The Relationship Between Size, Diversification and Risk

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Abstract

Property portfolio diversification takes many forms, most of which can be associated with asset size. In other words larger property portfolios are assumed to have greater diversification potential than small portfolios. In addition, since greater diversification is generally associated with lower risk it is assumed that larger property portfolios will also have reduced return variability compared with smaller portfolios. If large property portfolios can simply be regarded as scaled-up, better-diversified versions of small property portfolios, then the greater a portfolio's asset size, the lower its risk. This suggests a negative relationship between asset size and risk. However, if large property portfolios are not simply scaled-up versions of small portfolios, the relationship between asset size and risk may be unclear. For instance, if large portfolios hold riskier assets or pursue more volatile investment strategies, it may be that a positive relationship between asset size and risk would be observed, even if large property portfolios are more diversified. This paper tests the empirical relationship between property portfolio size, diversification and risk, in Institutional portfolios in the UK, during the period from 1989 to 1999 to determine which of these two characterisations is more appropriate.

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1. Introduction

Property portfolio diversification takes many forms, most of which, for a number of reasons, can be associated with size. Larger property portfolios have better diversification opportunities than smaller property portfolios since they have access to a wider assortment of property types. Larger portfolios can access more geographical areas, both domestically and internationally. Larger portfolios can purchase properties in a greater variety of lot sizes than smaller portfolios. Finally it seems reasonable to assume that large portfolios will generally have more sophisticated portfolio analysis techniques applied to them and so be able, in principle, to pursue a more purposeful diversification strategy. It appears uncontroversial, therefore, to suggest that larger property portfolios have a greater potential to diversify than smaller property portfolios. In addition, since greater diversification is usually associated with lower risk, it is assumed that larger property portfolios will also have reduced variability of returns compared with smaller portfolios. Overall therefore, if large property portfolios can simply be regarded as scaled-up, better-diversified, versions of small property portfolios, then the greater a portfolio's size, the lower the risk. This suggests that a significantly positive relationship between size and diversification should be observed which then translates into a significantly negative relationship between size and risk. If however large property portfolios are not just scaled-up versions of small portfolios, these relationships may not hold. Indeed results based on actual property portfolio data show that although smaller property portfolios are "on average" more risky than larger portfolios, some small portfolios can show very low levels of risk, while some larger portfolios can display high levels of risk. In other words although larger property portfolios enjoy greater diversification *potential* this does not guarantee lower risk compared with smaller portfolios (Cullen, 1991, Morrell, 1997 and Byrne and Lee, 2000 and 2001). Thus although it seems reasonable to assume that larger property portfolios are merely scaled-up versions of smaller portfolios with greater diversification potential and consequently lower portfolio risk, in practice this may not be the case.

This paper tests the empirical relationship between property portfolio size, diversification and risk using the returns from 136 UK property portfolios over the period 1989 to 1999. The paper is structured as follows. Section 2 provides a brief review of the measures of diversification used in the study. Section 3 shows the results of an initial investigation of the relationship between size, diversification and risk and suggests that there may be important differences between the investment characteristics of large and small property funds. The next section discusses these differences. Section 5 empirically tests the relationship between size and risk after controlling for such differences. Section 6 examines whether changes in market conditions through the study period affected relationships between asset size and risk. Finally Section 7 summarises the findings, draws some conclusions, and suggests areas for further research.

2. Measuring Diversification

Sharpe (1966) shows that the return of an asset (*i*) can be expressed by the following regression equation linking its return to the return of a market index (*m*):

$$R_i = \alpha_i + \beta_i R_m + \varepsilon_i \qquad (1)$$

where: R_i is the return of the asset *i*; R_m is the return on the market portfolio; β_i is the index of the systematic risk of asset *i;* α_i , is the intercept coefficient and ε_i is a random error term, which has an expected value of zero.

In equation 1 the market index serves as a proxy for systematic factors affecting the returns on all assets. Since the residual vector (ε_i) is by construction uncorrelated with the returns on the market (m), the following variance decomposition holds:

$$Var(R_i) = \beta_i^2 Var(R_m) + Var(e_i) \qquad (2)$$

The left-hand side of equation 2 represents the variance or 'total risk' associated with the asset's returns. Equation 2 decomposes return variability into two components: $\beta_i^2 Var(R_m)$ which represents the variability of asset (*i*) return that stems from systematic factors; while $Var(e_i)$ represents the return variability specific to the asset (the asset's return variability associated with market influences is referred to as systematic risk and that which is unique to the investment itself, is termed specific risk). The ratio of systematic risk to total risk measures the amount of variability in asset returns explained by the market index. It can be estimated by R^2 (the coefficient of determination) and provides a convenient measure of diversification, (Barnea and Logue, 1973). Barnea and Logue (1973) used the market model R^2 statistic to measure industrial diversification of conglomerate corporations, arguing that it "mirrors the diversity of the economy and the relative importance attaching to each segment of the firm's activities within the context of the whole economy". The Barnea and Logue approach was subsequently adopted in several other studies of conglomerate diversification (Amihud and Lev, 1981, Amihud, Kamin and Ronen, 1983, and Roll, 1988). In the present paper the R^2 statistic has a broader applicability. Here, R^2 provides a convenient way to measure the role of diversification in explaining the relationship between size and risk in property portfolios.

