Real estate portfolio diversification by property type and region

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Introduction

The top-down approach to portfolio allocation involves first, the decision as to how much to allocate to each broad asset category; and second, a decision on an optimal strategy within each asset category. In part, this involves the management of risk through diversification within the asset category.

For real estate portfolios, the conventional approach to defining diversification categories is to use property type and geographical region. Returns on different property types are believed to be driven by different economic factors: for example, offices by office employment, shops by retail sales and industrial properties by manufacturing output. Similarly, there should be differential performance across regions within each property type. However, the conventional approach to regional diversification is not without problems. The regions normally used in the UK are administrative (that is, geographical) rather than functional. Both MacGregor[1] and McNamara[2] suggest that an alternative approach to real estate portfolio construction may be to group regions by economic base. In this way the economies underlying the property markets within the unit of analysis will be more homogeneous. These ideas are related to work done in the USA, of which Hartzell *et al.*[3,4], Shulman and Hopkins[5], Mueller and Ziering[6] and Mueller[7] are examples. There is also an extensive literature in economic geography which challenges the appropriateness of the geographic region as a unit of analysis.

In the USA, the issue of homogeneity of the spatial units has led to the consideration of non-contiguous spatial groupings which combine areas of similar economic base. Shulman and Hopkins[5], Mueller and Ziering[6] and Mueller[7] all look at cities with similar dominant industry employment bases such as manufacturing, transportation, government services, and so on. This is linked to the issue of "scale": the larger the spatial unit, the less homogeneous

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will be its economic parts and the greater the scope for real estate portfolio diversification within the region. Despite the associated problems, a property type/region classification using geographical regions has been used widely for real estate portfolio construction in both the USA and the UK. Given the very different sizes of the two countries, the size of these spatial units varies greatly.

Investors in real estate, typically through a process of naïve diversification, have constructed diversified portfolios, although in many cases more effective strategies could be adopted. One question which arises is, starting from one property type in one region, whether it is more efficient to diversify across regions within a single property type or across property types within a region. That is to say, should investors remain in one region and seek diversification by property type *within the region*, or diversify across regions but remain *within the property type*. Another issue of importance is whether diversification by property type or region alone produces significantly worse results than full diversification by both property type and region.

This problem is relevant specifically to domestic investors, either British or American, who have not yet entered the real estate market or have entered it only marginally, or international investors seeking exposure to a country and unlikely to have sufficient investment funds to construct a portfolio diversified both by property type and region. A further practical consideration is that a more restricted diversification strategy is likely to be less expensive to implement.

The remainder of this study is as follows. In the next section, UK and US property returns data are presented. This is followed by a review of the relevant literature. In each of the next three sections the issue of property diversification is approached with a different method. Each section starts with an outline of the method used, and proceeds with the results for the UK and the USA. The first analysis involves the construction of correlation matrices for the returns disaggregated by property type and the matrices for returns disaggregated by geographic region. These matrices are subsequently compared with a formal test. In the second analysis, efficient frontiers for the USA and the UK are constructed and studied. Finally, principal components analysis is undertaken to investigate the similarities and differences between the returns for the different property types and regions. The article ends with conclusions and suggestions for further research.

Data

The US data used in this study come from the Russell NCREIF (RN) Property Index. This index is available from 1978, but the breakdowns by both region and property are only available from 1983. This article uses 40 quarterly observations for the period 1983-1992. The four property types which comprise the commercial real estate market (office; research and development/ office; warehouse; and retail) are used for each of the four geographical regions (East, Mid-west, West and South)[8].

The UK data are from the Investors Chronicle Hillier Parker (ICHP) Index and comprise 32 semi-annual observations from 1977 to 1993[9]. The UK data are

available disaggregated by three property types (offices; industrial; and retail) and by 11 regions (London, South East, South West, East Anglia, East Midlands, West Midlands, Wales, Yorkshire and Humberside, North, North West, Scotland). The data exclude shopping centres, mixed use buildings, and business space. Data for the UK 11 regions were also aggregated to produce three "super" regions as suggested by Key *et al.*[10]. These regions are London, South and North.

There are a number of limitations with these data sources. First, the time series are relatively short. Second, both are appraisal based and there is a growing literature on the problems of such indices as measures of market movement (see [11-16]). Third, the UK data are not from actual properties in actual portfolios, but rather hypothetical properties of a particular specification. The rents quoted are not provable rent or actual rent but a valuer's view of open market rent based on market knowledge[17]. Finally, different indices can give different measures of the market[18]. However, whatever the limitations, these indices probably give a reasonable view of market movements and should be reasonably robust for analyses within the real estate market. Caution is required for cross-national comparisons, not least as the RN data are quarterly and the ICHP data biannual.

Literature review

As suggested above, two dimensions have traditionally been used for diversification within real estate: property type and the geographical location of the properties. Miles and McCue[19], for example, used a sample of real estate investment trusts (REITs) and regressed the return to risk ratio against variables representing the extent of diversification by property type and geographic region. They found evidence that diversification by property type produces higher risk-adjusted cash yields than geographic diversification. In a later study, Miles and McCue[20] used property-specific data from a large commingled real estate fund. They found that correlations among returns on portfolios of properties differentiated by property type were significantly less than correlations among portfolios differentiated by region. Property type was a more efficient means of diversification.

A contrary view comes from Hartzell *et al.*[3] who considered five ways of diversifying a real estate portfolio by: geographic region, property type, property size, metropolitan statistical area (MSA) and lease maturity. The geographical areas considered by these authors were the very broad areas of the USA used in this study (East, Mid-west, West and South). On the basis of appraisal-based data on properties for the period from 1973-1983, they found that correlations between returns in the four regions were usually low. They pointed, however, to the need for more detailed diversification categories.

A study by Grissom *et al.*[21], using the standard four regions (East, West, Mid-west and South), showed evidence for the existence of regional markets for industrial real estate. This suggests the importance of regional diversification. This was undertaken in an arbitrage pricing theory (APT) framework.

The authors showed that the risk premiums associated with common systematic risk attributes vary for properties located in different regions. Also, the number of relevant factors was found to differ across regions.

