Homogeneous Commercial Property Market Groupings and Portfolio Construction in the UK

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FORTHCOMING IN ENVIRONMENT AND PLANNING A

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Abstract

Property portfolios are traditionally constructed by diversifying across geographical areas, property types or a combination of both. In the UK it is normal practice to use regions rather than towns or local markets areas as the geographical divisions. In this paper cluster analysis is used to construct homogeneous groups from 157 UK local markets using commercial property returns. The results show strong property type dimensions and only very broad geographical dimensions in the clusters. These clusters are found, generally, to have temporal stability with changes in cluster membership explained by the changing economic geography of the UK. The cluster-derived groupings are used to derive efficient investment frontiers and are compared to frontiers based on conventional heuristic groupings. It is shown that strategies based on parsimonious cluster-based groupings, appropriate for smaller investors, generate results that are comparable to those of conventional groupings and capture the main drivers of property performance.

1. Introduction

Investors, particularly large institutional investors, have increasingly used formal quantitative methods to construct portfolios of assets that optimise expected risk and return.[1] Such allocation procedures are typically based on Markowitzian (or mean-variance) concepts of optimizing the risk-return characteristics of the portfolio. Risk averse investors seek to increase portfolio return and decrease portfolio risk in an efficient manner. Such optimisation procedures aim to identify assets with low correlations to diversify away specific risk, that is,

[1] Clarke (1998) has suggested that pension fund trustees make decisions that are not fully rational in an economic sense. Here, we would emphasise the growing importance of actuarial assessment of investment management and increasing use of top-down optimised asset allocation models in structuring decisions among larger UK insurance companies and pension funds.

volatility unique to particular investment assets. The models identify a set of portfolios - the 'efficient frontier' -that combine assets in an optimal fashion.

When applied to direct (private) investment in commercial property, problems emerge due to the large lot size and indivisibility of most commercial real estate and the lack of individual property data. The average capital value of properties making up the IPD index at May 1998 was £2.6 million (IPD, 1998). As a result, investors have sought to identify homogenous groupings of properties to structure fund allocation. Property portfolios have, thus, traditionally been diversified across property sectors and geographical areas.

Classification of property markets assumes that the chosen groupings define the dimensions of market risk. It implies that, for example, office, retail and industrial markets are influenced differentially by the drivers of property market performance. By diversifying efficiently across those sectors, commonality in returns is achieved. The same applies for geographical or regional diversification and for combined sector-area classifications. If, however, the sector or area groupings used do not define the dimensions of market risk - for example, if the groupings are not homogenous - then optimal diversification will not be achieved. This might be the case where regional boundaries do not fully capture geographical influences on returns.

For the geographical dimension, broad regions are often defined. In the UK, a standard classification is into three 'super regions': London, the 'South' (the rest of Southern England) and the 'North' (the remaining peripheral areas).[2] The US has been divided into the regions of the East, Midwest, West and South. Research has suggested that these broad regions are too heterogeneous to generate substantial diversification benefits. Therefore, researchers and portfolio managers have sought to develop investment strategies which rely on groups which are much more homogeneous than these geographic regions and which would entail more heterogeneity across groups.

A basic idea is to define regions which are based on economic activity rather than on purely geographically-defined borders (see Hartzell *et al.* 1987; Malizia and Simons, 1991; Shulman

[2] In this context, 'North' and 'South' have a specific meaning rather than the more general meaning in 'north-south divide'.

and Hopkins, 1988). Efficient frontiers constructed from these classifications have been shown to dominate traditional geographic classifications in the US. Intuitively, this result is appealing as heterogeneity within the broad geographic regions would be expected.

The 'new regional science' literature places an increased importance on regions in determining economic performance.[3] As Healey notes '*in a world where integrated place-bounded relationships are pulled out of their localities, 'disembodied' and refashioned by multiple forces which mould them in different directions, the qualities of place seem to become more, not less, significant'* (1998, 1531). With technological, political and financial developments providing both greater locational freedom and greater integration, places compete to attract (and retain) firms and for market share in exporting products and services. This literature emphasises the important role played by institutional factors - as Amin and Thrift (1995a) suggest:

'*local institutional thickness can have a decisive influence on economic development … place appears to have become of critical importance as firms gravitate towards localities which offer the best institutional milieu'*. (page 103)

Those institutional structures will, additionally, influence the amount, location and quality of commercial property supplied.