To explain this, consider a hypothetical example. Suppose two property portfolios have similar levels of total risk, but the first portfolio's risk is predominately specific. It would be reasonable to believe that the first portfolio is less diversified than the second. In addition it could be also suggested that if the first portfolio were to increase its diversification (for example, by expanding the range of its holdings across more sectors or regions), then its specific risk would decrease. With no concurrent increase in systematic risk, the overall total risk of the portfolio would decrease by the same amount. Because a poorly diversified property portfolio is subject to shocks originating from sector, regional, or other types of concentration of holding, it is likely to display a large amount of specific risk - risk that a well-diversified portfolio is much more likely to avoid. However, diversification cannot help a well-diversified portfolio eliminate systematic risk since this risk is related to broad underlying economic conditions affecting the (property) market as a whole.

It follows that if large property portfolios are just scaled-up, better diversified versions of smaller property portfolios, then the greater a portfolio's size, the lower its specific risk. Since diversification only reduces specific risk, however, no relationship between size and systematic risk should be observed. Consequently, the end result would be an inverse relationship between size and total risk.

If large property portfolios are not scaled-up versions of small portfolios, these relationships may not hold. For instance, if large funds for some reason hold riskier assets or pursue risk-enhancing investment strategies, it may be that a positive relationship between size and either of the two components of total risk would be observed, even if large property portfolios are more diversified. The relationship between size and total risk would then be ambiguous.

Indeed in a recent study of 52 Real Estate Investment Trusts (REITs) in the US, Gyourko and Nelling (1996) find a significant positive relationship between the market measure of diversification (R^2) and firm's size, and a significantly negative relationship between total risk and size. Large REITs have significantly lower total risk but significantly higher systematic risk than smaller REITs. However, as argued above this should not be the case if large REITs are simply scaled-up, more diversified, property companies than smaller REITs.

In summary two possible property portfolio characterisations are identified. Larger portfolios could be scaled-up, better-diversified versions of smaller portfolios and so larger portfolios should have lower total risk. Alternatively, larger portfolios are somehow essentially different from smaller portfolios and so do not necessarily display lower total risk with increasing portfolio size. In order to determine which of the two characterisations is more appropriate, the next section uses the R^2 statistic as the measure of diversification to empirically test the relationship between property portfolio size, diversification and risk.

3. Diversification, Size and Risk

This section investigates the relationship between diversification, size and risk for a sample of 136 UK property portfolios from the Investment Property Databank (IPD) (see Acknowledgement). Using annual data, IPD computed the total risk (standard deviation); the portfolio Beta; and the R^2 for the 136 funds with continuous return histories from 1989 to 1999. The returns relate to standing investments only; i.e. transactions and developments were excluded. From these statistics and using equation 2, the systematic and specific risk of each fund could then be calculated. These results, together with a number of investment characteristics for each fund grouping discussed below, were provided by IPD. In order to maintain confidentiality and so that no individual fund can be identified from the data, each fund was placed in one of five classes (quintiles) based on the size of the fund in 1989 (see Table A in the Appendix).

Using these data Table 1 shows the empirical relationship between size, R^2, and the various measures of risk. Contrary to the expectations of portfolio theory, as size increases so does total return variability. Although initially as size increases there is a slight fall in total risk, in general as size increases total risk increases! In fact there is a statistically significant difference between the total risks of the highest and lowest groups at the 3% level.

Table 1: Average (Median) Total, Systematic and Specific Risk and R^2

Average	Fund G1 %	Fund G2 %	Fund G3 %	Fund G4 %	Fund G5 %
Total Risk	9.37	9.37	8.53	10.26	10.02
Systematic Risk	7.98	8.33	7.50	9.34	9.04
Specific Risk	1.21	1.36	0.71	0.70	0.70
R^2	0.76	0.71	0.84	0.87	0.87

Table 1 also shows the relationship between size and the two components of total risk: systematic and specific risk. Systematic risk increases, falls, rises again and continues to rise, i.e. once size exceeds an average of £50m there is a positive relationship between size and systematic risk. In a similar way specific risk rises then falls and declines with increasing size once size exceeds an average of £50m. Finally, Table 1 shows the relationship between R^2 and size. As size increases so does R^2 and reaches a peak of about 87 percent on average in quintiles four and five, with an overall average of 78 percent. Using similar data for 162 property funds over the period 1987 to 1996 Morrell (1997) finds that the overall specific risk declines as systematic risk increases with size with an average of 81 percent. The patterns illustrated in Table 1 provide empirical support for the classic view that size enhances diversification, since fund-specific risk makes a smaller contribution to total risk for funds in the top quintile. Fund-specific risk makes a bigger contribution to total risk at the small fund level than for the largest funds. The percentage of specific risk falls from 28 percent to 16 percent as size increases. However, size also appears to induce funds to hold certain properties or invest in certain segments of the market that increase the total risk of the fund. Indeed the systematic risk increases by 16 percent as size increases from funds with assets of less than an average of £19m to those with assets of £1224m on average.