On the premiss that there should be more diversification potential across regions with different economic bases than across purely political or geographic boundaries, several authors have suggested the segmentation of the market according to economic factors. Such an approach has been used for some time by geographers considering industrial diversification[22,23]. For real estate, Hartzell *et al.*[4] have used a hybrid of the geographic and economic approaches. They divided the USA into eight contiguous regions based on similar underlying economic fundamentals (New England, Mid-Atlantic corridor, Old South, Industrial Mid-west, Farm belt, Mineral extraction area, Southern California and Northern California). Their results show that eight-region diversification provides benefits that cannot be achieved from the traditional four-region diversification. This was confirmed by Malizia and Simons[24] who used "demand" variables of population, income and employment rather than real estate returns and found that the eight-region classification used by Hartzell *et al.*[4] in 1987 offered better diversification than either the traditional four geographical regions or an alternative eight-region geographical classification.

Shulman and Hopkins[5] broadened the concept of economic diversification by analysing 60 MSAs, which they classified into homogeneous portfolios based on employment characteristics. These authors concluded that this classification should be superior to four- or eight-region diversification but did not provide a test of this hypothesis. An approach based on economic factors was also adopted by Corgel and Gay[25] who investigated whether repayment risks of mortgages could be reduced. They divided employment data for the 30 largest standard metropolitan areas (SMAs) in the USA into eight industry groups, and did mean-variance portfolio analysis on the thus obtained time series. This analysis was found to outperform other diversification strategies not based on economic characteristics.

For Europe, these findings were confirmed by Hartzell *et al.*[26] who characterized 74 commonly recognized European regions as diversified, or as specialized in one out of nine industrial categories. The regions with a common specialization were scattered throughout Europe, so regionally diverse investments were not necessarily economically diverse.

A formal test of the superiority of economic-based diversification strategies for real estate portfolio diversification was undertaken by Mueller[7]. He compared the appropriateness of using the four-region classification, the classification of Hartzell *et al.*[4] and his own classification. This latter comprises nine economic categories based on one digit SIC codes: mining; government; manufacturing; finance, insurance and real estate; services; transportation; military; farm; and diversified. Each of the 316 MSAs of the USA was categorized in one of these groups. Mueller reported that the four-region classification was least efficient in terms of diversification. The eight-region classification gave much better diversification results. He further showed that a

diversification strategy based on his own classification, which relies solely on economic base, provided even greater risk-adjusted return possibilities.

Stock market researchers have considered a similar question to the one addressed by this study, that is, whether diversification should be undertaken according to type of industry or according to country. Authors who have examined this issue used data for the individual stocks, which is a different approach from that used here. The conclusions of these studies are mixed. Roll[27], for example, found that each country's industrial structure plays a major role in explaining stock price behaviour. A contrary view is found in Heston and Rouwenhorst[28] who concluded that diversification across countries within an industry is a much more effective tool for risk reduction than industry diversification within a country.

Of the studies outlined above, only Miles and McCue[19] suggested that diversification by property type should be preferred to diversification by region. Since that study was conducted, however, several researchers have shown that economic rather than purely geographic regions should be used. As a consequence, the conclusion by Miles and McCue probably stems from the inappropriateness of the large scale geographic classification they used which dilutes differences between regions. Moreover, the time series on which their study was based were relatively short. In this study, the use of UK real estate data allows the issue of diversification by property type and region to be considered at a spatial scale not possible using US data. The results of three separate analyses are now considered.

Analysis of the correlation matrices

Markowitz[29,30] showed that the opportunities for risk reduction in investment portfolios are negative functions of the correlations between asset returns. This implies that the benefits of geographic diversification can be determined by measuring the correlations between time series of real estate returns aggregated by region. Similarly, correlating real estate returns aggregated by property type can give information about the usefulness of diversification by property type. Deciding which one of the two approaches to real estate diversification is more effective can be done by comparing the correlations of both approaches: the lower correlations imply which diversification strategy would be best.

One way to compare the property type and regional correlations is to determine which of the two correlation matrices is lower. A formal and straightforward approach to this was developed by Jennrich[31,32]. However, it can only be used to compare two correlation matrices of equal dimension. Thus, it is only possible to compare the regional and property type correlation matrices when the numbers of regional and property type classifications are equal. For the USA, a four-region by four-property type disaggregation is used and for the UK a three-region by three-property type disaggregation.

The correlation matrices for the four US property types and four US regions are shown in Tables I and II. All correlations are significantly different from zero at 0.1 per cent. The matrices are significantly different from each other at

the 7 per cent level, suggesting greater diversification benefits for geographic diversification than for property type diversification. This supports the results found in the US literature. Using the Jennrich test, we also investigated whether the correlation matrices differed from the unity matrix. This was done to see if there was significant potential for diversification. The matrices were found to be different from unity at the 0.001 level.

The estimated correlation matrices for the three UK property types and three UK regions are shown in Tables III and IV. As for the USA, all correlations are significantly different from zero at 0.1 per cent. The matrices are significantly different from each other only at the 54 per cent level, suggesting that there is little difference between property type and geographic diversification at this scale of spatial disaggregation. The difference between the US and the UK results could be attributed to differences in the construction of the data series, to the different sizes of the regions, to the different time periods, or to different phases of the long-term real estate cycles. Again, the matrices were found to differ from unity at the 0.001 level, indicating significant diversification potential.

As the number of regions differs from the number of property types, there is no test for the UK 11 region data comparable with the one undertaken above. It is, nonetheless, informative to analyse this data. This is done by calculating the correlations between all market segments, in which a market segment is defined as one property type in one region. The full matrix is given in the Appendix, while Tables V and VI summarize important features. Table V shows the numbers of insignificant property type correlations (out of a possible three) within each region. This allows the scope for diversification within a region and across property types to be assessed. The correlations between the office and

Table I.
US correlation matrix based on quarterly returns, 1983-1992 by property type

	Property types			
	Office	Retail	R&D	Warehouse
Office	1.000	0.844	0.833	0.872
Retail		1.000	0.840	0.897
R&D			1.000	0.806
Warehouse				1.000

Note: all correlations are significantly different from zero at 0.1 per cent

Table II.
US correlation matrix based on quarterly returns, 1983-1992 by region

	Regions			
	East	Mid-west	South	West
East	1.000	0.894	0.685	0.889
Mid-west		1.000	0.650	0.846
South			1.000	0.737
West				1.000

Note: all correlations are significantly different from zero at 0.1 per cent

industrial markets are always significant but the correlations between retail and the other two property types are weakest the further the region is from London, suggesting greater scope for within region diversification.