Leitner (1994) attempted to link US office cycles, urban economic development and investment. While finding some convergence in the timing of cycles, she noted differences in cycles arising from city-specific economic and political conditions. Property, in turn, may have an impact on local growth: as Ball and Wood (1996) note, there exists a complex two-way relationship between economic performance and building investment. Turok (1992) listed five ways in which property-led urban regeneration may affect local economic performance: through the direct impact of construction activity, through contributing to growth and expansion of local business, through attraction of inward investment, through positive externalities from an improved physical environment and through facilitating restructuring

[3] For example, see discussions in Amin and Thrift (1995a, 1995b), Cooke *et al.* (1998), Healey *et al.* (1995), Nijkamp (1993), Storper and Scott (1992, 1995).

processes. This last factor would suggest that the changing functions of cities would be reflected in the performance of local property markets.

This has major implications for the definition of regions in structuring portfolio investment strategies. If local institutional factors play a major role in determining economic health, then, in as far as economic well-being drives property market performance, it will not be possible to 'read off' future performance simply on the basis of geography - particularly if the spatial boundaries are those of the static administrative regions. Nor will a functional classification necessarily generate superior results: different institutional structures in similar types of towns may result in quite different spatial outcomes (see, for example, Raco, 1998). Nonetheless, global and national forces are likely to have common impacts both spatially and sectorally, impacts that will be reflected in property market forecasting. Here there is an echo both of Massey's (1979) question '*in what sense a regional problem?*' and her stricture that '*geography matters'* (Allen & Massey, 1984).

Most previous studies have used *a priori* regions as the basis for empirical analysis of diversification benefits. These studies typically rely on economic data to classify and analyse regions. In part, this reflects the paucity of commercial property data at low levels of aggregation. The economic factors used (such as employment levels, industrial structure, output or growth rates) represent drivers of occupational demand for property. However, they neglect the critical supply side in property markets. An analysis based on property performance itself, would capture both supply and demand drivers.

More recently, cluster analysis has been applied to property data in an attempt to construct homogenous property groupings (see Goetzmann and Wachter, 1995a, for the US and Hoesli *et al.*, 1997; Jackson, 1997 for the UK). These cluster studies have not formally tested whether the cluster groupings generated might enhance the performance of a property portfolio through construction of efficient frontiers or comparison with existing, heuristic, classifications.

In this paper, we addresses these issues. A large dataset of property specific information was made available, which permitted analysis of the geographical and sectoral dimensions of diversification. The data were used to construct property market groupings with high levels of

homogeneity within groups and high levels of heterogeneity across groups. The characteristics of the groups were then examined in an attempt to determine the drivers of diversification and to see whether they conformed to the heuristic groupings used in practice. The cluster groups were then used to construct efficient property investment portfolios and the results compared to those for traditional groupings.

An important motivation was to determine whether a more parsimonious grouping procedure could generate results that were comparable to the traditional groupings. This is important in property investment, since many institutional investors (notably smaller pension funds) are unable to construct property portfolios that are diversified across all the traditionally identified sector and regional groupings since this would exceed their capital allocation. If it is possible to define a simpler classification that generates adequate results, then these funds could reach their target property allocations while minimising specific risk.

Unlike the paper by Hoesli, Lizieri and MacGregor (1997), the focus of this paper is on the construction of efficient property investment portfolios, a topic not addressed in the earlier study. Another major contribution of this paper is that the clustering method is refined and applied to a better data set which encompasses two complete property cycles. Moreover, the present analysis is conducted in real terms, which eliminates spurious correlations due to inflation. The clustering results reported in this study should, thus, be more appropriate than the ones reported in Hoesli *et al*.

The remainder of the paper is organised as follows. The next section reviews previous research on property portfolio diversification. Section three describes the data and methodologies employed. Results are presented and discussed in section four. Finally, section five concludes the paper and suggests directions for future research.

2. Previous work

Property portfolios are traditionally diversified across property types and/or geographical regions. Miles and McCue (1982) have shown, for the US, that diversification by property type should be preferred to diversification by geographical region. This conclusion, however,

is based on the use of data for very broad geographical regions (East, Midwest, West and South). Since the study by Miles and McCue was undertaken, several researchers have shown that diversification strategies based on economic regions make it possible to achieve better diversification benefits than strategies based on broad geographical regions.

