Risk Reduction and Real Estate Portfolio Size

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There is remarkably little empirical evidence of the advantages of increased size on risk levels in real estate portfolios based on actual portfolios. This paper improves this by examining the portfolio risk of a large sample of actual real estate data in the UK over the period from 1981 to 1996. The results show that real estate portfolios of larger sizes tend, on average, to have lower risks than smaller sized portfolios and, more importantly, that portfolios with only a few assets can have very high or very low risk. For fund managers to be confident that their portfolio will have a risk level like the average, they need to hold portfolios of a considerably greater size than they might expect, or can sensibly acquire. Previous studies suggesting that only 20–40 properties are needed to reduce the risk of a property portfolio down to the market level are a significant underestimate. The actual figure is likely to be 400–500 properties, well above that of even the largest fund in the UK. Size alone does not necessarily lead to a reduction in portfolio risk. Other factors are of greater importance. Copyright © 2001 John Wiley & Sons, Ltd.

INTRODUCTION

The investigation of the impact that portfolio size has on risk (volatility) is of continuing interest in real estate markets (see Byrne and Lee, 2000 for a review). The general approach uses the returns from a sample of properties and then simulates portfolios of various sizes, usually with equal weighting, and then calculates the average level of risk for each portfolio size. The averaged results by and large indicate that an increase in portfolio size is accompanied by a reduction in portfolio volatility, and that most of the reduction occurs within the first 20–40 properties, after which any fall in risk level is marginal. The advice to an investor from these averaged simulation results is that they only need to hold a portfolio containing relatively few properties.

It can be argued that this general approach is deficient because an individual investor owns only one portfolio, and results based on a more global average are not really relevant to his/her particular case, which may be substantially different from the average. Indeed, a few studies have alluded to the fact that the simulations themselves display a good deal of variability around the mean portfolio risk level (Barber, 1991; Cullen, 1991; Byrne and Lee, 2000). This is especially so for portfolios of a small size. Thus, investors who have relied on the previous studies based on average portfolio results can have little confidence that their portfolio will display the same level of portfolio risk as that suggested by averaged results. In addition, studies based on equal-weighted simulations may be felt to be irrelevant to real estate portfolios, which are typically value-weighted. Indeed the work of Morrell (1993b), Schuck and Brown (1997) and Byrne and Lee (2000) suggests that value-weighted portfolios are sub-optimal because the portfolios have a higher total risk by comparison with equal-weighted portfolios. Simulations, even value weighted, probably seem unrealistic to most practitioners. Results from actual data would be desirable but

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there is remarkably little empirical evidence based on actual property portfolios. The few studies in the UK that have used the returns from actual portfolios (Cullen, 1991; Morrell, 1993a, 1997) suggest that the amount of risk reduction in real estate portfolios is limited, and that a large level of variability exists around the mean portfolio risk level, especially for small sized portfolios. The objective of this paper is to extend this analysis further by studying the affect of portfolio size on risk reduction using actual property data over the period from 1981 to 1996.

RISK REDUCTION

Markowitz (1952) showed that the variance of a portfolio of n assets is given by:

$$\sigma_P^2 = \sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_i \sigma_j \rho_{ij}, \quad j \neq i \qquad (1)$$

where σ_p^2 = portfolio variance, σ_i^2 = the variance of asset i; $\rho_{i,j}$ = the correlation between assets i and j; n = the number of assets.

Equation (1), in the special case where σ_i equals the average standard deviation $\bar{\sigma}$ and $\rho_{i,j}$ equals the average correlation coefficient $\bar{\rho}$ for all i, becomes:

$$\sigma_P^2 = \sum_{i=1}^{n} w_i^2 \bar{\sigma}^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \bar{\sigma}^2 \bar{\rho}, \quad j \neq i \qquad (2)$$

It will be noted that for any given w_i, the sum of all w_i for $j \neq i$ must equal $(1 - w_i)$. Substituting into the last term of Equation (2) produces:

$$\sigma_P^2 = \bar{\sigma}^2 \bar{\rho} + \bar{\sigma}^2 (1 - \bar{\rho}) \sum_{i=1}^{n} w_i \qquad (3)$$

In addition, if we assume equal weighting, Equation (3) simplifies to:

$$\sigma_P^2 = \bar{\sigma}^2 \bar{\rho} + \bar{\sigma}^2 (1 - \bar{\rho}) \frac{1}{n} \qquad (4)$$

