as the basis for both analytical methods based on summary statistics, and for simulation exercises.

Limiting the longitudinal analysis to the relatively small sub-set of IPD properties continuously recorded for ten years raised possible problems of survivor bias - that the characteristics of these long-held assets are in some way different from the whole population of available properties. However, tests for consistency in the annual returns and annual standard deviations with a larger set of properties, held over the five years 1999 to 2004, suggested there was no association between length of holding period and these key characteristics for the purposes of this analysis.

Well established Monte Carlo simulation methods have been used in both cross section and time series to construct hypothetical portfolios of varying sizes. For each simulation trial, portfolios of from 1 to 500 properties (in steps of 1 up to 20 properties, then steps of 10 up to 100 properties, and steps of 50 from 100 to 500 properties) were obtained by random selection without replacement from the available universe of individual properties. For each portfolio size, the random selection process was repeated 20,000 times in the case of the cross sections and 5,000 times for the time series returns. Average returns, standard deviations and ranges in standard deviations were then calculated from the sets of trials at each portfolio size.

4 Results

This section first describes the key characteristics of individual property returns in annual cross section, which underlie all the results that follow. We then take in turn the results produced from cross-sectional analysis and from longitudinal analysis of the individual property data. The final part of this section briefly compares the theoretical results with the risk characteristics of actual investment funds tracked by IPD.

4.1 Individual Property Risk

Across all properties in the sample, the standard deviation in returns about the index average for individual years has ranged between 35.1% and 16.9% (Table 1 – the years selected represent the main turning points in the property cycle). The standard deviation in return across properties within the IPD in 2004 was 16.9% with an interquartile spread of 11.5 pp. By way of comparison, the standard deviation in returns across all equities listed on the FTSE in 2004 was 42.5% with an interquartile spread of 32.5%.

Table 1 Dispersion in individual property total returns, selected years

	Standard Deviation %					
	1988	**1991**	**1997**	**2001**	**2004**	**Average**
Std. Retail –South East	36.8	31.1	15.3	13.4	15.4	22.4
Std. Retail – Rest UK	33.5	30.4	15.2	12.1	14.5	21.1
Shopping Centres	17.3	13.9	9.5	7.7	8.0	11.3
Retail Warehouses	15.5	14.7	12.3	30.5	11.0	16.8
City Offices	21.3	41.5	41.2	31.9	28.5	32.9
West-End Offices	41.6	19.1	28.7	15.5	28.7	26.7
Rest of S.E. Offices	34.0	17.5	16.2	11.3	12.9	18.4
Rest of UK Offices	32.8	17.7	23.3	11.3	10.4	19.1
Industrial South East	33.5	13.6	12.8	14.4	11.6	17.2
Industrial Rest UK	24.3	13.9	10.4	10.5	10.4	13.9
All Property	**35.1**	**26.6**	**21.3**	**18.2**	**16.9**	**23.6**

Table 1 splits the summary statistics into 10 primary market segments, which are extensively used in IPD's portfolio reporting service, and therefore stand as the split of the market most commonly used by fund managers in asset allocation. There are large and persistent differences in the spread of returns within segments. Averaged across years, City and West End offices show the greatest spreads in return. Shopping centres, retail warehouses and Rest of UK industrials all show standard deviations less than half those found in the central London office segments. The larger return spreads seen in Central London segments may appear surprising given that they are the most geographically compact of all the segments.

There appears to have been a downward trend in one-year dispersion at the all-property level, and within each of the market segments – though again this is less marked in the Central London office segments. A number of factors may have contributed to this fall in return spreads.

Within segments, the two most important factors are likely to have been a long term increase in average lot sizes and a decreasing variability in the spread of valuations. Since 1981, the average lot size in the IPD has risen four-fold after adjustment for rising capital values. Since high valued properties show much tighter spreads of returns, this effect has probably accounted for the bulk of the narrowing. Previous work by IPD (RICS, 2006) has also shown that the spread of valuations around transactions prices has narrowed over time, accounting for a further substantial proportion of the narrowing within segments. At the all-property level, a further narrowing is likely to have resulted from a fall in the weighting of offices, where return spreads are greatest, and also a narrowing in the range of returns across segments.

4.2 Cross Sectional Analysis

As a first step in the analysis, portfolios were been constructed from annual cross-sectional data by sampling portfolios from the records for 11,000 – 15,000 properties each year. The portfolio returns were value-weighted. This exercise was carried out at the all property level each year from 1981 to 2004. For market segments, to limit computing time to a manageable level, simulated portfolios were constructed for the years 1988, 1991, 1997, 2001 and 2004, selected to represent a range of market states through the period.

Figures 1 and 2 summarise the results of the all property portfolio simulations for a single year, 1994. Figure 1 shows the mean standard deviation from 20,000 simulations at each portfolio size. Figure 2 shows the same results in the form of spreads in total returns across the 20,000 simulations at each portfolio size. (Note that in these charts and those which follow, the gaps in the lines show changes in the steps at which portfolio sizes were increased.)