When the insignificant correlations are grouped by property type (Table VI), it is clear that there are strong correlations within property types and across regions, particularly within retail. There are also strong correlations between the industrial and office property types and less significant correlations between retail property and the other two property types. These correlations are to be expected as both the industrial and office markets are driven by profits in the economy and the retail market is driven by wages; thus shocks to profits will affect the office and industrial markets and shocks to wages will affect the retail market[1].

Table V shows the percentage of significant correlations for each market segment with all other market segments. There are two striking features: first, the percentage of significant correlations is high in the office and industrial markets and relatively much lower for the retail market; and second, the percentage of significant correlations decreases with the distance from London and the South East (the region around London).

In the UK it is a conventional wisdom that retail property offers least scope for regional diversification: retail sales tend not to have strong regional differences and the supply response of the retail property market does not differ significantly across regions. This is consistent with the results presented in Tables V and VI. In contrast, in the office market, as the London market is driven by the financial sector and has a strong international dimension, opportunities should exist for regional diversification within the office market.

	Property types		
	Industrial	Office	Retail
Industrial	1.000	0.848	0.622
Office		1.000	0.702
Retail			1.000

Note: all correlations are significantly different from zero at 0.1 per cent

Table III.
UK correlation matrix based on semi-annual returns, 1977-1993 by property type

	Regions		
	London	South	North
London	1.000	0.847	0.732
South		1.000	0.841
North			1.000

Note: all correlations are significantly different from zero at 0.1 per cent

Table IV.
UK correlation matrix based on semi-annual returns, 1977-1993 by region

	Region											
	L	SE	EA	SW	EM	WM	W	NW	YH	N	S	Total
Insignificant property type correlations within regions [a]												
Number	0	0	1	1	1	1	1	2	2	2	2	13
Significant correlations between market segments [b]												
Industrial	93.8	96.9	90.6	93.8	87.5	75.0	84.4	68.8	68.8	65.6	37.5	78.4
Office	90.6	93.8	62.5	71.9	62.5	87.5	68.8	65.6	65.6	65.6	65.6	72.7
Retail	53.1	62.5	65.6	59.4	62.5	62.5	75.0	65.6	46.9	40.6	50.0	58.5
Total	79.2	84.4	72.9	75.0	70.8	75.0	76.0	66.7	60.4	57.3	51.0	69.9

Notes:

[a] Within each region there are three property type correlation coefficients. The number in each cell in the table represents the number of correlations which are insignificant at 5 per cent. Other things being equal, the larger the number, the greater the scope for property type diversification within the region

[b] A market segment is defined as one property type in one geographic region. Since three property types and 11 regions are examined, there are 33 markets segments. The number in each cell represents the percentage of correlations between the row (property type/column (region) and all other property type regions which are significant at 5 per cent

Table V.
UK correlations based on semi-annual returns for 11 regions and three property types, 1977-1993

	Industrial	Office	Retail
Industrial	4	6	62
Office		3	84
Retail			0

Note:
A market segment is defined as one property type in one geographic region. Since three property types and 11 regions are examined, there are 33 market segments.The insignificant correlation coefficients (at 5 per cent) between one property type/region and another are grouped, for all regions, according to the two property types involved

Table VI.
Insignificant correlations between market segments by property type, based on semi-annual returns, UK, 1977-1993

There is no evidence here to support this: the London market is highly correlated with the other regional office markets. This result may be a consequence of the level of aggregation which does not treat the main financial centre in the City of London separately from the other London office markets which are less specialized. The results for industrial property also show strong regional correlations within the property type.

In summary, the results show that the scope for diversification within a region varies from region to region and is greatest the further from London, while the diversification within property type is generally limited but is better for office and industrial property. Retail property is poorly correlated with either industrials or offices. Thus, full diversification by both property type and region is to be preferred.

Analysis of the efficient frontiers

While correlation matrices of asset returns provide information on one aspect of diversification, they do not consider the asset risks which, together with the correlations, determine portfolio risk. Nor do they consider the trade-off between risk and return and so do not give insights into the link between an investor's relative risk aversion and an optimal diversification strategy. These, however, can be gained by comparing the efficient frontiers of the different diversification strategies. Three types of efficient frontiers are constructed:

(1) The four efficient frontiers for diversification within each property type but across all regions.

(2) The four efficient frontiers for diversification within each region but across all property types.

(3) The efficient frontier for full diversification across all property types and regions.

The results for the USA and the UK are shown in Figures 1 to 7. For each country, a separate graph is presented for each property type showing: the frontier for diversification within that one property type and across regions; the four frontiers for diversification within each region and across property types; and the full diversification frontier. These graphs can be compared to see which strategy gives the best possible risk/return trade-off for different levels of risk aversion of the real estate investor.