Equation (4) shows that the total risk (variance) of a portfolio can be broken down into two components. The first component, represented by the first term on the right hand side of Equation (4), cannot be eliminated by increasing the number of investments in a portfolio. This component of risk is, therefore, common to all investments, and is called systematic or market risk (see Elton and Gruber, 1977). In contrast, the second term on the right hand side of Equation (4) can be eliminated effectively by increasing the number of investments in a portfolio. The elimination of this part of total risk will be achieved rapidly, because as n increases $1/n$ approaches zero very quickly. This component of risk is labelled non-market or residual risk. The level of risk reduction that can be achieved in a portfolio is limited, or bounded by, the risk of the market. Hence, the reduction in risk within a portfolio of increasing size can only come about by the elimination of the non-market or residual variance inherent in the investment. Two methods have been suggested in the literature to measure the impact of size on portfolio risk, the first graphical and the second statistical.

In the graphical approach, researchers usually simulate portfolios of increasing size (typically equally-weighted), based on individual data, and calculate the level of risk (standard deviation or variance of returns) for each portfolio. The individual portfolio risks are then averaged and plotted against portfolio size. The resultant graphs typically show an initial rapid decline in average portfolio risk, which then tapers away towards some 'market' level.[1]

The statistical approach follows much the same procedure, with a large number of portfolios of increasing size simulated from individual data, from which some measures of the risk are calculated for each portfolio, and the resultant values for each portfolio are size averaged. The researchers may then display the results graphically and/or more usually employ regression methodology to derive the relationship between the measure of risk and the portfolio size.

The first regression approach adopted in the literature was suggested by Evans and Archer (1968) and simply relates the standard deviation (total risk) of a portfolio to the number of investments held using the following equation:

$$\sigma = \alpha + \beta(1/n) \qquad (5)$$

Evans and Archer (1968) argue that the regression of total risk (standard deviation) on $1/n$ shows the impact of portfolio size on the non-market risk within the portfolio, because any fall in the value of total risk must be a consequence the elimination of non-market risk within the portfolio. Evans and Archer found that this model explained 98.6% of the variability of the mean standard deviation for US stock market securities. Their analysis also showed that the reduction in total risk was substantial up to portfolios of eight

to ten securities, after which the standard deviation of the portfolio became asymptotic to the risk of the market.

The second method, suggested by Wagner and Lau (1971), uses the proportion of market risk in a portfolio to indicate the reduction in risk achieved by increasing portfolio size.

Wagner and Lau (1971) use the single index model (SIM) to determine how much of the variability in returns of a portfolio can be explained by some market index:

$$R_i = \alpha_i + \beta_i R_m + e_i \tag{6}$$

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

The coefficient of determination (R^2) of such a regression indicates the proportion of variability in returns that can be explained by the market. The amount that is unique or specific to the portfolio itself, the non-market risk, is given by $(1 - R^2)$. A regression of R^2 on $1/n$ using Equation (7) indicates the number of investments to hold to reduce the amount of non-market risk to an 'acceptable' level:

$$R^2 = \alpha + \beta(1/n) \tag{7}$$

Using this approach, Wagner and Lau (1971) again found that the increase in R^2 was substantial up to eight or ten securities, after which the gain is marginal. Based on the Evans and Archer and Wagner and Lau approaches, the initial impression is that security portfolios need to have only a few investments to be fully diversified down to the market level.

In the real estate market, using these approaches, Brown (1988, 1991) finds that, for equal-weighted portfolios, 'after about ten properties have been included within a portfolio the reduction in risk which can be achieved by holding more properties diminishes dramatically'. This supports the findings of Evans and Archer and Wagner and Lau. However Brown also acknowledges that this reduction in portfolio risk is likely to be hampered by the indivisibility of individual properties, and the preference of fund managers to follow value-weighting schemes in developing their portfolios. Brown finds that value-weighted portfolios are less diversified than equal-weighted portfolios, and so would require more properties

to bring risk down to the systematic (market) risk level. Using the regression approach of Wagner and Lau, Brown finds that, even assuming an equal-weighting scheme, it would be necessary hold more than 200 properties to achieve an R^2 of 95%. Only 45 shares are required to achieve the same level in the UK stock market. The effect of value weighting would be to require an even greater number of properties (Byrne and Lee, 2000).