In 2004, the IPD all property return was 18.3% and the standard deviation in return of individual properties around that mean was 16.9%. Adding a second property to a 1 property portfolio yielded the largest single reduction in expected standard deviation, to 9.1%, removing nearly 60% of the risk of investment in a single property. A portfolio of 40 properties would have an expected standard deviation of 2.6%, removing 75% of the risk of an individual property – a finding consistent with previous studies which suggested “the bulk” of specific risk could be removed with portfolios around that size. Cutting the expected standard deviation in return around the IPD average to less than 1%, however, would require a portfolio of 350 properties.

Repeating this procedure for every year from 1981 to 2004 yields the results summarised in Figure 3, which shows the expected standard deviation in returns for a range of simulated portfolio sizes.

Figure 1 Cross-section: average standard deviation of simulated portfolios 2004

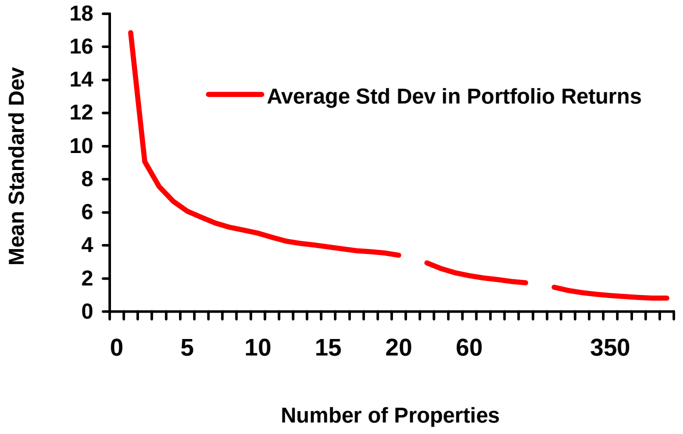


Figure 2 Cross-section: spreads in returns of 20,000 simulated portfolios 2004

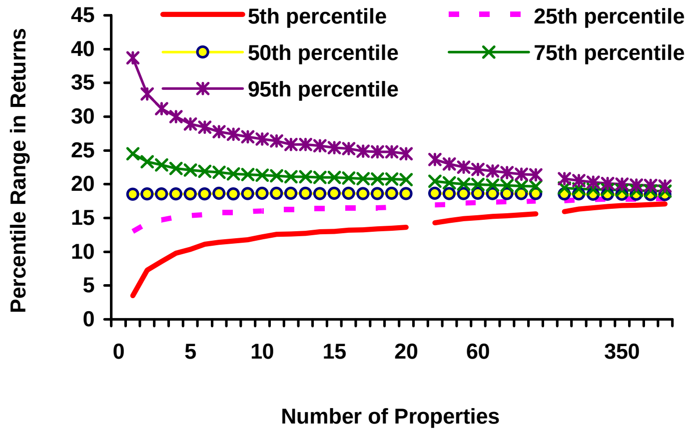


Figure 3 Cross-section: average standard deviation of simulated portfolios 1981-2004