US results

The efficient frontiers for the USA are provided in Figures 1 to 4. Figure 1 shows clearly that for office and R&D/office properties the best strategy would have been to diversify across property types within one region. Indeed, the regional frontiers, that is those frontiers which contain portfolios of different types of real estate, all lie well above the property type frontier, which contains portfolios of geographically diversified properties of one type. This result suggests that an effective geographical diversification could not have been achieved in office and R&D/office properties. These exhibits also show that for

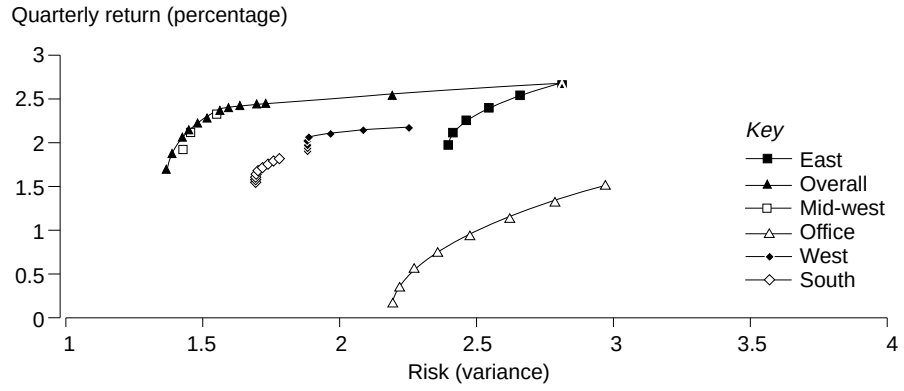

Figure 1.
US geographical diversification within office properties versus diversification by property type and overall diversification

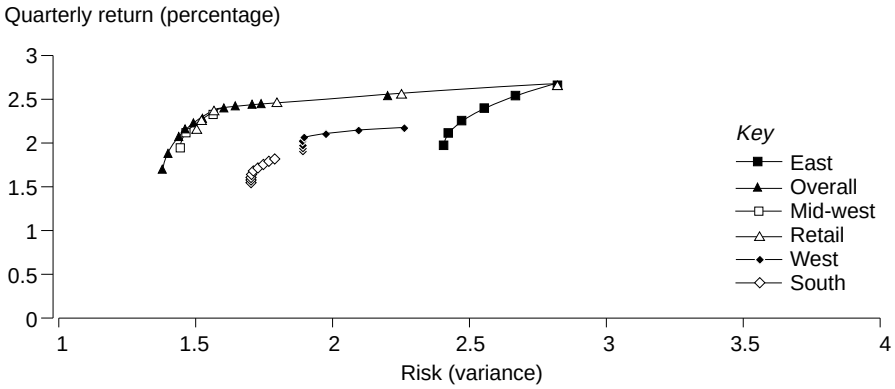

Figure 2.
US geographical diversification within retail properties versus diversification by property type and overall diversification

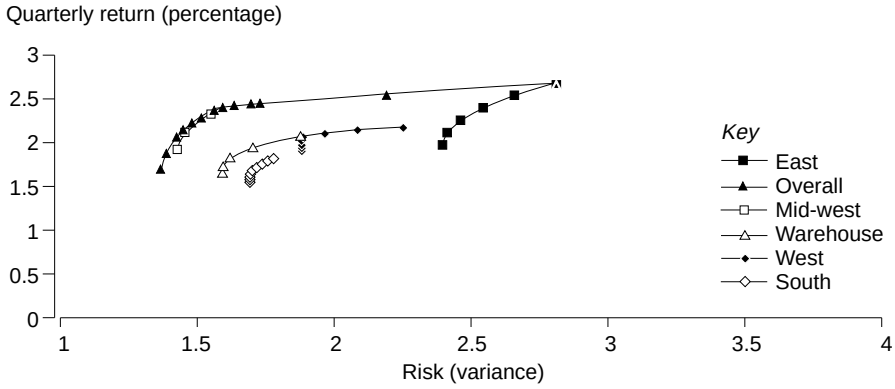

Figure 3.
US geographical diversification within warehouse properties versus diversification by property type and overall diversification

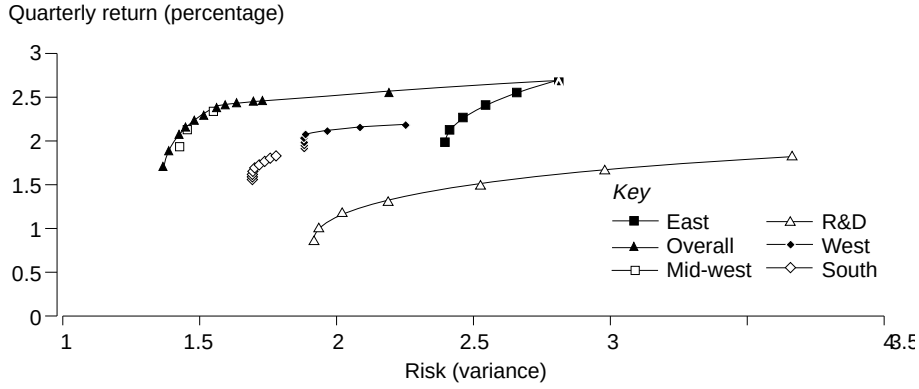

Figure 4.
US geographical diversification within R&D properties versus diversification by property type and overall diversification

office and R&D/office properties much of the diversification benefits have been exploited when diversification within the property type has been undertaken: the overall frontier does not lie far above the regional frontiers.

For retail properties, there seems to exist more diversification potential across regions than within regions, as can be seen in Figure 2. Most of the diversification benefits are used when geographical diversification is undertaken. For warehouses, the conclusion is mixed: the property type frontier lies in between the geographic frontiers (Figure 3). Thus, diversification should have taken place according to both property type and region. However, for each property type, for very risk-averse investors in the Mid-west, diversification across property types within the region would have sufficed.

The results do not fully support the conclusion of the correlation matrix analysis as they suggest that for two of the property types a between property types and within region diversification strategy is better than a between regions and within property type diversification strategy. However, the correlation matrix analysis did not address precisely the same issue: it merely compared correlations between property types and regions. It is clear from these results that there are property type differences contained within the average. Thus, the picture is mixed for the USA: no compelling evidence has been found to suggest that in all cases a regional strategy should have been preferred to a property type strategy. Indeed, on balance, the opposite conclusion might be suggested.