However, Tole (1982) suggests that the results of Evans and Archer and Wagner and Lau and, by association, those of Brown can be misleading for investors, as they are based on 'averaging techniques', essentially designed to obtain satisfactory regression coefficients. Such averaging, by its nature, reduces the variability of the data, and so magnifies the statistical fit of the regressions. It can be argued that these previous approaches are potentially flawed because of the fact that an individual investor owns only one portfolio, and results based on the average are not really relevant to his/her particular case, which may be substantially different from that average (Newbould and Poon, 1993). Tole (1982) presents a diagram showing that the original data used by Evans and Archer based on 60 simulations for each portfolio size from 1 to 40 securities display a wide variation around the average standard deviation level. The simulation results of Byrne and Lee (2000) suggest a similar picture in the UK property market. Byrne and Lee find that, for the 20 asset level, there is still a 5% chance of having a risk level approximately 15–25% above the average, depending on the sector or region chosen and the weighting scheme employed. At the 40 asset level, the deviation from the average is still 11–18%. Only at the 200 + asset portfolio is the deviation small enough to be ignored.

When Tole applied the approach of Evans and Archer to 55 simulated portfolios, without averaging the individual standard deviations, the resulting R^2 was only 14%, rather than the 98.6% found from the 'averaged' regressions. Such a low level of statistical fit implies that the confidence an investor can have that their portfolio will behave in the same way as the average is likely to be weak, to say the least. As a consequence, an investor who follows the advice contained in previous studies which are based on the results of average portfolio risks may be exposing themselves, potentially, to much greater risk than they

intend. Tole argues that the 'true' measure of risk reduction in a portfolio should not be the 'average', but the worst position. This is similar to the argument of McDonald (1975), who suggests most investors see diversification as designed to reduce the 'probability of *ex post* returns being an adverse surprise'. Investors who wish to avoid such adverse surprises from an unfortunate selection would be better off looking at the worst case rather than the average standard deviation or variance when considering the risk reduction effect of increasing sample sizes. This is a view shared by Fung (1979). In the approach of Evans and Archer, this will be the upper bound of the spread around the average. In the case of the Wagner and Lau approach, it will be the lower bound. Using this definition of risk reduction, Tole finds that 25–40 securities are required to achieve a level of risk reduction within the US stock market, rather than the 8–10 suggested previously.

In any case, property professionals may feel that the results of simulations, even when value weighted, are not really representative of the diversification strategies actually followed by fund managers. It may be felt that the results based on the performance of actual funds may be markedly different from the output of simulations. Indeed, this seems to be the case. In particular, Cullen (1991) finds that when portfolio risk, measured by standard deviation, is plotted against the number of properties within a portfolio, 'volatility is not reduced as fund size increases'. However, when specific risk is plotted against portfolio size, Cullen finds that this measure of risk does decline as fund size increases; although, again, the graphs display a wide variation around the average level. Cullen concludes that although large-scale diversification does 'appear to preclude the highest standard deviation levels'; this is only achieved for portfolios of 250 properties or above. Small portfolios, with less than 100 properties, 'exhibit very high volatility levels as well as very low ones'. Morrell (1993a, 1997) draws similar conclusions, finding that, although there is a general tendency for the largest funds to achieve high levels of risk reduction, many also display high levels of specific risk. Small funds, in contrast, can show remarkably high levels of risk reduction, even with relatively few properties in their portfolios. Morrell (1997) also finds that the average systematic risk (R^2) in the 162 portfolios analysed was

only 81%, with a quarter of the funds having R^2 values less than 76%. Thus, work on actual property portfolios shows that the theoretical benefits to portfolio risk of increasing portfolio size are difficult to achieve in practice.

In the light of this work, and the criticisms of Tole (1982), any analysis should, if possible, be based on the risk levels of actual portfolios, rather than averaged simulated results, so as to obtain a better representation of the impact of portfolio size on portfolio risk levels. Using actual property portfolios over the period 1981–1996, this study investigates whether it is possible to achieve a reduction in portfolio risk down to that of the market and the number of properties needed to obtain this level.