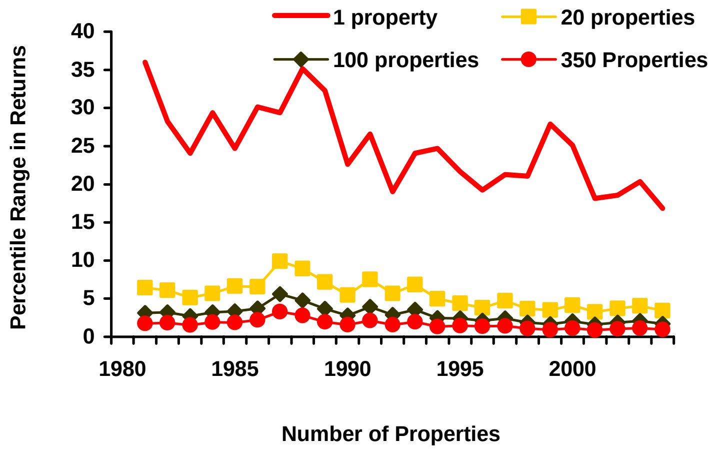


Table 2 Cross-sectional analysis: dispersion of simulated portfolio returns

	Number of Properties in Hypothetical Portfolio					
	1	**5**	**10**	**20**	**50**	**100**
2004 – Standard Deviation in Returns on Hypothetical Portfolios						
Std. Retail –South East	15.4	6.3	4.7	3.6	2.4	1.7
Std. Retail – Rest UK	14.5	5.4	4.0	3.0	2.0	1.4
Shopping Centres	8.0	3.9	2.7	1.9	1.1	0.7
Retail Warehouses	11.0	5.7	4.5	3.2	2.2	1.5
City Offices	28.5	6.0	3.9	2.8	1.9	1.3
West-End Offices	28.7	6.6	4.9	3.5	2.2	1.4
Rest of S.E. Offices	12.9	5.7	4.0	2.8	1.7	1.2
Rest of UK Offices	10.4	4.7	3.4	2.3	1.5	1.0
Industrial South East	11.6	4.9	3.4	2.3	1.6	1.1
Industrial Rest UK	10.4	5.0	3.9	2.9	1.8	1.3
All Property	**16.9**	**6.1**	**4.7**	**3.4**	**2.3**	**1.7**
Average of Five Years – Standard Deviation in Returns on Hypothetical Portfolios						
Std. Retail –South East	22.4	8.3	6.3	4.8	3.2	2.3
Std. Retail – Rest UK	21.1	7.4	5.5	4.0	2.6	1.8
Shopping Centres	11.3	5.8	4.1	3.0	1.8	1.1
Retail Warehouses	16.8	7.0	5.2	3.7	2.4	1.6
City Offices	32.9	9.5	5.7	4.0	2.5	1.7
West-End Offices	26.7	9.5	6.5	4.6	2.9	2.0
Rest of S.E. Offices	18.4	8.5	6.4	4.7	3.1	2.2
Rest of UK Offices	19.1	7.6	5.8	4.3	2.7	1.9
Industrial South East	17.2	6.7	4.9	3.6	2.4	1.7
Industrial Rest UK	13.9	6.7	5.0	3.6	2.4	1.6
All Property	**23.6**	**9.3**	**7.2**	**5.6**	**3.9**	**2.9**

There has been a clear down-trend in both the standard deviation of all properties around the IPD average within each year (ie the 1 property portfolio), and in the expected standard deviation of portfolios in all size ranges. In the first five years of the series, standard deviation across all properties averaged 28.5%, and the expected standard deviation for a 20 property portfolio averaged 4.6%. In the last five years of the series, those figures dropped to a standard deviation of 19.8% for individual properties, and an expected standard deviation of 2.8% for a 20 property portfolio. Annual outcomes have broken away from the downtrend only in 1988 / 1989, perhaps due to the large swing in the market and wide spread between segment returns in those years, but also in 1999 / 2000 where there is no such immediately obvious explanation.

The same procedure may be used to create simulated portfolios in each of the market segments. Table 2 condenses results for segments to show risk reduction across a range of portfolio sizes for 2004, and results averaged over the five years 1999-2004. When expressed as a percentage risk reduction from a 1 property portfolio, most segments show similar results in both the 2004 results and the averaged results over five years.

Table 3 Summary Statistics for Longitudinal Samples of Continuously Held Properties

	Std. Retail -South East	Std. Retail - Rest UK	Shopping Centres	Retail Warehouses	City Offices	West-End Offices	Rest of S.E. Offices	Rest of UK Offices	Industrial South East	Industrial Rest UK	Other Property	All Property
Number of Properties 1994-2004	368	418	27	116	50	125	160	88	209	145	22	**1,728**
Number of Properties 1999-2004	702	741	54	270	125	251	336	207	459	378	196	**3,719**
Average Std Dev 1994-2004	10.2	11.8	10.1	11	10	9.8	10.6	12.8	11.7	11	11.2	**11**
Average Std Dev 1999-2004	11.6	12	8	9.6	13	12.9	9.7	7.2	8	6.8	14.5	**10.4**
Intercorrelation between Properties 1994-2004												
Average	0.22	0.2	0.21	0.27	0.29	0.21	0.22	0.18	0.16	0.16	0.23	**0.18**
Standard Deviation	0.34	0.35	0.33	0.33	0.31	0.33	0.5	0.37	0.36	0.34	0.35	**0.34**
Correlation between Properties and Index 1994-2004												
Average	0.42	0.44	0.37	0.36	0.11	0.14	0.3	0.11	0.28	0.39	0.07	**0.41**
Standard Deviation	0.33	0.34	0.31	0.34	0.35	0.37	0.33	0.31	0.33	0.31	0.32	**0.3**

Generally, a 10 property portfolio achieves a risk-reduction of 65% to 75%, and a 100 property portfolio a risk reduction of 85% to 90%. The notable exceptions are the City and West End office markets, where the base risk of a 1 property portfolio is much higher, but lower intercorrelations between properties mean that the risk reduction benefits of added properties are much greater. So for these markets a 10 property portfolio achieves a risk reduction of 80% to 85%. It would appear that, for large-scale investors in the Central London offices, high market and specific risk may be offset by higher risk reduction benefits.

In general, the range in returns for specialist segment portfolio is smaller than the range in balanced fund returns (i.e. the all property level results), because the range in balanced fund returns is stretched by variations in performance across different sectors of the property market.

4.3 Longitudinal analysis

This section constructs portfolios using time series data for 1,728 properties continuously recorded by IPD over the ten years from 1994 to 2004. Table 3 gives summary statistics for individual properties over this period and the five year period 1999 to 2004.

At the all property level, it would appear that standard deviation in returns for individual assets converges to a long run figure around 10%-11%. Volatility is a little higher on the longer-run figures because they include years of higher year-on-year variation in the market index. On this measure, the average risk of a single property held over ten years at 11% is 2.5 times the standard deviation on market index returns over the same period at 4.4%.