UK results

The efficient frontiers for the UK are provided in Figures 5 to 7. Since the UK regions are much smaller than the US regions, it is reasonable to expect that there should be greater opportunities for economic diversity across regions and so for diversification within each property type and across regions. However, in

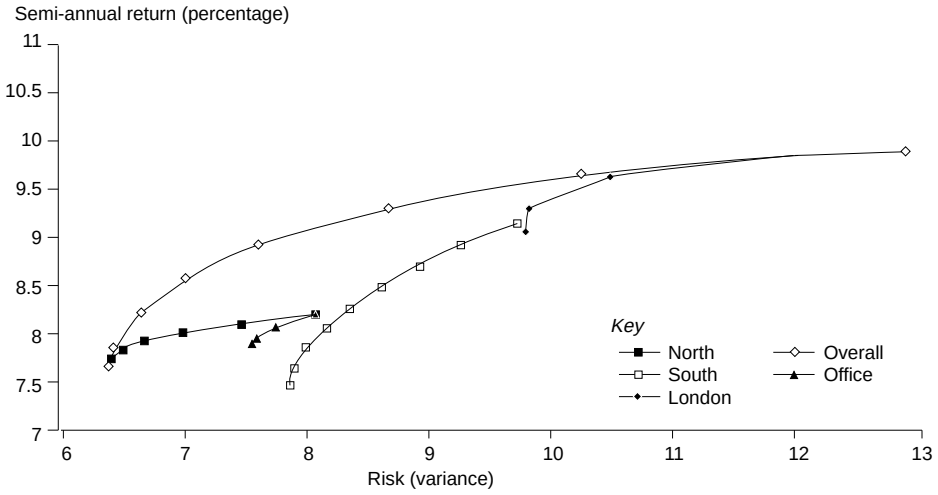

Figure 5.
UK geographical diversification within office properties versus diversification by property type and overall diversification

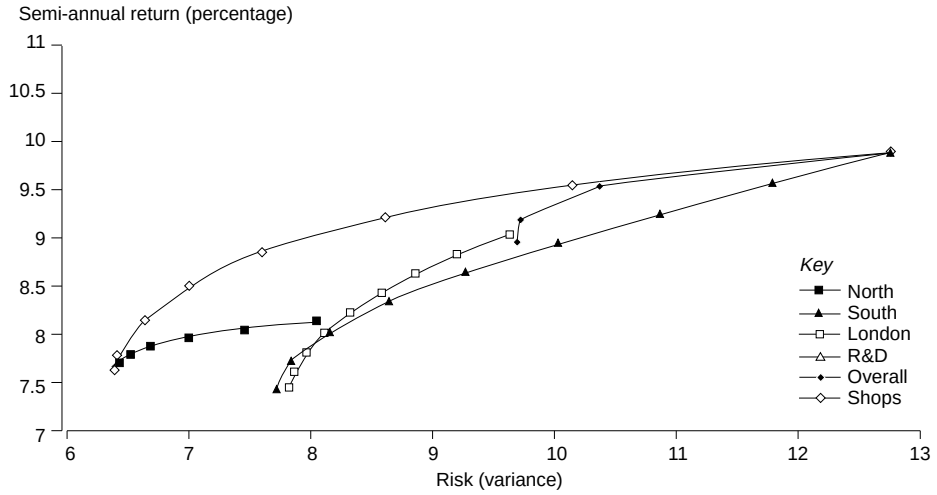

Figure 6.
UK geographical diversification within retail properties versus diversification by property type and overall diversification

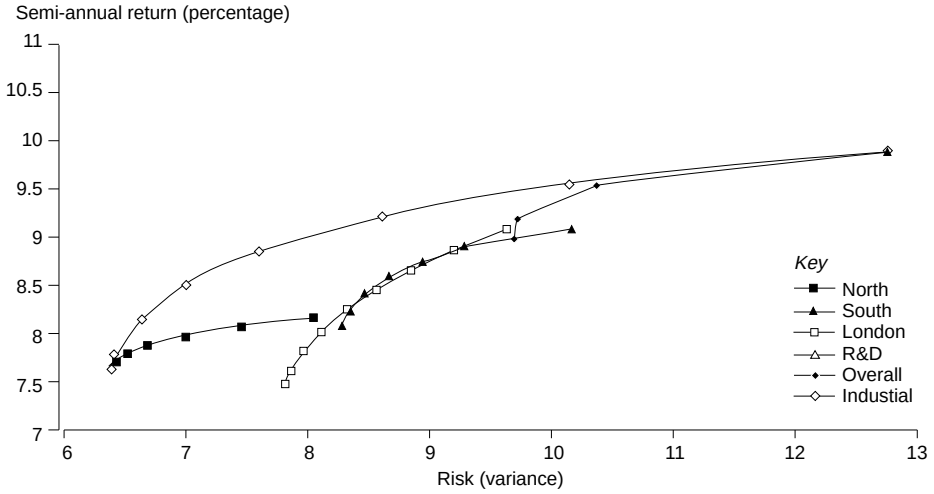

Figure 7.
UK geographical diversification within industrial properties versus diversification by property type and overall diversification

the UK, within region and across property type diversification appears to be better than diversification within retail property. A similar but less conclusive result is evident for industrial property. For office property, the results are mixed. For all three types of properties, the results suggest that full diversification, across property types and regions, would be best, except for the

most risk-taking and most risk-averse investors. As for the USA, this analysis disaggregates the correlation matrix analysis. It confirms the earlier results.

Principal components analysis

Another way to analyse the benefits of the two diversification strategies is offered by the arbitrage pricing theory (APT) as developed by Ross[33]. Contrary to the capital asset pricing model (CAPM), where the only factor influencing returns is the market, the basic idea of the APT is that asset returns are determined by a set of orthogonal factors, instead of just one factor. Although Ross does not indicate what these factors are, they most probably will be related to economic activity. Chen *et al.*[34], for example, show that variables such as unexpected inflation, changes in the term structure of interest rates and changes in industrial production explain stock returns. For real estate, Chan *et al.*[35] have used a similar approach and also found promising results.

Using the APT model diversification is based on the idea that risk reduction can be obtained by investing across factors, instead of investing within factors. After all, if a portfolio is exposed to only one factor, it is not very well diversified. An optimally diversified portfolio should be exposed to all important factors. The question is, then, to identify which factors are important. For this study this translates into the question: are property type and/or geographic region important factors in generating real estate returns? If they both are, one would have to diversify across both dimensions to obtain optimal diversification. However, if only one dimension is found to be important, then that would be the dimension to keep in mind when building a real estate portfolio.