Since specific risk declines with increased size, this implies that size enhances diversification within property portfolios. However, portfolio size is positively associated with increased systematic risk, suggesting that large portfolios have an increasing propensity to invest in certain risky assets or following riskier investment strategies. Thus the difference in total risk shown in Table 1 is a consequence of the counterbalancing effects of increasing systematic risk and reducing specific risk associated with enlarged portfolio size. This lends support to the contention that large property portfolios cannot be classified simply as re-scaled, better-diversified, versions of smaller portfolios.

In order to explore the relationships between size and diversification, Table 2 presents the correlation between size, R^2 and the various measures of risk. To avoid any potential simultaneity problem, size is measured at the beginning of the period of analysis[1]. Using the Pearson correlation coefficient, the correlation between size and R^2 is 0.372, which is significant at better than the 1% level, confirming the results of Gyourko and Nelling (1996). The significance of the relationship between R^2 and size was also tested using the Spearman rank correlation method to avoid any potential bias because of extreme values in the data. The computed rank correlation coefficient (0.435) confirms the Pearson correlation coefficient, and suggests that the relationship between size and R^2 is both strong and robust.

However, the finding that size and R^2 are positively related leaves unanswered the question whether increased size results in low total risk. Column 3 of Table 2, using both the Pearson and Spearman correlation coefficients, shows that size and total risk are not negatively related. There is no evidence that size is associated with lower risk. Indeed the opposite is the case as there is a significantly positive relationship between size and risk at the 5% level.

[1] For instance, an abnormally strong performance by a set of property funds may lead to a spurious negative relationship between size and R^2 if the strong performance promotes asset growth.

Table 2: The Correlation Relationship between Size, R-squared and Risk

Correlation	R^2	Risk Total	Risk Systematic	Risk Specific
Pearson	0.372	0.182	0.333	-0.383
Spearman	0.435	0.195	0.357	-0.374

Note: The correlations are all significant at the 5% level.

The fourth and fifth columns of Table 2 show the correlation between size and the two components of total risk. The Pearson's correlation coefficient in column 4 shows that systematic risk is significantly positively related to size, which is not predicted by portfolio theory. In contrast there is a significant negative relationship between size and specific risk, as is to be expected. These significant relationships are confirmed using the Spearman correlation coefficient. These counterbalancing relationships are consistent with the positive relationship between size and diversification and the incongruous result that large funds are *more* risky than small funds.

The results in Table 2 have two implications. First, whilst larger property funds appear more diversified, that is they display a larger R^2 value than smaller funds, they also appear to have higher levels of systematic risk. Second, he results suggest that larger property funds cannot be characterised as scaled-up, better diversified, versions of smaller property funds. If larger funds were nothing more than re-scaled versions of smaller funds, portfolio theory suggests that larger property funds should display lower specific risk than smaller funds, but have similar levels of systematic risk. The results here confirm the predicted negative relationship between fund-specific risk and size but display the counter-intuitive result of a significant positive relationship between systematic risk and fund size. Large property portfolios are likely to be different to smaller portfolios in their asset holdings and investment structures. It may be however that the increased systematic risk associated with larger property funds is simply a by-product of these differences in investment holdings and/or asset characteristics of larger property funds. The next section explores this hypothesis.

4. Portfolio Structure, Size and Risk

In order to investigate any differences in investment asset structure between large and small funds, data were provided on fund's holdings in 11 market segments, as used by IPD to analyse portfolio performance. The 11 segments split the market into six property types and five broadly defined regions. At first sight such a classification scheme would seem to be too widely drawn to be of much practical benefit in analysing performance. However, Frodsham and Key (1996) find that these segments closely track the most comprehensive sector/regional classification that IPD has been able to devise for performance analysis. Thus the 11 market segments offer an easy way to identify the investment characteristics of the funds of various sizes.

It is clear from Table 3 that there are significant differences in the median asset holdings of funds in the top quintile compared with those funds in the lowest quintile. In particular the largest funds typically have a significantly higher percentage of their funds in the Office market, especially in Central London. Larger funds also hold a significant amount in Shopping Centres. In contrast smaller funds hold greater percentages of high street Shops and Industrial properties. Consequently it is not surprising to see funds of a different size display different risk profiles.

Tables 1 and 2 suggest that large property funds are more diversified than smaller funds. Such diversification will generally come from portfolio spread across the market segments. In order to capture a measure of spread in property holdings across the market segments a Herfindahl-type index of diversification was calculated; see Gyourko and Nelling (1996). The Herfindahl index is shown in equation 3.

$$H = \sum_{i=1}^{n} w_i^2 \qquad (3)$$

where n is the number of market segments and w_i is the fraction of the fund's asset holdings in segment *i*. The values of the Herfindahl index lie between 1 and 1/n. So, for example, if a property fund holds all its assets in one segment the Herfindahl Index is equal to one. In contrast if the fund has equal amounts in each of the 11 segments, i.e. the fund follows a naï ve diversification strategy, the Herfindahl index would equal 0.09. Using this index it is clear that smaller property funds are less diversified than larger funds. This matches the results in Table 2, which uses the market model R^2 to quantify the amount of diversification in the funds.