Results at the segment level are not wholly consistent over the two periods, or with the cross sectional data discussed in the last section. On the ten year figures, there are fairly small variations in individual property risk across segments. Despite the large dispersion in returns shown by the annual cross section results, the Central London office segments are at the lower end of the risk range. Measured over five years, however, there is a wider spread in property risks across segments, and the Central London office segments again appear as the most risky.

At the all property level, the average intercorrelation between individual buildings is low, at 0.18, but with a wide spread around that average indicated by a standard deviation more than double the mean. Within segments, average intercorrelations between properties are not much greater than across all properties – indicating the low proportion of property level variance explained by segment attributes. Industrial properties and office properties outside the South East show lower intercorrelations than the other segments, perhaps due to a wider spread of locations and lower average lot sizes.

On average, individual property returns over ten years are moderately correlated with returns on the all property index, showing a correlation of 0.41. Perhaps surprisingly, the correlations between individual properties and their respective segment averages are at most little higher, and usually a lot lower, than the correlations with the all property average. Correlations with the segment average are particularly low in office segments, with the exception of the Rest of the South East. Again, this is a reflection of the weak explanatory power of the segmentation in explaining property returns (on this, see also Devaney and Lizieri, 2005).

Simulated portfolios were constructed from the ten year sample of data by the sampling methods described in the last section. As in the cross-sectional analysis, portfolios are value-weighted. The results are summarised in Figures 4 and 5.

Over the ten year period, the standard deviation in the market Index was 4.5%, and the expected risk of a single property portfolio was 11.0% - a difference of 5.5 pp. The extent of simple risk reduction with increasing portfolio size is rather greater than found in the cross-sectional variation in annual returns. Thus a 12 property portfolio is enough to reduce the total risk by 80% from that of a single property, and a portfolio of 30 properties reduces that risk by 90% - giving an expected standard deviation in portfolio return of 5.1%, only 0.60 pp above the standard deviation of the index. A portfolio of 150 properties shows an expected standard deviation of only 4.6%, cutting out 99% of the risk of a single property portfolio.

Figure 4 Longitudinal: average standard deviation of simulated portfolios 1994-2004

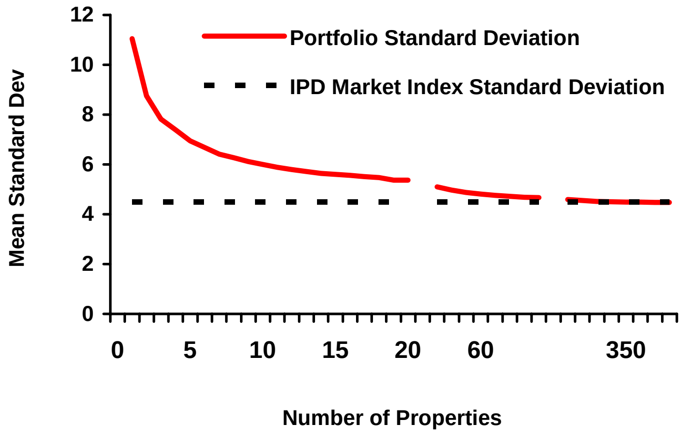
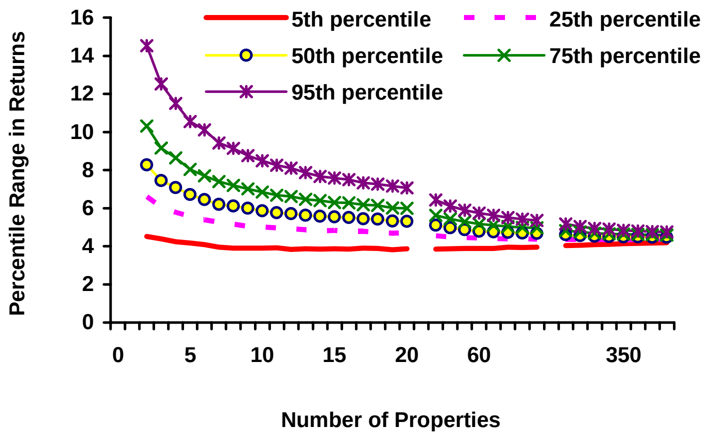


Figure 5 Longitudinal: spreads in returns of 20,000 simulated portfolios 1994-2004



Overall, because individual properties are weakly correlated with each other, and mildly correlated with the market index, the expected risk of portfolios falls quite sharply with increasing size. Figure 5, however, demonstrates that smaller portfolios still show a high probability of departing from the expected (average) risk by large margins. A 12 property portfolio may cut the expected excess risk by 80% but 25% of 12 property portfolios would have risk more than 2.6 pp above the market index. To cut the probability of risk less than 1% above the market index to less than 25% requires a portfolio of 30 properties

Figure 6 Longitudinal: standard deviations simulated vs analytical results 1994-2004