The analysis comprises two stages. The first stage involves the extraction of a set of orthogonal factors from the real estate returns matrix. This is an ($l \times m \times T$) matrix, where l is the number of property types, m is the number of regions, and T is the number of observations. Each element of this matrix reflects the real estate return in market segment l, m at time t. The number of factors extracted is ($l \times m$). For the factor extraction, one can use factor analysis, but Chamberlain and Rothschild[36] have found that principal components analysis can be used to establish an approximate factor structure. This method is computationally and conceptually simpler than factor analysis. Therefore, principal components analysis is used to extract common factors from the real estate returns matrix.

In this first stage of the analysis, the factors are just vectors of returns, without any clear relationship to economic variables. This stems directly from Ross[33], who gives no indication as to what these factors might be. Establishing the relationship between the factors and the property returns is the key to the second stage of the analysis. This is done simply by correlating the factors with the original ($l \times m$) individual property type/region real estate return series. The correlation pattern provides information on whether the factors have the dimension of property type or geographic area. For example, if it is observed that correlations show similar patterns among real estate returns for the same

property type across regions, it can be concluded that diversification is most useful across property types. On the other hand, similar correlation patterns within a region for the different property types would imply that risk reduction can be accomplished best by investing across different regions.

It is likely that one dominant factor and several less important ones will be found (this kind of result is typical in the empirical APT literature[34]). In this study, this dominant factor can be thought of as the national real estate market factor. As the main interest of this study is within real estate diversification rather than mixed-asset diversification, this national real estate market factor is not a main concern. Therefore, the analysis is repeated to exclude the market influence. This is done using two separate approaches. In the first, principal components analysis is undertaken on the real estate returns in excess of the national real estate market; in the second, in order to examine the robustness of the first approach, real estate returns are regressed on the real estate market and principal components analysis is undertaken on the regression residuals. The resulting factors should provide a clearer picture of the dimensions of real estate returns.

The relationship to be considered is that between factors (the components) and the return for the real estate market in each property type/region. Thus, the square of each correlation between the property type/region and the components is calculated. This gives the explanatory power of the components over the real estate return in each property type/region. However, this power is particularly interesting in relative terms. Therefore, the ratio between the squared correlation and the total variance explained by the component is calculated for each market segment l, m. This is a simple way to summarize and compare the structures of the components. This part of the analysis uses data for the US four property types and regions and the UK three property types and regions.

US results

The results of the principal components analysis for the USA are shown in Table VII. As expected, for returns, the first component is dominant, accounting for 65.7 per cent of the variance. As none of the other components accounts for more than 10 per cent of the variance, only the first is considered. None of the components has a clear or pronounced dimension which is either property type or region. The correlations with the market are generally high, particularly for offices; there are relatively lower figures for warehouses and retail. This tends to confirm the earlier results that there is limited scope for diversification across regions within offices and R&D/offices, some within warehouses and rather more within retail. However, the comparison is far from conclusive.

The first two components of the excess returns each account for around 20 per cent and the second two each for 10 per cent of the total variance. The first two components are presented for illustration. Again the results show no clear regional or property type dimension and are open to various interpretations. The first and second components suggest little scope for diversification within the office and R&D/office property types respectively. This tends to confirm the

	East	Mid-west	South	West
Returns: component 1 (65.7 per cent variance explained)				
Office	1.32	1.22	0.62	1.19
Retail	0.93	0.70	0.85	1.23
R&D/office	1.11	0.87	0.85	0.96
Warehouses	0.79	0.76	1.07	1.16
Excess returns: component 1 (23.8 per cent of variance explained)				
Office	0.09	0.06	0.00	0.06
Retail	0.97	1.05	1.30	0.05
R&D/office	0.35	0.55	0.18	3.87
Warehouses	0.00	1.09	0.32	0.12
Excess returns: component 2 (21.3 per cent of variance explained)				
Office	0.06	0.08	3.15	0.94
Retail	1.31	1.22	0.07	1.46
R&D/office	0.15	0.08	0.38	0.00
Warehouse	3.00	1.41	0.75	0.70
Residuals: component 3 (11.7 per cent of variance explained)				
Office	0.13	0.65	0.85	1.62
Retail	1.28	0.50	0.37	0.94
R&D/office	3.76	0.04	0.85	0.02
Warehouse	1.03	1.28	1.97	2.56

Note:
Numbers reflect for each market segment *l*, *m* the ratio between the squared correlation the market segment has with a component and the total variance explained by the component. A market segment is defined as one property type in one region

Table VII.
US results of principal components analysis based on quarterly returns, 1983-1992

results of the efficient frontiers analysis. When the analysis is undertaken on the residuals, the first two components each account for around 20 per cent and the second two each for 10 per cent. Whereas no significant conclusion can be drawn from the first two components, the third component suggests little scope for diversification within warehouse property. This is consistent with the efficient frontiers analysis.

When the three analyses are compared, there are some similarities: each has a component which combines warehouses in the East and offices in the South; and each has a component which can be interpreted as R&D/office in the West. Retail is the only property type which does not have a component which either includes or excludes it entirely, which suggests scope for regional diversification within retail property and so tends to confirm the efficient frontiers analysis. As with the efficient frontiers, there is no evidence to suggest that property type or regional diversification should always be preferred over the other. Indeed, as with the efficient frontiers, there is some evidence to suggest that diversification among property types within a region may sometimes be preferred.

UK results

The results of the principal components analysis for the UK three regions and three property types are shown in Table VIII. The first component of the returns accounts for 65.9 per cent of the variance. This component does not have particularly high or low scores for any of the property type/regions, but could be interpreted as London and the South, except London retail, which, since it is significantly affected by tourism, would be expected to have a lower correlation. The overall picture is of a tendency towards regional, rather than property type, components, particularly between the South and London and the North. The retail components are all highly correlated with the market, but the Northern office and industrial markets are relatively lowly correlated. This suggests less potential for diversification within retail property and thus supports the earlier results.