DATA

The data used in this paper come from two sources. First, the *IPD Annual Digest* (Investment Property Databank, IPD, 1996), and second, the *Local Markets Report* (IPD, 1998). These sources offer different levels of aggregation of the individual property data, upon which the results are based, to protect confidentiality. The IPD database, at the end of 1998, contained 13 933 properties with an aggregate value of £75.3 billion. The data in the *Local Markets Report* provide the lowest level of published aggregation within the IPD database. The data consist of the total returns on properties in the three sectors, retail, office and industrial, at various locations, giving a total of 392 property portfolios. The locations are based, for the most part, on local authority boundaries drawn up in the 1992 Local Government Act. The individual local authority portfolios were combined into mixed town-level property portfolios on a value-weighted basis to form 111 portfolios. In contrast, the *Annual Digest* presents the results of the UK real estate market in a number of aggregations. First, by three property types, offices, retail and industrial, across the standard regions of the UK, with further divisions for the London area to account for the dominance of this region in UK property funds. These produce 41 different property portfolios. These individual property types were combined into 12 mixed-property portfolios. Second, by 28 market segments, as used by IPD to analysis portfolio performance. The highest level of

aggregation is into the three property types, retail, office and industrial. In total, therefore, the analysis presented below is based on 587 property portfolios varying in size from 6–6806 individual properties. The summary statistics are presented in the lower part of Table 1.

This table prompts the following comments. As the level of aggregation increases, the data do show a fall in total risk (variance) towards the market level, but the decline is small and depressingly slow. So, for example, even at the highest levels of aggregation, there is still some way to go to reach the market risk level, implying that property fund managers are likely to need *very* large numbers of properties to attain the level of risk of the market. Although the spread of the data, as measured by the range (max–min), around the average level of total risk declines with the increase in aggregation, the data still show a large amount of variability at even the highest levels of aggregation. On this basis, there can be little confidence on the part of property fund managers that their portfolio will behave like the average, as suggested by Tole (1982). The level of market risk (R^2) within the lowest aggregated or local market data is very variable, from almost zero to over 90%. This indicates that the market explains very little of the variability in property returns at an individual level, so that the variability of individual property returns is mainly due to their unique or specific factors: location, location and location. Even so, as portfolio size increases, average R^2 values also increase as the influence of the market on portfolio returns begins to bite. Nonetheless, the impact of the market on even the most highly aggregated portfolios is still low compared with the impact of a stock market index on equity portfolios. This being so, real estate portfolios are unlikely to be able to track the returns of the market, especially if they are small sized portfolios of less than say, 100 properties. Finally, it will be noticed that the amount of specific risk in the portfolios tends to decline with increased portfolio size, but again, the effect is slow, and the data still display large levels of variability in even the largest aggregations. The following section analyses these effects in more detail.

ANALYSIS AND RESULTS

The average number of properties in each portfolio was calculated over the whole period from 1981 to 1996. These portfolio size data were compared using three measures of risk. The first of these was total risk (variance in log form). Second, a measure of market risk, the coefficient of determination (R^2), was calculated for each portfolio, relative to the *IPD Annual Index*. Finally, non-market risk, or residual variance (in log form), was calculated using the following equation:

$$R \, \mathrm{Var}_i = \mathrm{Var}(R_i) - \beta_i^2 \, \mathrm{Var}(R_m)$$

where $R \, \mathrm{Var}_i$ is the residual or unsystematic variance of portfolio i, $\mathrm{Var}(R_i)$ is the variance of returns for portfolio i, $\mathrm{Var}(R_m)$ is the variance of market returns and β_i is the slope of the regression of return of portfolio i on the returns of the market using Equation (6).

A regression of $R \, \mathrm{Var}_i$ on the number of properties was then made, in Equation (9), to measure the risk reduction as portfolio size increases:

$$R \, \mathrm{Var}_i = \alpha + \beta(1/n) \qquad (9)$$

Using the data for the 587 portfolios, Figure 1 shows the impact of portfolio size on total risk (variance in log form)[2]. As will be readily appreciated, there is a great deal of variability in the variance, especially at low portfolio sizes, i.e. less than 100 properties. Also, as the number of properties in the portfolios increases, there is only a minor reduction in portfolio risk. Indeed, a number of portfolios with portfolio sizes in the hundreds show higher levels of risk than for portfolios of less than 50 properties.

This supports the conclusions of Cullen (1991) and Morrell (1993a, 1997) that portfolio risk has little to do with the number of properties in the portfolio. Figures 2 and 3 present much the same picture. Although it may be true on average, portfolio size does not necessarily lead to a reduction in portfolio risk in all circumstances. This has important implications for fund management because it implies that two funds with the same number of properties are more than likely to have widely differing levels of risk (variance), even for portfolios of hundreds of properties. Even so, increasing the number of properties within a portfolio into the thousands is unlikely to do much to increase the fund manager's level of confidence.