Table 3: Asset Structures of Typical Large and Small Funds

Investment Characteristics	Typical Small	Typical Large	Difference
Market Segments %			
SE Retail	21.30	9.77	-11.53
Rest of UK Retail	18.46	7.76	-10.70
Shopping Centres	0.97	13.82	12.85
Retail Warehouses	2.53	2.55	0.02*
City Offices	1.46	16.32	14.86
W.E. Offices	7.94	18.19	10.25
SE Offices	20.65	13.14	-7.51
Rest of UK Offices	8.01	4.97	-3.03*
SE Industrials	11.97	8.01	-3.96
Rest of UK Industrials	5.53	2.47	-3.06
Other	1.18	3.00	1.81*
Herfindahl Index	0.27	0.17	-0.10
Property Size £m	1.33	6.19	4.86
Beta	0.88	1.01	0.13

Note: There is a significant difference in the characteristics of the typical large and small funds at greater than the 5% level except for those marked *

Table 3 also shows that as the fund size increases, the Beta of the fund tends towards the market average of one. Indeed there is a significant correlation (0.257) between size and Beta. Gyourko and Nelling (1996) also find a significantly positive relationship between REIT Betas and size. They attribute this to the greater capacity of larger REITs to access the debt market compared with smaller REITs. Larger REITs are able to use greater amounts of debt compared with smaller REITs and so have greater leverage and hence higher Beta risk. In this case the significantly higher Beta value of property funds in the top quintile compared with that of funds in the lowest quintile cannot reflect differences in leverage and is probably best attributed to the ability of bigger funds to hold large lot size properties, particularly

Offices. In contrast the smaller funds hold a significantly greater proportion of their investments in the Retail sector. These differences in holdings can have a profound affect on the overall Beta of the portfolio. Byrne and Lee (1999) found that the largest proportion of low Beta properties is in the Retail sector. In contrast the high Beta properties were concentrated in the Office and Industrial sectors (see also Table B in the Appendix). More importantly studies by Miller and Scholes (1972) and Klemkosky and Martin (1975) in the equity market indicate that Beta and specific risk are positively related. This suggests that a high Beta risk portfolio is likely to require a greater number of securities than a low Beta risk portfolio to achieve the same level of risk reduction. The simulation results of Byrne and Lee (1999) show that this is the case in the property market. Indeed in some cases the high Beta portfolio never achieved a reduction in specific risk down that of the low Beta portfolios. Consequently high Beta portfolios will show higher levels of total risk than low Beta portfolios with the same number of properties.

Larger funds typically hold properties of a larger lot size than funds in the lowest quintile. This is presumably a consequence of their holdings in the Office market, especially in Central London, and their holdings in Shopping Centres. Again this is likely to lead to larger funds displaying differences in risk characteristics when compared with smaller funds. Ziering and McIntosh (1999) for example, comparing the performance of large (or trophy) properties with that of smaller sized properties in the US, find that lot size has a profound affect on performance. Conventional wisdom would seem to suggest that large size properties will display more stable returns than smaller properties because of better locations, more creditworthy tenants and the premium associated with trophy status. Ziering and McIntosh (1999) find, however, that whilst properties in the highest size category provide the highest returns in the long run, such properties also display the greatest volatility. More importantly trophy buildings performed particularly badly in the property market recession. Consequently property funds which show a skewed distribution towards larger lot size properties will display higher levels of risk.

The overall picture that emerges from Tables 1, 2 and 3 is that larger funds have different risk characteristics when compared with smaller funds, and that these differences can be attributed to the disparate asset structures of the funds. These differences between the investment activities of large and small portfolio managers may be masking the risk-reducing effects that increased size has on specific risk, and which would expected if the big property portfolios *were* simply better-diversified, scaled-up versions of smaller portfolios. Hence, when analysing the impact of size on risk like is not really being compared with like. These differences in asset structures between large and small funds need to be accounted for. The following section investigates this issue in more depth.

5. The Empirical Relationship between Diversification, Size and Risk

This section examines the differences in the asset characteristics of large and small property portfolios to try to account for the anomalous results between diversification, size and risk identified in the previous section. The forms of analysis are multiple regressions of both systematic and specific risk against size and a series of variables describing the portfolio investment structure of the funds. The following regressions are estimated:

$$\mathrm{Log}(\text{Systematic Risk}_i) = \alpha_i + \beta_i \log(\text{Size}_i) + \gamma_i \sum_{i=1}^{n} X_i + \varepsilon_i \quad (4)$$

$$\mathrm{Log}(\text{Specific Risk}_i) = \alpha_i + \beta_i \log(\text{Size}_i) + \gamma_i \sum_{i=1}^{n} X_i + \varepsilon_i \quad (5)$$

where Size is the actual size[2] of fund *i*; α_i, β_i and γ_i are the regression coefficients to be estimated and X_i is a vector of investment characteristics. To avoid any potentially spurious relationships between the variables both size and the investment control characteristics are measured at the beginning of the period of analysis. This timing convention ensures hat the direction of causality flows from size and the set of control variables X to the dependent variable.