The first component of the excess returns accounts for 44.1 per cent of the total variance. It has high scores for industrials and offices in the North and London retail. In addition, it is similar to the second component of returns. The third component is highly correlated with retail and also industrials in London and the South. The tendency is again towards more potential for

	London	South	North
Returns: component 1 (65.9 per cent of variance explained)			
Industrial	1.23	1.31	0.67
Offices	1.23	1.05	0.61
Retail	0.82	1.02	0.85
Excess returns: component 1 (44.1 per cent of variance explained)			
Industrial	0.34	0.84	1.59
Offices	0.08	0.75	1.70
Retail	1.16	0.57	0.11
Excess returns: component 3 (16.9 per cent of variance explained)			
Industrial	1.95	1.30	0.39
Offices	0.38	0.12	0.04
Retail	1.30	1.42	3.14
Residuals: component 1 (44.4 per cent of variance explained)			
Industrial	0.45	1.33	1.01
Offices	0.00	1.46	0.61
Retail	1.19	0.52	0.90

Table VIII.
UK results of principal components analysis based on semi-annual returns, 1977-1993

Note:
Numbers reflect for each market segment *l*, *m* the ratio between the squared correlation the market segment has with a component and the total variance explained by the component. A market segment is defined as one property type in one region

regional diversification within a property type, rather than property type diversification within a region. For the residual returns, the first component accounts for 44.4 per cent of the variance. It has high correlations with all market segments except for London offices. The pattern is more mixed than for other analyses, suggesting potential for both regional and property type diversification.

When the three analyses are compared, there are some similarities: London retail and London offices are dissimilar from other property type/regions; and Northern industrials and offices are different from the other office and industrial markets. Retail is the only property type which highly correlates with the components but these explain little of the variance. The UK results suggest that diversification within property types and across regions is most effective, while the US results tend to suggest more scope for diversification across property types within regions.

Conclusion and suggestions for further research

The sections above have considered diversification within a real estate portfolio. Three forms of analysis and three data sets covering the USA and the UK at different levels of geographical aggregation were used. The central research issue was whether, starting from one property type in one region, it is more effective to diversify across regions within a single property type or across property types within a region. In general, it is possible to obtain a clearer answer to this question in the USA than in the UK, although the answer varies from property type to property type. For retail property investments, diversification across regions is more effective, while this does not hold for office and office/R&D properties. For the UK, the opposite result was obtained for retail property and diversification across both property types and regions was to be preferred for the other two property types.

The results for the USA suggest that office and office/R&D properties have similar performance across regions, whereas the retail sector has greater diversification across regions. In the UK, for the riskiest portfolios, diversification within London is almost as effective as countrywide diversification.

The results offer some insights into real estate performance and may offer some input into the determination of a diversification strategy for a real estate portfolio. There are two major qualifications on the results. The first is that they are historical results and they may not be a good proxy for the future correlations. Historical returns are unlikely to be a good proxy for future returns and that probably also holds for the correlations calculated between real estate categories. Investigating sub-samples would be a good way to determine the importance of this problem, but more observations are needed to do this properly.

The second qualification is that investors have objectives which are more complex than just the trade-off between the level of period return and the volatility of period return. This is particularly true when the periods, as in this

analysis, are three and six months. Investors may well have longer horizons than that, or may have liabilities to which they must match their assets.

In the review of previous work at the beginning of this study, reference was made to the work undertaken in the USA to devise groupings based on the economic base rather than geographic regions, which would result in greater scope for location diversification. In the UK such work is much less developed in real estate and has focused on the classification of towns. This work has not yet made full use of the research available in economic base theory.

Behind the analysis of regional economic base is the reasonable presumption that similarity in economic structure and performance should lead to similarity in real estate performance. However, such analyses which focus on demand proxies ignore supply or, at best, assume no differences in supply responses across property type or region. Testing the economic base ideas with highly disaggregated returns data is therefore very important. The UK data allow comparisons of the economic similarity of regions and the similarity of property performance. It could be undertaken at three spatial scales: the three regions; the 11 regions; and at town level. It would then be possible to infer from the UK results whether the proxying of real estate performance with economic performance is valid and perhaps at what spatial scale.

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$$\chi^2 = 0.5 \times tr(Z^2) - \text{diag}'(Z)S^{-1}\text{diag}(Z),$$

where $Z = c^{1/2}R^{-1}(R_1 - R_2)$, with R_1 and R_2 the correlation matrices to be compared;

$R = (n_1R_1 + n_2R_2)/(n_1+n_2)$, with n_1 and n_2 the number of observations on which the matrices are based;

$c = n_1n_2/(n_1+n_2)$; and

$S = (\delta_{ij} + r_{ij}r^{ij})$, with δ_{ij} the Kronecker delta, r_{ij} the elements of R, and r^{ij} the elements of R^{-1}.

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Appendix: UK 11 region correlation matrix