This is confirmed, in Table 2, by the regressions of the three measures of portfolio risk on the average number of properties within the 587 portfolios. The regressions progress from the lowest

Table 1. Summary Statistics for the Portfolio Sub-Divisions

Sub-divisions	Number of portfolios	Number of properties			Total risk			R^2			Specific risk		
		Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min	Average
Local market data													
Retail	206	285	6	24	6.90	3.65	4.59	88.54	16.87	58.94	6.26	2.41	3.62
Office	93	403	6	32	6.31	3.92	4.99	91.12	0.31	67.51	5.32	2.08	3.74
Industrial	93	60	6	17	5.96	4.16	5.07	92.97	0.27	64.62	5.54	2.29	3.90
Mixed	111	300	19	64	5.34	3.55	4.60	94.76	1.08	75.93	4.42	1.74	3.04
Annual data													
Standard regions													
Retail	14	1570	25	465	5.34	3.88	4.29	86.76	48.55	75.75	3.61	2.14	2.79
Office	16	920	23	265	5.61	3.13	4.79	92.98	19.45	64.44	4.22	2.52	3.51
Industrial	11	754	23	192	5.22	3.89	4.84	83.11	12.42	50.51	4.73	3.11	4.01
Mixed	12	3182	48	895	5.05	3.27	4.31	96.71	44.81	73.46	3.49	1.64	2.75
Segments	28	5510	25	914	5.40	3.81	4.53	97.51	42.54	74.46	4.16	1.34	3.01
Sector data		Number of properties			Total risk			R^2			Specific risk		
Retail	1			6806			4.17			88.02			2.05
Office	1			4362			5.02			97.66			1.26
Industrial	1			2174			4.84			75.67			3.43

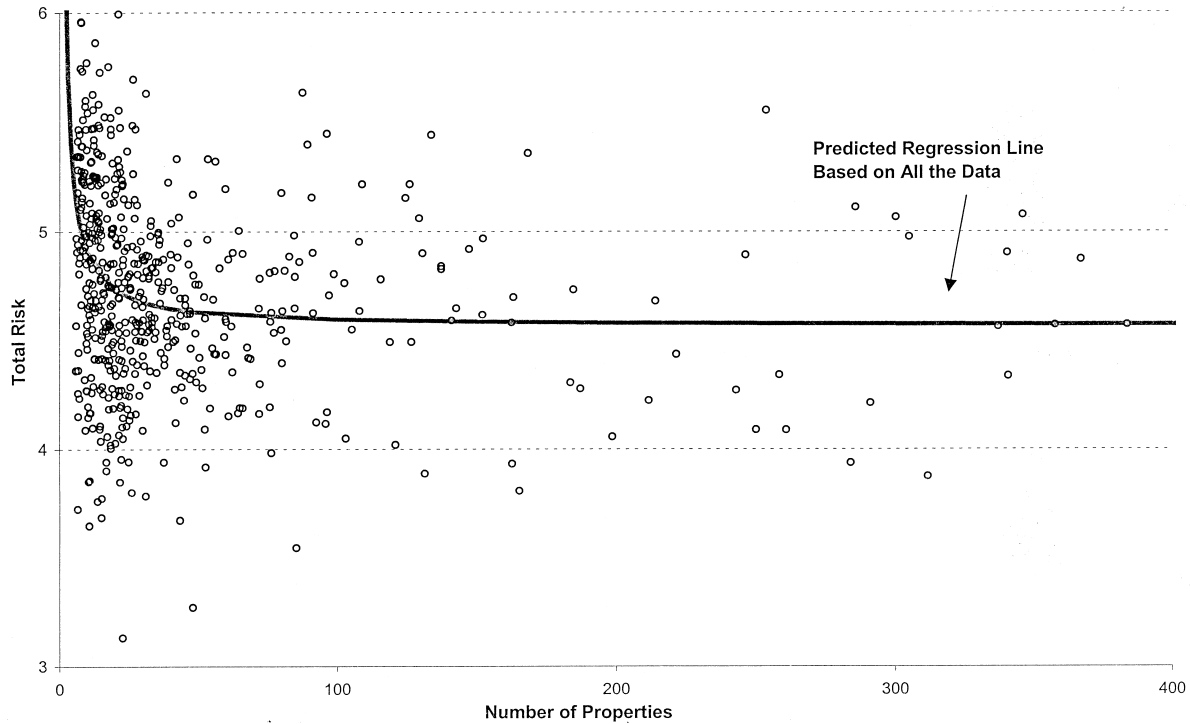*Manage. Decis. Econ.* **22:** 369–379 (2001)

Figure 1. Average number of properties and portfolio variance.

level data sets, the individual local authority (LA) data to the highest levels of aggregation, the property type data, where the overall LA1 data is the combination of the individual LA, and the overall LA2 data, which also include the mixed-town data. The overall data regression includes all the data sets.