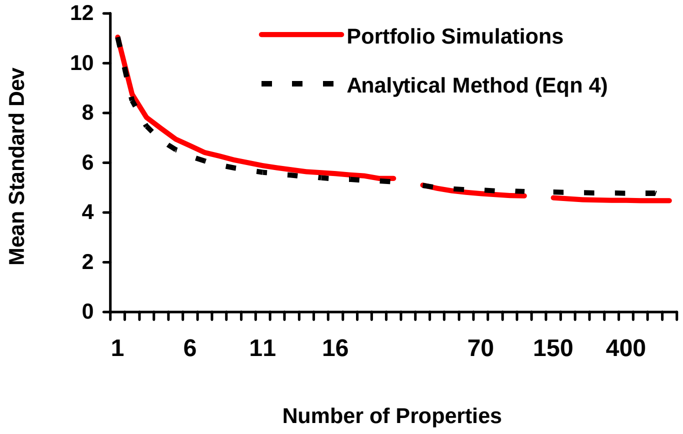


Figure 7 Longitudinal: Diversification (R-squared) simulated vs analytical results 1994-2004

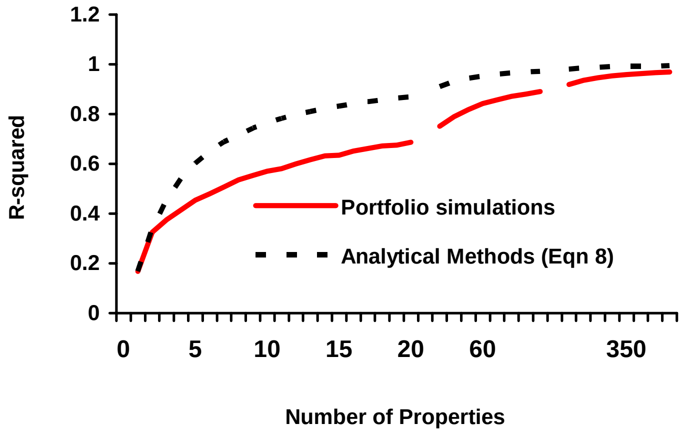


Figure 7 Longitudinal: diversification (tracking error) of simulated portfolios 1994-2004

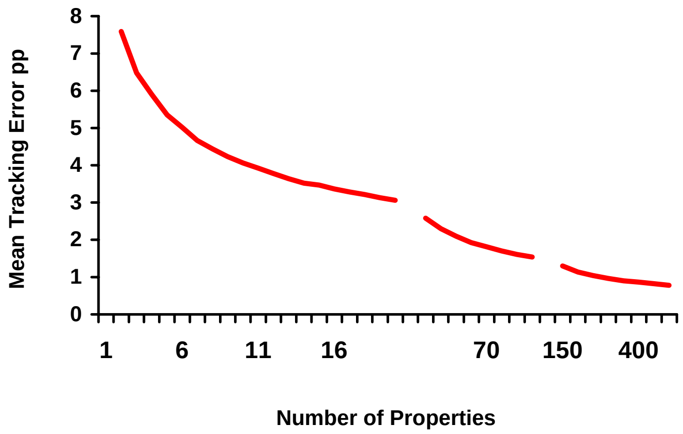


Figure 6 demonstrates that results from the simulation exercise (which are value weighted) are very close to those which would be produced more directly by analytical methods (which assume equal weighting). The analytical result applies Equation 4 from Section 2.1, calibrated with the average property standard deviation of 11.0% and average intercorrelation of 0.18 from Table 3. Simulated risk is between 1.07 and 0.94 times that predicted by analytical methods throughout the range of portfolio sizes. Simulated portfolios tend to show higher than predicted risk at the lower end of the size range, and slightly lower risk for larger portfolios. Though the differences between the two methods are small, they are most likely to reflect rather lower correlations between large lot size properties than between small lot sizes.

In contrast to the results for simple risk reduction, the extent of diversification shown as feasible by the simulation method differs a lot from the predictions of a simple analytical method (Figure 7). Diversification by the analytical method is predicted by Equation 8 from Section 2.1, with average standard deviation for individual properties at 11% and the average correlation between properties and the IPD market index at 0.41. As before, the difference between the two sets of results are that the simulations are value-weighted, while the analytical method assumes equal weights. The simulated portfolios show much lower diversification potential than the analytical prediction, especially in the mid-range of portfolio sizes between 3 and 50 properties. The difference suggests that large high value properties are less strongly correlated with the benchmark index than those with small lot sizes. While this implication holds true at the all property level, taking in variation in lot size across segments, it does not mean that the same is necessarily true within market segments.

Figure 8, meanwhile, presents estimates of tracking error (the standard deviation of the annual differences in standard returns between the portfolio and the market index), a measure of diversification and portfolio risk more widely used in fund analysis. The expected tracking error for a 2 property portfolio is 7.6%, falling to 4.1% for a 10 property portfolio, and 2.6% for a 30 property portfolio. Tracking error falls below 1% only for portfolios of nearly 300 properties.

These, fuller, measures of diversification are less comfortable than the simpler risk reduction results. Because the average correlations between individual properties and the market index are only 0.41, a fairly large portfolio (say 50 properties) may approach quite close to the same risk as the market index over a period of years, but still vary substantially from the index returns year by year. Which measure is most appropriate depends, ultimately, on the investment objective.