The purpose of these regressions is to determine how portfolio size is related to the two components of total risk *after* controlling for any investment differences between large and small property portfolios included in the control vector X. In particular the aim is to see if the coefficient between systematic risk and size remains significantly positive after including the portfolio investment attributes. The regression examines the extent to which the elements of X help to explain the puzzling positive correlation between systematic risk and size illustrated above, in that although portfolio theory predicts a significant and negative relationship between size and specific risk, increased size should have no impact on systematic risk.

[2] In this case the actual size, rather than the asset class, was used in order to make the interpretation of the regression coefficients meaningful. In order to maintain confidentiality all calculations were performed by IPD from the specifications in equations 4 and 5.

Table 4: Regression of Fund Systematic and Specific Risk on Asset Size and Fund Investment Characteristics.

Dependent variable:	**Log (Systematic Risk)**		**Log (Specific Risk)**	
	Without Controls	With Controls	Without Controls	With Controls
Constant	1.863 (29.208)**	1.569 (3.058)	0.812 (4.042)**	2.534 (1.450)
Log(Size)	0.052 (4.086)**	-0.007 (0.252)	-0.191 (4.796)**	-0.224 (2.546)**
SE Retail		0.010 (1.891)**		-0.028 (1.598)
Rest of UK Retail		0.003 (0.545)		-0.023 (1.283)
Shopping Centres		0.006 (1.068)		-0.010 (0.504)
Retail Warehouses		-0.004 (0.712)		-0.012 (0.541)
City Offices		0.007 (1.404)		-0.013 (0.728)
West End Offices		0.010 (1.848)*		-0.019 (1.053)
SE Offices		0.004 (0.835)		-0.017 (0.966)
Rest of UK Offices		0.003 (0.593)		-0.011 (0.606)
SE Industrials		0.006 (1.177)		-0.014 (0.797)
Rest of UK Industrials		0.005 (0.675)		-0.004 (0.185)
Herfindahl Index		-0.293 (1.006)		0.904 (0.910)
Property Size £m		0.070 (1.343)		-0.030 (0.170)
Adjusted R-squared	10.42%	23.77%	14.01%	14.35%

Note: * indicates significant at the 10% level, ** indicates significant at the 5% level

Table 4 contains the results from estimating equations 4 and 5[3]. Columns (2) and (3) present the estimated regression coefficients and t-statistics in parentheses when systematic risk is the dependent variable; columns (4) and (5) show the results when the dependent variable is specific risk. Columns (2) and (4) present the results when size is the only explanatory variable, while columns (3) and (5) presents the results of size after including the fund size control variables. The results in table 4 show quite clearly that once the investment attributes of the various funds are accounted for, size displays the relationship with each component of risk that is predicted by portfolio theory. The coefficient of the

[3] When running the regressions, in order to avoid the problem of multicollinearity associated with the market segment data which sums to 100%, one of the segments needed to be dropped from the analysis. The segment removed was "Other" which typically represents less than 2% of fund investment.

relationship between size and systematic risk becomes insignificant when the fund's investment characteristics are included in the regression, with a significant increase in adjusted r-squared from 10 to 24 percent. In contrast the coefficient between size and specific risk displays a significantly negative relationship in both specifications, i.e. including or excluding the fund control variables.

In comparing the results in columns (2) and (3) with those of columns (4) and (5), it is evident that controlling for differences in fund investment structure leads to a reduction in the magnitude of the positive size coefficient in the systematic risk regression and a increase in the magnitude of the size coefficient in the specific risk regression. The size coefficient is reduced from 0.052 to -0.007 in the systematic risk regression, and from -0.191 to -0.224 in the specific risk regression. The size coefficients are, on average, biased upwards when the fund investment control variables are omitted from the regressions. This is due to the difference in the investment characteristics of large funds, which increase both their systematic and specific risk levels. These increases in risk offset the potential for risk reduction associated with the enhanced diversification benefits accruing to larger funds.

The results explain the counter-intuitive unconditional correlations between size and the components of risk shown in Table 2. Portfolio theory would suggest that, holding fund investment attributes constant, an increase in size should reduce specific risk. Consistent with this, these results imply that larger funds have lower levels of specific risk than smaller funds after controlling for differences in investment structure, the extent of diversification and the average property size. In fact the results show that large property funds achieve economically important reductions in risk through diversification. Doubling the size of a property fund would lead to a 22.4 percent reduction in specific risk. Portfolio theory also suggests that an increase in size should have no direct impact on systematic risk, again after holding investment characteristics constant. The results in Table 4 are consistent with this since the coefficient of size is insignificantly different from zero, once investment characteristics are taken into account.