Table 2 shows the coefficients of the regressions in Equations (5), (7) and (9), together with the coefficients of determination (R^2), and the standard errors of the regressions. The signs of the beta coefficients are all correct, and in all but one case, are significant at the 5% level. The level of significance is particularly strong for the residual variance regressions, as suggested by portfolio theory. Risk does, on average, decline significantly as the number of assets in the portfolio increases. However, as will be appreciated the amount of variability explained (adjusted R^2) by all the regressions is small, and considerably below that produced by previous studies using averaged data.

Panel A of Table 2 shows the regression results for total risk on number of properties. The coeffi-

cient of determination (adjusted R^2) is small, never more than 7.5%, and can be as low as 1.3%. As a result, the standard errors around the regression results are very high. It is this that will leave the investor with little confidence that their portfolio will behave 'like the average'. The number of properties within a portfolio has little or no impact on the level of total risk of the portfolio, confirming the results of Cullen (1991) and Morrell (1993a, 1997).

The results for the measure of systematic risk, in panel B, are only slightly better, with the goodness of fit coefficient reaching a maximum of 14%, but the lowest is less than 1%, for industrial property. The average R^2, as indicated by the Alpha, is only 74%, slightly less than that reported by Morrell (1997). As can be seen in Figure 2, there is again a great deal of variability around the regression line, especially at the lower portfolio sizes. For example, at the 20 property level the R^2 values range from 0 to 92%. However, at approximately the 300 property level, the spread is less, ranging from 56–95%. There is a tendency for the amount of systematic risk in any
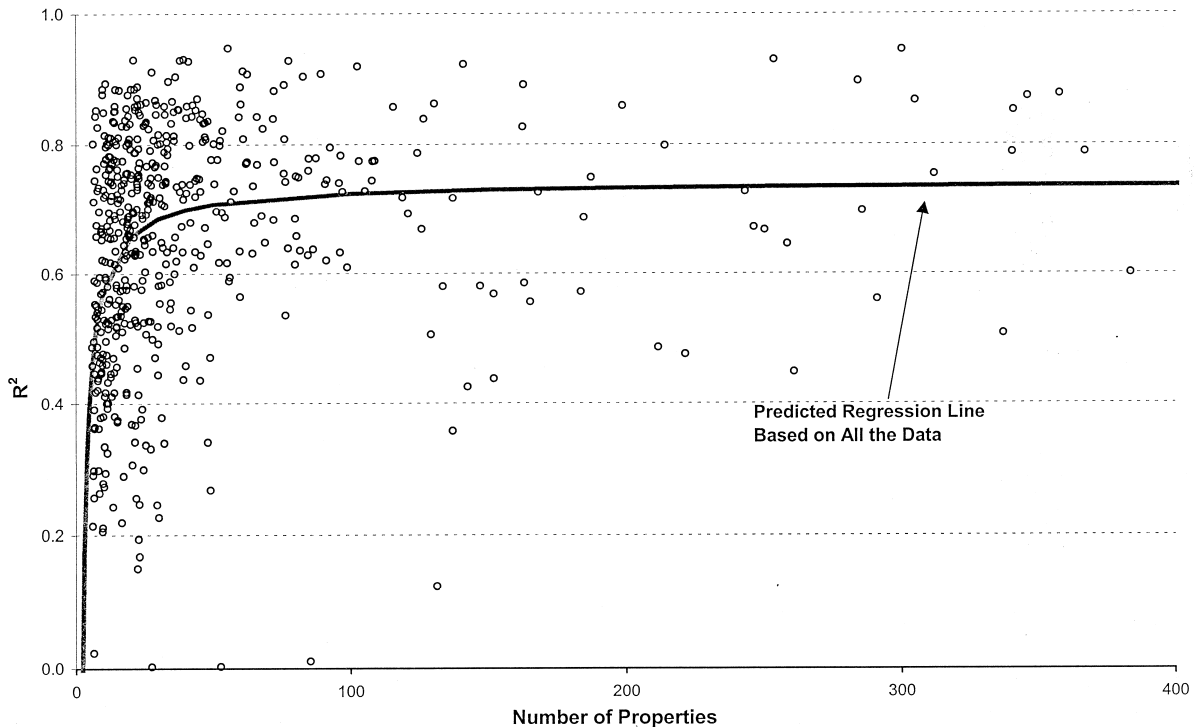
Figure 2. Average number of properties and R^2.