An investor seeking only property's return and risk characteristics over a holding period would be primarily concerned with risk reduction. An investor seeking the additional diversification benefit of property investment relative to other assets would also be concerned with full diversification and tracking error. The former, if the risk reduction target is set at (say) avoiding 90% of the specific risk of an individual property, can be achieved with fairly small portfolios of 20 properties. The latter, if the diversification target is set at an expected tracking error of less than 2% requires 60 properties, and 300 properties if that target is set at a tracking error under 1%.

Thus far, the longitudinal analysis has been carried out at the all property level, replicating the task of constructing a UK balanced fund. On those results, at average lot sizes in 2005, creating a 60 property balanced fund with an expected tracking error of 2% (and R-squared of 0.84) would cost a total of £833 million. Exactly the same simulation techniques have been used to estimate the number of properties and portfolio value needed to create specialist funds aiming to track an IPD segment benchmark with varying levels of risk tolerance (Table 4). In these cases, the benchmark index is the appropriate segment index over the period. For City offices and shopping centres, the small sample sizes of continuously held properties mean it is not possible to generate portfolios with high levels of diversification, and also that results for all portfolio sizes should be taken as indicative.

In terms of the number of properties, in most segments 10-15 properties are needed to construct a moderately diversified portfolio (taken as R-squared of 0.75, consistent with a tracking error around 2.5%) – setting apparently low thresholds for specialist funds. The main exception is Rest of UK offices, where the large spread of locations is reflected in a low correlation between individual properties and the segment benchmark.

The amount of capital needed to construct those segment-tracking specialist portfolios, however, varies over a much wider range. Average lot sizes in the IPD at the end of 2005 ran from £7 million for Standard Retails through £22 million for City offices, and £84 million for shopping centres. Accordingly, the size of fund needed for a moderately diversified shopping centre fund runs to over £1 billion, while equally well diversified standard retail and industrial funds could be held with only £100 million. To construct a balanced portfolio via a funds of funds approach requires participation in funds with a total value of £2.5 billion.

Table 4 Longitudinal simulations: portfolio sizes required to achieve given diversification

	Number of Properties			Total Portfolio Value £m		
Extent of Diversification R^2	0.50	0.75	0.90	0.50	0.75	0.90
Std. Retail – S East	3	16	70	21	110	483
Std. Retail – Rest UK	2	9	30	13	60	200
Shopping Centres[1]	3	12	-	255	1,018	-
Retail Warehouses	3	12	60	75	299	1,494
City Offices[1]	3	10	40	67	222	887
West-End Offices	3	11	60	49	178	970
Rest of S.E. Offices	4	14	60	62	219	937
Rest of UK Offices	6	30	-	59	296	-
Industrial South East	3	11	40	28	103	375
Industrial Rest UK	4	15	50	24	91	303
All Property	**7**	**30**	**150**	**94**	**401**	**2,007**

4.4 Empirical evidence on portfolio risk

Having established theoretical estimates of risk reduction and diversification potential, this section briefly reviews the evidence on portfolio size and risk shown by the actual investment funds covered by IPD over from 1981 to 2004. In 2004, IPD separately recorded 231 different funds, which allows some partitioning of the sample into balanced portfolios (ie covering a broad spread of market segments) and specialist funds with a narrower concentration.

Over time, the structure of portfolios appears to have run in the face of the principles of diversification. The average number of properties per fund has fallen steadily from 93 in 1981 to 45 in 2004. A number of factors have driven this halving in average portfolio size. Fund managers have, typically, weeded smaller properties out of their portfolios, with an especially large sell-off of unit shops, and concentrated their holdings in large lot size shopping centres and retail parks. This trend has been driven mainly by a desire to cut management costs.

Table 5 The Dispersion in Portfolio Total Returns from Balanced Funds, 1985-2004

	Average Number of Properties	Lower Quartile	Median	Upper Quartile	Inter-Quartile Range
1985	81	6.0	8.9	11.7	5.7
1986	77	7.3	10.5	14.0	6.8
1987	72	16.9	21.9	26.8	9.9
1988	68	25.2	29.6	34.4	9.2
1989	67	11.4	16.7	21.5	10.0
1990	66	-10.7	-7.6	-4.1	6.6
1991	63	-4.2	0.7	4.4	8.6
1992	61	-4.3	-0.5	3.1	7.4
1993	58	15.0	20.2	24.2	9.1
1994	58	9.7	12.3	15.4	5.7
1995	58	1.3	3.8	5.7	4.4
1996	57	7.8	9.5	11.1	3.3
1997	57	12.8	15.7	18.0	5.2
1998	60	9.7	11.8	13.5	3.8
1999	62	12.7	14.2	15.8	3.1
2000	60	8.8	10.9	12.7	3.9
2001	54	5.7	7.6	9.2	3.5
2002	51	8.2	10.2	11.9	3.6
2003	48	9.6	11.5	12.9	3.3
2004	48	16.7	18.9	20.6	3.9

Note. Figures are portfolio returns, not managed standing investment returns. The returns in this table reflect the impact of indirect investments, developments and trading. Returns are un-geared.