Comparing the results in Table 3 with those in Table 4 it becomes clear why larger funds exhibit greater systematic risk than smaller funds. It is obvious from Table 3 that larger funds hold significantly more of their investment holdings in The City and West End Office markets. Unfortunately these two segments had the highest levels of risk of all the market segments analysed, (IPD, 2000) (see Table 8). Larger funds also held significantly less in the South East Retail sector, the market segment with the least variability and lowest Beta value. As a consequence the effect of size on systematic risk is overstated when these variables are omitted from the regression.

Not all the characteristics of large funds are risk-enhancing. In particular larger funds are able to spread their investments more evenly across a wider variety of market segments and property types. This is shown by the Herfindahl-type index of the funds in the top quintile which is significantly lower (showing greater diversification) compared with the figure for bottom quintile. In the top quintile, 86 percent of the funds were represented in 9 out of the 11 segments. In contrast, of the funds in the lowest quintile, only one fund had holdings in nine segments, and more than 60 percent had holdings in six segments or less. Thus a fund that increases its spread of holdings across a wider range of market segments should see an increase in diversification and a reduction in specific risk without any increase in systematic risk and will see total risk fall. Diversification works in reducing risk!

6. Changes in the Relationship Between Asset Size and Risk

The results above may, however, be time dependent because the data used cover one of the most turbulent periods in the UK property market and return volatility was severely overstated. For example, the largest property funds traditionally have had large weightings in the Central London Office market, a bias that worked well in the late 1980's boom, but proved ruinous in the crash of the early 1990's. It would be interesting therefore to see if the results changed during a period of greater calm in the market when differences in portfolio composition should have little impact on portfolio risk. Further analysis could also investigate whether there was a convergence in the portfolio composition of large and small funds over the 1990s. Such a convergence is logical as fund managers try persistently to match the benchmark's asset structure in attempting to reduce tracking error risk. IPD suggests that this process has already begun with the largest funds decreasing their holdings in Central London Offices and reallocated the funds into Shopping Centres and Business/Retail parks (Estates Gazette, 1998). As a result the performance of such funds need not be so dependent on a few trophy buildings in the most volatile region. This being so, then the risk-enhancing features observed in Tables 1, 2 and 3 will have been reduced, if not eliminated altogether, and the need to control for such differences in assessing the impact of size on the two measures of risk will not be necessary. In order to see if the counter-intuitive relationship between asset size, diversification and risk identified above continued to exist into the 1990s the analysis was repeated for the period 1994-1999[4].

Table 5 shows the empirical relationship between property funds' asset size, the various measures of risk and the market measure of diversification (R^2). Table 5, when compared with Table 1 shows that by 1994 the average total risk for all funds had fallen significantly, especially for the largest funds, the largest funds still showing less, but now insignificantly less, total risk than smaller funds. Asset size now displays an inverse but insignificant relationship with total risk based on correlation analysis results[5]. Furthermore although systematic risk shows a slight increase with increases in fund size the result is not significant, again based on correlation analysis. In contrast specific risk falls significantly as fund size increases, with a Pearson correlation coefficient of -0.236 between size and specific risk. However, the R^2 statistics show that smaller property funds appear less diversified than in 1989. Nonetheless the overall level of diversification between 1989 and 1994 is approximately the same. It is evident that the risk-reducing benefits of diversification now affect the total risk of all property funds. Indeed by 1994, Table 5 shows that the unconditional relationships between size, diversification and risk are consistent with MPT. Consequently it is unlikely that the inclusion of the control variables will be required in testing for the relationships between size and the two components of risk.

[4] The sample used consists of the original 136 property funds. It was possible to increase the sample size for this period by an additional 44 funds, making a total of 170 property funds. This extended sample includes funds which had only recently joined the IPD database and so could not be included in the eleven year analysis. A comparison of the performance of the two samples showed that they were essentially the same, and so the original 136 were used here.

[5] The results are not shown here but can be obtained from the authors.

Table 5: Average (Median) Total, Systematic, Specific Risk and R^2 1994 - 1999

Average	Fund G1 %	Fund G2 %	Fund G3 %	Fund G4 %	Fund G5 %
Total Risk	5.59	5.06	4.98	4.81	4.88
Systematic Risk	4.24	4.22	4.13	4.21	4.37
Specific Risk	1.03	0.76	0.75	0.57	0.39
R-squared	0.67	0.76	0.69	0.79	0.86

Note: The classification of common sample of funds into the five groups uses their 1989 asset size values

The regression results in Table 6 show that even without the control variables the relationships between asset size and the two components of risk (systematic and specific) now show the relationships predicted by MPT. There is no association between size and systematic risk and the relationship between size and specific risk shows that doubling the size of the fund leads to a significant reduction in risk of just over 15 per cent.

Table 6: Regression of Fund Systematic and Specific Risk on Asset Size and Fund Investment Characteristics: 1994 - 1999

Dependent variable:	Log(Systematic Risk)	Log(Specific Risk)
Constant	1.406	0.177
	(10.778)	(0.571)
Log(Size)	-0.002	-0.151
	(0.077)	(2.448)*
Adjusted R-square	-0.07%	3.56%

Note: * indicates significant at better than the 1% level.