portfolio to increase as the number of properties increases, but the effect is only marginal, and even very small portfolios can show much higher levels of market risk than the largest portfolios. This suggests that most, if not all, portfolios will display high levels of tracking error (the variability of their portfolio returns relative to some benchmark of performance). This is likely to be the case, even for portfolios of thousands of properties. The tracking errors of small portfolios are likely to be huge, even for value-weighted portfolios. Fund managers may fool themselves into thinking that they must be tracking the market if they display the same value weighting as the market across property types and regions, when in fact, they should have very little confidence that this is really the case.

In contrast, the figures in panel C for specific risk (residual variance in log form) generally show much stronger results, the adjusted R^2 values reaching a high of 22%. Even so, the results are still weak in comparison with those reported in previous work based on 'averaged' simulations. Hundreds, if not thousands, of properties will be needed for fund managers to feel confident that the main influence on their portfolios returns is

that of the market rather than the unique or specific factors in the property returns.

The high levels of non-market risk within even the largest portfolios suggest that the performance of a property portfolio is a result of some unique or specific features (of its component parts). This has important implications for performance measurement services that try to attribute the fund manger's contribution to property portfolio performance. If the risk level of even the largest funds is a consequence of their unique characteristics, rather than the influences of the market, it becomes difficult to isolate those features of fund performance which are resulting from *structure* or *policy* (sector and regional weighting relative to the benchmark) and the *selection* or *property* component (the manager's skill in choosing the right property).

The regression results confirm the images presented in Figures 1–3. Increasing portfolio size leads, on average, to a reduction in risk, however measured, but the one area where the effect is greatest is in the reduction of the specific or residual risk in the portfolio, as suggested by portfolio theory. Nonetheless, the results, even for the specific risk regressions, are weak, confirming
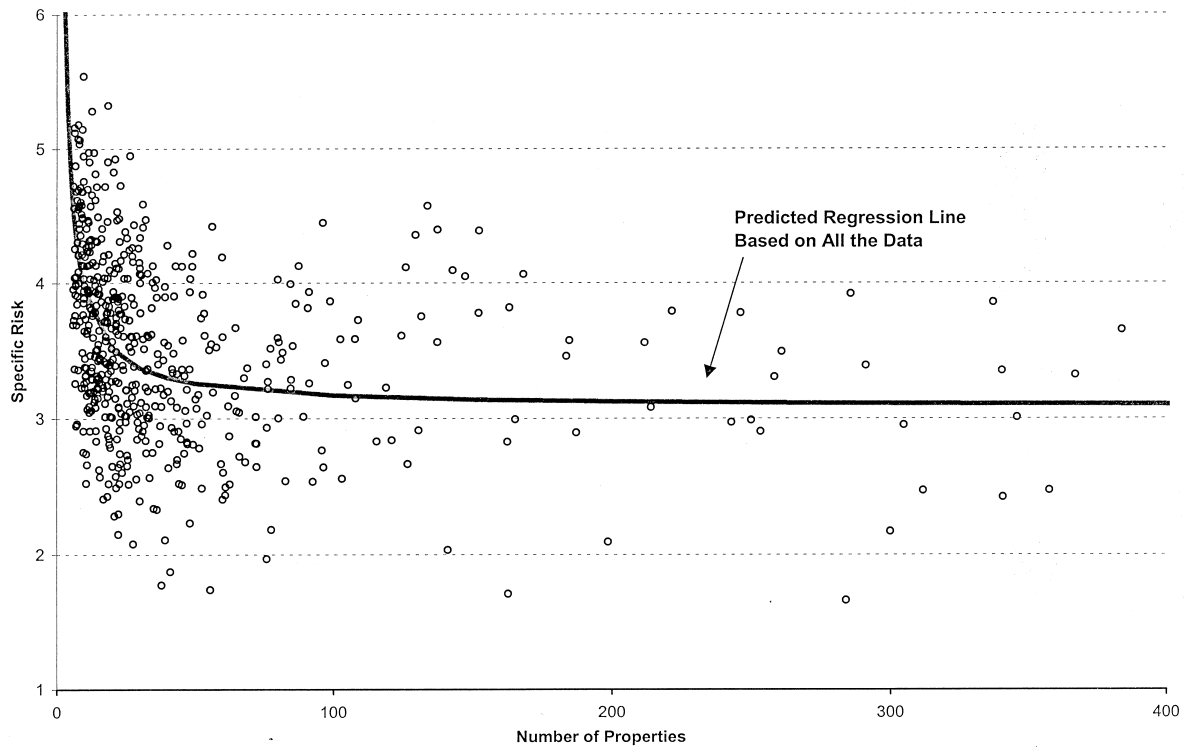
Figure 3. Average number of properties and specific risk