Over the last decade, there has also been a proliferation of new pooled investment vehicles such as limited partnerships, many of them set up to give specialist focus, and often seeded out of the direct portfolios of large institutions and property companies. Since, on average, IPD funds now hold 12% of their property exposure through indirect pooled vehicles – an in many cases over 20% indirect – many investors are seeking to diversify through holdings in pooled vehicles rather than within their own portfolios. Although the average number of properties in the direct portfolios of balanced funds has shrunk from 97 to 48 properties since 1981, those with substantial indirect holdings are likely to be exposed to a larger number of underlying assets than before.

In any event, despite a fall in portfolio sizes, the spread of returns across balanced funds has shrunk over the last twenty years (Table 5). The interquartile range has narrowed steadily over the last decade, from an average of over 8 pp in the last five years of the 1980s to less than 4 pp average over the first five years of the 2000s.

A number of factors may account for this convergence in returns. First and foremost, the dispersion of fund returns will have narrowed as a result of the decreased ranges in individual property returns discussed in Section 4. Our cross-sectional simulations showed that, for a 50 property portfolio, expected standard deviation would also have halved, from 5.5% over the last five years of the 1980s to 2.5% over the first five years of the 2000s. In addition, the figures in Table 5 show the number of assets directly held in funds, while the returns also include the impact of holding indirect investments which, as noted above, may have provided a balancing increase in diversification as direct portfolios have shrunk. The returns figures also include the impact on performance of development activity, which is a large risk factor for individual funds, and the typical exposure to development has fallen substantially since the early 1990s.

To strip out some of those factors, the summary statistics on spreads of returns in Table 6 are based only on direct portfolios of standing investments. Funds have been split into specialists, with a single sector focus, and balanced funds investing across a range of size bands.

The actual performance of funds in this single year is broadly consistent with the results from our cross sectional simulations. For balanced funds, these suggested an expected standard deviation of 4.7% for a 10 property fund, 3.4% for a 20 property fund, and 2.1% for a 60 property fund.

Table 6 Number of Properties and the Range in Fund Returns in 2004

Number of Properties	Number of Funds	Standard Deviation in Returns [1]	Average Total Return [2]
Specialist Funds			
<10	19	4.5	15.1
10+	23	4.3	18.2
Balanced Funds			
<10	8	5.5	15.8
10-24	54	3.3	19.3
25-49	66	2.7	19.2
50-74	25	2.7	18.8
75-149	27	2.4	18.9
150+	9	1.4	19.6

1. Standard deviation across individual fund returns in 2004.
2. Unweighted average.

Specialist funds, on average, held 32 properties in 2004. The average is heavily skewed by a few very large portfolios, so the median number of properties for specialist funds was only 10 properties. Against the cross sectional and longitudinal results for hypothetical portfolios, the majority of specialist funds would appear to be poorly diversified. At a median size of 10 properties, our cross sectional results suggest specialist funds will show standard deviations around their segment benchmarks of 3% to 4% in any one year. From the longitudinal simulations, it requires 10-15 properties to achieve a moderate degree of diversification (defined as an R-squared of 75%) within most segments, which is half the number required to achieve the same diversification in a balanced fund. These findings suggest that investors seeking diversification through indirect investment should spread their segment exposure across several vehicles. That strategy might, however, be traded off against the potential gains from concentrating exposure in selected funds expected to out-perform segment benchmarks.

Unfortunately, even with a total of 231 fund records, the sample of funds is not large enough, and the variation of fund structures within the broad categories of balanced and specialist is too large, to give a more precise comparison of hypothetical prediction and empirical results at this stage.

5 Conclusions

The analysis has revisited the issues of risk reduction and diversification using the fullest possible property data set, and a full range of the methods applied in previous work. In the main, the results provide confirmation of previous work, benefiting from a larger number of individual properties, and a longer time period, thus allowing a more robust quantification for segments of the market, for sub-sets of fund types, and of trends over time.

Overall, the results confirm previous studies, that a large measure of risk reduction can be achieved with portfolios of 30-50 properties, but that full diversification of systematic risk can only be achieved in very large portfolios of 200 and more properties. At 2005 average lot sizes values, the capital value of a 30-50 property portfolio would be £400-£700 million, and the value of a 200 property portfolio would be £2.8 billion.

The large span between those two sets of figures demonstrates the critical importance of careful definition of terms, and of quantified investment objectives, in any discussion of risk management in property portfolios. High property-specific risks and low inter-correlations between individual properties mean that risk reduction gains are easily obtained for both balanced all property funds, and specialist segment-focussed funds.

On results for recent years, expressed as the extent to which the risk of an individual property is reduced in a single year or over a holding period, the attainable risk reduction of 75%-80% with only 10-12 properties sounds impressive. But that still leaves an expected standard deviation in expected portfolio returns around the market index of 4.5% in any one year, and increase in standard deviation over the market index through a ten year holding period of 1.5 pp. Because the results do not seem sensitive to value weighting, analytical methods based on summary statistics appear to provide a satisfactory method of estimating risk reduction.