	LI	LO	LR	SEI	SEO	SER	EAI	EAO	EAR	SWI	SWO	SWR	EMI	EMO	EMR	WMI	WMO	WMR	WI	WO	WR	NWI	NWO	NWR	YHI	YHO	YHR	NI	NO	NR	SI	SO	SR
LI	1.00	0.77	0.55	0.93	0.78	0.67	0.86	0.43	0.59	0.89	0.61	0.54	0.85	0.41	0.53	0.71	056	0.47	0.70	0.48	0.64	0.61	0.51	0.51	0.69	0.50	0.48	0.61	0.54	*0.26*	*0.20*	0.36	0.38
LO		1.00	0.62	0.80	0.74	0.68	0.63	0.47	0.60	0.79	0.59	0.57	0.65	*0.34*	0.69	0.59	0.55	0.48	0.62	0.40	0.66	0.47	0.46	0.64	0.55	0.43	0.64	0.40	0.43	0.43	*–0.10*	*0.34*	0.50
LR			1.00	0.54	0.48	0.68	0.43	*0.18*	0.63	0.49	0.21	0.65	0.38	*0.00*	0.65	*0.27*	*0.18*	0.48	*0.30*	*0.05*	0.64	*0.27*	*0.08*	0.55	*0.30*	*0.00*	0.73	*0.28*	*0.11*	0.42	*0.00*	*0.27*	0.49
SEI				1.00	0.81	0.73	0.86	0.57	0.64	0.90	0.72	0.59	0.87	0.46	0.57	0.75	0.65	0.52	0.79	0.46	0.64	0.62	0.53	0.59	0.70	0.53	0.43	0.62	0.53	0.35	*0.26*	0.44	0.47
SEO					1.00	0.71	0.74	0.62	0.61	0.72	0.77	0.54	0.70	0.46	0.51	0.59	0.68	0.48	0.67	0.47	0.56	0.42	0.50	0.58	0.50	0.47	0.50	0.39	0.44	0.47	*0.00*	*0.30*	0.39
SER						1.00	0.50	*0.29*	0.85	0.59	0.38	0.83	0.48	*0.04*	0.79	*0.32*	0.39	0.74	0.42	*0.20*	0.77	*0.25*	*0.10*	0.76	*0.29*	*0.06*	0.73	*0.26*	*0.09*	0.65	*0.00*	*0.20*	0.66
EAI							1.00	0.62	0.48	0.83	0.74	0.49	0.91	0.57	0.43	0.76	0.68	0.44	0.82	0.60	0.51	0.67	0.68	0.52	0.79	0.64	*0.31*	0.71	0.68	*0.19*	0.45	0.54	*0.31*
EAO								1.00	*0.28*	0.52	0.77	0.33	0.61	0.69	*0.30*	0.56	0.62	*0.33*	0.63	0.55	*0.18*	0.38	0.53	0.47	0.46	0.55	*0.17*	*0.34*	0.39	*0.34*	*0.19*	0.45	*0.19*
EAR									1.00	0.56	*0.33*	0.86	0.44	*0.07*	0.84	0.38	0.42	0.74	0.38	*0.21*	0.85	*0.27*	*0.16*	0.77	*0.23*	*0.08*	*0.68*	*0.21*	*0.15*	0.71	*0.00*	0.43	0.72
SWI										1.00	0.67	0.49	0.88	0.45	0.54	0.75	0.56	0.37	0.75	0.43	0.62	0.61	0.57	0.51	0.71	0.54	0.37	0.60	0.57	*0.27*	*0.29*	0.44	0.38
SWO											1.00	0.34	0.74	0.67	*0.33*	0.73	0.84	0.37	0.79	0.60	*0.34*	0.52	0.72	0.46	0.60	0.70	*0.22*	0.48	0.57	*0.30*	*0.25*	0.46	*0.34*
SWR												1.00	0.37	*0.08*	0.85	*0.28*	0.36	0.87	0.43	*0.26*	0.75	*0.08*	*0.17*	0.83	*0.15*	*0.06*	0.73	*0.07*	*0.11*	0.68	*–0.10*	*0.27*	0.73
EMI													1.00	0.60	0.39	0.89	0.69	*0.33*	0.82	0.56	0.52	0.77	0.71	0.43	0.86	0.71	*0.22*	0.80	0.75	*0.15*	0.53	0.57	*0.29*
EMO														1.00	*0.13*	0.67	0.57	*0.14*	0.51	0.89	*0.09*	0.52	0.85	*0.12*	0.62	0.91	*0.02*	0.49	0.78	*0.18*	0.35	0.55	*0.08*
EMR															1.00	0.35	0.38	0.73	0.38	*0.30*	0.81	*0.26*	*0.25*	0.79	*0.26*	*0.15*	0.78	*0.22*	*0.19*	0.64	*0.00*	*0.34*	0.68
WMI																1.00	0.73	*0.32*	0.79	0.60	0.48	0.82	0.79	0.33	0.84	0.80	*0.19*	0.77	0.82	*0.16*	0.50	0.67	*0.31*
WMO																	1.00	0.49	0.74	0.61	0.42	0.68	0.63	0.59	0.71	0.68	*0.25*	0.59	0.59	*0.30*	*0.31*	0.46	0.49
WMR																		1.00	0.45	0.36	0.67	*0.22*	*0.22*	0.86	*0.21*	*0.17*	0.69	*0.15*	*0.18*	0.74	*0.00*	*0.23*	0.65
WI																			1.00	0.46	0.47	0.59	0.61	0.57	0.71	0.60	*0.22*	0.63	0.60	*0.18*	*0.31*	0.47	*0.30*
WO																				1.00	*0.21*	0.50	0.83	*0.29*	0.61	0.83	*0.23*	0.46	0.76	*0.33*	0.36	0.49	*0.20*
WR																					1.00	0.40	*0.23*	0.71	0.39	*0.17*	0.68	0.39	*0.26*	0.59	*0.00*	0.41	0.59
NWI																						1.00	0.59	*0.28*	0.92	0.66	*0.15*	0.92	0.70	*0.05*	0.59	0.60	*0.25*
NWO																							1.00	*0.19*	0.70	0.93	*0.16*	0.58	0.93	*0.16*	0.47	0.60	*0.21*
NWR																								1.00	*0.32*	*0.14*	0.70	*0.24*	*0.17*	0.67	*0.00*	*0.30*	0.65
YHI																									1.00	0.76	*0.16*	0.92	0.80	*0.03*	0.63	0.59	*0.27*
YHO																										1.00	*0.00*	0.62	0.91	*0.09*	0.47	0.53	*0.19*
YHR																											1.00	*0.10*	*0.12*	0.65	*–0.30*	*0.21*	0.52
NI																												1.00	0.69	*–0.10*	0.65	0.55	*0.17*
NO																													1.00	*0.08*	0.56	0.61	*0.18*
NR																														1.00	*–0.20*	*0.32*	0.49
SI																															1.00	0.43	*0.02*
SO																																1.00	*0.30*
SR																																	1.00

Notes: Italics indicate insignificance at 5 per cent – L = London, SE = South East, EA = East Anglia, SW = South West, EM = East Midlands, WM = West Midlands, W = Wales, NW = North West, YH = Yorkshire and Humberside, N = North, S = Scotland, I = Industrial, O = Office, R = Retail

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