Table 2.   Results of Regression of Risk on the Number of Properties

Risk measure	Alpha	Beta	t-statistic alpha	t-statistic beta	Adjusted R^2 %	Standard error
Panel A: log variance						
LA retail	4.43	2.65	70.60	2.99	3.73	0.45
LA office	4.87	2.02	53.61	1.47	1.27	0.45
LA industrial	4.88	2.43	52.44	2.26	4.28	0.38
Overall LA1	4.60	3.04	93.11	4.55	4.80	0.48
Overall LA2	4.57	3.36	127.68	6.22	6.99	0.45
Overall	4.56	3.40	151.54	6.94	7.45	0.46
Panel B: R^2						
LA retail	0.71	−1.95	35.21	−6.87	18.38	0.15
LA office	0.73	−1.00	21.27	−1.93	2.91	0.17
LA industrial	0.70	−0.71	15.70	−1.37	0.93	0.18
Overall LA1	0.71	−1.33	41.63	−5.77	7.65	0.17
Overall LA2	0.75	−1.76	57.93	−9.00	13.78	0.16
Overall	0.74	−1.69	67.37	−9.45	13.12	0.17
Panel C: residual or specific risk						
LA retail	3.17	7.37	41.02	6.76	17.92	0.56
LA office	3.49	4.43	25.11	2.11	3.67	0.68
LA industrial	3.51	5.05	22.14	2.76	6.70	0.64
Overall LA1	3.30	6.40	52.35	7.50	12.41	0.61
Overall LA2	3.09	8.56	62.97	11.54	20.86	0.62
Overall	3.08	8.80	73.50	12.90	22.06	0.63

the findings of Tole (1982) that without the 'averaging' effect typically found in simulation studies, the regressions generally lack power and display large standard errors.

CONCLUSIONS

This paper has re-evaluated the potential for risk reduction in the UK real estate market across the whole spectrum of portfolio sizes in numerous regions and types using actual data over the period 1981–1996.

When the full data set is used, the statistical significance of the regressions on three standard measures of portfolio risk on size is greatly reduced. The results confirm the findings of Cullen (1991) and Morrell (1993a, 1997). Real estate portfolios of a large size tend, on average, to have lower risks than small sized portfolios, but portfolios with relatively few properties can still have very high or very low risk. An individual investor who uses advice based on the results of average portfolios may be exposed to greater risk than they anticipate. Fund managers can have little confidence that their portfolio will display the same level of risk as the average. Their portfolio could be significantly higher or lower than they anticipated, especially at small sizes. The results suggest that for fund managers to be confident that their portfolio will have a risk level more like the average they need to hold portfolios of a considerably greater size than they might expect, or can sensibly hold. The results of previous studies, which suggest that only 20–40 properties are needed to reduce the risk of a real estate portfolio down to the market level, are a significant underestimate. The actual number is more likely to be around 400–500 properties, well above that of the largest fund in the UK. Size alone does not necessarily lead to a reduction in portfolio risk. Clearly, other factors are of greater importance.

NOTES

1. See, for example, Jones Lang Wootton (1986), Barber (1991), Cullen (1991), Myer *et al.* (1997) and Byrne and Lee (2000) for studies in the property market, and Evans and Archer (1968), Wagner and Lau (1971), Johnson and Shannon (1974), Tole (1982) and Lloyd *et al.* (1981) for studies in equity and bond markets.

2. In order to simplify the presentation of the data, Figures 1–3 only show the data up to the 400 property level, even though the data contains portfolio sizes up to more than 6000 properties. Graphs showing the full data are available on request.

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