Full diversification gains, the probability of tracking the market index year-by-year through a holding period, is much harder to achieve. This reflects the moderate correlations between individual property returns and benchmark returns at both all property and segment level, and the impact of value weighting.

Our results demonstrate that value weighted portfolios show much weaker diversification gains with increasing size, because properties at larger lot sizes tend to be more weakly correlated with their benchmarks. So, over a ten year holding period, diversification in terms of an impressive sounding R-squared at 0.75 to 0.80 can be achieved with balanced portfolios of 30-50 properties, but that equates to a less comfortable annual tracking error of 2.5% to 2.0% per year. Very full diversification, set at an R-squared of 0.90 and a tracking error under 1.5% per year requires portfolios of more than 100 properties, or a portfolio value of £1.4 billion. Because of the value weighting impact, full diversification cannot be measured by simple analytical methods.

We hope these findings provide a framework for a wider understanding of the definitional and measurement issues essential to the discussion of diversification issues in the industry, and in reporting to investment clients.

There are potential areas of further development from the methods used in this study. One possible qualification to the results is that they have been based on sampling from the entire universe of properties recorded by IPD, with no restrictions on lot sizes, building quality, leasing status or other determinants of volatility. It may be that fund managers seeking to construct benchmark tracking portfolios within a total portfolio value limit would select only stabilised properties with less likelihood of disturbance from (say) required capital spending, tenant defaults, or interrupted cash flows. If this is the case, our results may overstate the number of properties needed to achieve given risk targets for deliberately constructed balanced or specialist portfolios.

On a related but tangential point, our work has constructed portfolios purely by random selection, an underlying assumption of zero manager skill in asset selection and management. Simulations allowing for specified degrees of manager skill in selecting properties with (say) returns above the median would cast more light on the actual levels of skill attained by real world managers.

References

Barber, C. 1991. 'Modern Portfolio Theory; Fact and Fantasy'. Paper presented as part of the seminar series *Property in a Portfolio Context* organised by the Society of Property Researchers and the RICS.

Brown, G. R. 1988. Reducing the Dispersion of Returns in UK Real Estate Portfolios. *Journal of Valuation*. 6 (2): 127-147.

Brown, G. R. 1991. *Property Investment and the Capital Markets*. London: Chapman & Hall.

Brown, G. R. and Matysiak, G. A. 2000. *Real Estate Investment: A Capital Market Approach*. Harlow: FT Prentice Hall.

Brown, G. R. and Schuck, E. J. 1996. Optimal Portfolio Allocations to Real Estate. *The Journal of Real Estate Portfolio Management*. 2 (1): 63-74.

Byrne, P. and Lee, S. 2000. Risk Reduction in the United Kingdom Property Market. *Journal of Property Research*. 17 (1): 23-46.

Byrne, P. and Lee, S. 2003. An Exploration of the Relationship Between Size, Diversification and Risk in UK Real Estate Portfolios: 1989-1999. *Journal of Property Research*. 20 (2): 191-206.

Cullen, I. 1991. 'Risk Management in Investment Property Portfolios', Paper presented as part of the seminar series *Property in a Portfolio Context* organised by the Society of Property Researchers and the RICS.

Devaney, S. and Lizieri, C. 2005. Individual Assets, Market Structure and the Drivers of Return. *Journal of Property Research*. 22(4): 287-307.

Elton, E. J. and Gruber, M. J. 1977. Risk Reduction and Portfolio Size: An Analytical Solution. *Journal of Business*. 50 (4): 415-437.

Evans, J. L. and Archer, S. H. 1968. Diversification and the Reduction of Dispersion: An Empirical Analysis. *The Journal of Finance*. 23 (5): 761-767.

JLW. 1986. *Risk and Asset Allocation: Implications of Portfolio Strategy*. London: Jones Lang Wootton.

Markowitz, H. M. 1952. Portfolio Selection. *The Journal of Finance*. 12: 77-91.

Markowitz, H. M. 1959. *Portfolio Selection: Efficient Diversification of Investments*. Yale CT: Yale University Press.

Morrell, G. D. 1993. Value Weighting and the Variability of Real Estate Returns: Implications for Portfolio Construction and Performance Evaluation. *Journal of Property Research*. 10: 167-183.

Morrell, G. D. 1997. *Property Risk and Portfolio Construction*. Paper Presented to the Sixth IPD Investment Strategies Conference, Brighton, 27-28 November 1997.

Schuck, E. J. and Brown, G. R. 1997. Value Weighting and Real Estate Portfolio Risk. *Journal of Property Research*. 14 (3): 169-187.

Sharpe, W. F. 1963. A Simplified Model for Portfolio Analysis. *Management Science*. 9 (2): 277-293.

Sharpe, W. F. 1964. Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *The Journal of Finance*. 19: 425-442.

Statman, M. 1987. How Many Stocks Make a Diversified Portfolio? *Journal of Financial and Quantitative Analysis*. 22: 353-363.

Young, M. S., Lee, S. L. and Devaney, S. P. 2006. Non-Normal Real Estate Return Distributions by Property Type in the U.K. *Journal of Property Research*. 23(2): 109-133