Why is this? As seen above in Table 3 larger funds showed significantly different investment characteristics than smaller property funds. One possibility, which may explain this convergence in total risk across the funds, is that the differences observed in portfolio holdings between property funds of differing sizes have been reduced, so that the riskiness between property funds of differing sizes of the property funds would be eliminated. An alternative proposition is that property funds of differing sizes have maintained their differences in portfolio structure but that there has been a change in the relative riskiness of the market segments, especially if there has been a regression to the mean. If high risk segments have become less risky while lower risk segments have become more risky, even if the differences in segment holdings between large and smaller property funds are maintained, there will be a convergence in risk across funds. A third possibility is that both processes have occurred with even greater convergence of risk levels across the sample.

Table 7 shows that the first contention cannot be accepted readily because small and large funds still show significant differences in their holdings in all sectors[6]. Larger funds still hold significantly more in the Office and Shopping Centres market segments and significantly less in the Retail, Industrial and Retail Warehouse sectors. However, there has been a number of notable changes in investment holdings between 1989 and 1994. Smaller funds, by 1994,

[6] The average (mean) asset holdings are shown here rather than the median figures so that percentage changes can be computed, something that would be impossible given the zero holdings shown in Table 3 for small funds in 1989.

held considerably less in South East Retail but slightly more in the Rest of the UK. In contrast holdings in the Retail Warehouses sector tripled and holdings in Industrials in the Rest of the UK more than doubled. The smallest funds reduced their holdings in the Office sector, especially in the West End, by more than 50%. As a consequence of these changes smaller funds are much more evenly spread across the country resulting in a significantly lower Herfindahl index. This confirms the significant relationship in Table 5 between diversification as measured by R^2 and asset size. As with the smallest funds the larger funds also reduced their holdings in the Central London Office market, the largest funds reducing their holdings in the City by 40% and in the West End by 35%. The monies were reallocated to the Retail Warehouses and Shopping Centres sectors. The largest funds doubled their exposure to Retail Warehouses and increased their holding in the large lot size Shopping Centres segment by 40%. As a result there is little change in the average lot size or portfolio spread (Herfindahl index). Thus it seems that the reduction in total risk by 1994 and the alignment of the relationship between size, diversification and risk on the path predicted by portfolio theory must have an alternative explanation.

Table 7: The Mean Asset Structures of Small and Large Property Funds 1989 and 1994

Investment	89		94		% Change	
Characteristics	Small	Large	Small	Large	Small	Large
SE Retail	21.3	9.8	16.8	8.4	-21.3	-14.0
Rest of UK Retail	18.5	7.8	20.7	8.7	12.1	11.7
Shopping Centres	1.0	13.8	0.5	19.5	-49.5	41.4
Retail Warehouses	2.5	2.6	9.6	5.5	279.1	114.5
City Offices	1.5	16.3	2.0	9.9	39.7	-39.6
W.E. Offices	7.9	18.2	3.5	11.9	-55.5	-34.8
SE Offices	20.7	13.1	16.4	12.8	-20.5	-2.9
Rest of UK Offices	8.0	5.0	7.0	7.0	-12.2	41.4
SE Industrials	12.0	8.0	11.6	8.3	-2.8	3.7
Rest of UK Industrials	5.5	2.5	11.7	4.3	111.2	75.7
Other	1.2	3.0	0.1	3.8	-92.4	26.3
Herfindahl Index	0.3	0.2	0.2	0.2	-22.2	-5.9
Property Size £m	1.3	6.2	1.3	5.8	-1.5	-6.3

Note: The classification of funds into the two groups uses their 1989 asset size values.

A more likely explanation seems to be the convergence in market segment risk. Table 8 shows the riskiness of the IPD market segments over the periods 1989 to 1999 and 1994 to 1999. It is clear from this table that there was a considerable reduction in the total risk (standard deviation) of the market segments as a whole. The standard deviation is down from a simple average of over 9% per annum to less than 1% per annum. These changes in total risk levels are accompanied by noticeable shifts in systematic (Beta) risk across the market segments. Most noticeable is the substantial reduction in risk of the Office market segments. From being the most risky segments in 1989 Offices in London, especially City Offices, became the one of the least risky segments by 1994. This is true for both systematic risk (Beta) and total risk (standard deviation). In contrast, although the Retail sector as a whole shows a fall in total risk along with the market in general, the sector also shows an increase in market risk, especially in the South East. In particular it appears there as been a 'regression to the mean' across the market segments, with the high risk sectors showing falls in risk while the least risky segments show increases. Consequently, although larger funds reduced their holdings in the Office sector and increased their holdings in the

Retail sector, because they still hold a greater weight of their portfolios in the Office sector than smaller funds the average risk of the largest funds should now be less than that of the smallest funds. At the same time larger funds still show greater levels of diversification (as measured by R^2 and the Herfindahl Index) consequently they also should display lower levels of specific risk than smaller funds, as shown in Table 5. The counter-intuitive results displayed in Tables 1-2 are eliminated by the convergence of risk levels within the property market rather than a convergence in portfolio holdings between property funds of a different size.

Table 8: The Risk of the IPD Market Segments 1989 and 1994

	Standard Deviation		Beta	
	89	94	89	94
SE Retail	8.38	4.76	0.88	1.06
Rest of UK Retail	7.53	4.53	0.74	1.01
Shopping Centres	7.83	3.96	0.80	0.88
Retail Warehouses	11.97	6.20	0.94	1.06
City Offices	12.38	3.81	1.26	0.78
W.E. Offices	13.86	4.75	1.42	1.05
SE Offices	10.39	5.77	1.09	1.22
Rest of UK Offices	9.63	4.67	0.72	0.79
SE Industrials	9.84	6.26	0.94	1.33
Rest of UK Industrials	9.06	4.48	0.65	0.93
Other	7.58	3.18	0.64	-0.15

7. Conclusion

This paper has focused on the empirical relationship between asset size, the level of diversification and the portfolio risk of UK property portfolios. Using a conceptually sound measure of overall portfolio diversification (R^2) it has been shown that a significantly positive correlation between size and diversification does not necessarily translate into a negative correlation between size and risk. Indeed, using a sample of 136 property funds with eleven years of data once total risk is decomposed into its two components (systematic and specific risk) the data show that size is negatively related to specific risk but positively related to systematic risk. This result runs counter to portfolio theory that predicts that only specific risk is affected by portfolio size and thus explains the lack of association between size and portfolio variance. In addition it implies that large property portfolios cannot be classified as scaled-up versions of smaller portfolios. However, once the investment differences between large and small portfolios are controlled for the positive relationship between size and systematic risk is eliminated while that between size and specific risk is strengthened.

Using data from a less turbulent period for the property market shows that the considerable fall in risk for the market segments has lead to a convergence in total risk between the largest and smallest funds even though the two groups still point up considerable differences in portfolio composition. At the same time larger funds show significantly less specific risk than smaller funds because of their greater levels of diversification but similar levels of systematic risk. The relationships between asset size, diversification and risk predicted by modern portfolio theory are now demonstrated without the need to control for any differences between funds. In fact the analysis shows that increasing portfolio size may lead to a larger reduction in specific risk than previous studies have identified, with the proviso that this increase is not accompanied by other risk-enhancing activities.

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References

Amihud, Y. and Lev, B. (1981) Risk Reduction as a Managerial Motive for Conglomerate Mergers, *Bell Journal of Economics*, **12**, 605-617.

Amihud, Y., Kamin, J.Y. and Rosen, K. (1983) Managerialism, Ownership and Risk, *Journal of Banking and Finance*, **7**, 189-196.

Barnea, A. and Logue, D.E. (1973) Stock-Market Based Measures of Corporate Diversification, *Journal of Industrial Economics*, 51-60.

Byrne, P.J. and Lee, S.L. (1999) *On the Process of Risk Reduction in the UK Real Estate Market*, A Paper presented at the RICS Cutting Edge Research Conference, Cambridge, September.

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

Byrne, P.J. and Lee, S.L. (2001) Risk Reduction and Real Estate Portfolio Size, *Managerial and Decision Economics*, forthcoming.

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

Estates Gazette (1998) *Escape from the Hothouse*, July 14, 61.

Frodsham, M. and Key, T. (1996) *Market Segments & the Analysis of Property Portfolio Performance.* A Paper presented at the European Real Estate Society Conference, Belfast, June.

Gyourko, J. and Nelling, E. (1996) Systematic Risk and Diversification in the Equity REIT Market, *Real Estate Economics*, **24**, 4, 493-515.

Investment Property Databank (2000) *IPD Property Investment Digest*.

Klemkosky, R.C. and Martin, J. (1975) The Effect of Market Risk on Portfolio Diversification, *Journal of Finance*, **30**, March, 147-154.

Miller, M.H. and Scholes, M. (1972) Rates of Return in Relation to Risk: A Re-examination of Some Recent Findings, in M.C. Jensen, ed., *Studies in the Theory of Capital Markets*, Praeger, New York, 60-62.

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

Roll, R. (1988) R^2, *Journal of Finance*, **63**, 541-566.

Sharpe, W.F. (1966) A Simplified Model for Portfolio Analysis, *Management Science*, **9**, 2, 277-293.

Ziering, B. and McIntosh, W. (1999) Property Size and Risk: Why Bigger is not Always Better, *Journal of Real Estate Portfolio Management*, **5**, 1, 105-112.

Appendix

Table A: Fund Groupings: Size Statistics £m

Fund Group Size £m	Fund Group 1	Fund Group 2	Fund Group 3	Fund Group 4	Fund Group 5
Average	19.18	50.15	124.70	321.42	1224.64
Median	18.00	49.52	114.80	300.83	802.99
SD	9.36	11.07	46.56	80.11	969.61
Number of Funds	28	27	27	27	27