Mueller (1993), for instance, shows that the efficient frontier based on nine economic categories (mining, government, manufacturing, finance, insurance and real estate, services, transportation, military, farm and diversified) dominates both the four region frontier and an eight region frontier (New England, Mid-Atlantic corridor, Old South, Industrial Midwest, Farm belt, Mineral extraction area, Southern California and Northern California) as suggested by Hartzell, Shulman and Wurtzebach (1987). The conclusion by Miles and McCue (1982) could, thus, be because not enough heterogeneity exists across the four broad geographical regions or that there is too much intra-group heterogeneity.

The need for more refined diversification strategies is clearly confirmed by a recent study at the metropolitan level in the US (Rabianski and Cheng, 1997). Their results indicate that property performance within metropolitan areas is highly heterogeneous and that low or negative correlations exist among most submarkets. A similar result is reported by Malizia (1996) who groups metropolitan warehouse markets based on economic fundamentals.

Similar results have been found for Europe. Hartzell, Eichholtz and Selender (1993) use regional employment characteristics to investigate diversification in European property portfolios. They report that regions with a common specialisation are scattered over Europe and that a large number of regions are internally diverse. This confirms the need to think of geographical diversification not in terms of broad regions but rather in terms of smaller and economically homogeneous areas.

A different aspect of within property portfolio diversification is examined by Eichholtz *et al.* (1995). These authors investigate, for the UK and the US, whether diversification by property type within a region is better than diversification between regions within a property type. They also examined whether diversification by property type or region alone produces much worse results than full diversification by both property type and region. The US results 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 across property types within London is almost as effective as countrywide diversification by region and property type.

Cluster analysis has been used in several real estate studies in order to extract homogeneous groupings. Goetzmann and Wachter (1995a) use rent and vacancy rate data for 22 US metropolitan markets. They argue that diversification across regions can help to reduce the overall risk of a real estate portfolio. The same authors (Goetzmann and Wachter, 1995b) apply clustering techniques to 24 international markets. For the UK, Cullen (1993) analysed IPD data and found that industrial property was relatively homogeneous and that retail property partitions largely in terms of ownership and lease terms rather than location or function. Only office markets showed a clear geographical sub-structure, with City of London offices being distinctive.

Hoesli, Lizieri and MacGregor (1997) use cluster analysis to examine dimensions of diversification in UK commercial real estate markets. The results suggest that property type is the most important dimension in determining different market behaviour. There is also evidence of a geographic factor but one which does not conform to the standard eleven region administrative classification but rather towards the existence of a central London factor. However, unlike the data used in this paper, the data used by Hoesli, Lizieri and MacGregor (1997) covered only the period from November 1977 to May 1995 and so did not cover two property cycles. Also, nominal returns were used which could induce spurious correlations due to inflation.

Cluster analysis is also used by Jackson (1997, 1998) on rental growth data for retail properties in 60 towns and seven clusters are produced. As in the studies by Cullen (1993) and Hoesli, Lizieri and MacGregor (1997), no attempt is made by Jackson to construct efficient property investment portfolios based on the cluster results.

The importance of property type in constructing property portfolios is also reported by Lee and Byrne (1998). These authors construct efficient portfolios based on sectoral, regional and functional classifications. They use the functional classification by Green and Owen (1990) who classify Travel To Work Areas (TTWA) based on *a priori* assumptions about the

importance of an area's urban and regional characteristics. Green and Owen also develop a classification using cluster analysis on variables measuring demand and supply aspects of local labour markets.

Lee and Byrne compare a range of efficient frontiers based on sectors, 'super regions', administrative regions and the Green and Owen functional groups. They find that sector appears to dominate region in defining a portfolio diversification strategy and that certain functional groups outperform conventional administrative regions. They comment that '*the principal issue to be resolved is the development of a set of widely acceptable functional groupings since the evidence now coming forward indicates that such groupings offer generally superior risk/return performance than the static Standard Regional classification widely used in the UK*' (Byrne & Lee, 1998, 52). However, the homogeneity of the Green and Owen groupings with respect to property performance is not tested; nor do Lee and Byrne compare mixed sector-region portfolios.

3. Data and methodology

3.1 Data

The data were provided by CB Hillier Parker and consist of estimated asking (open market) rents and initial yields (capitalisation rates) for carefully defined standardised properties in specified locations in the United Kingdom.[4] In some locations, the rents refer to actual buildings, in others to the asking rent for a typical property. They, thus, represent valuers' views of market conditions based on market knowledge.

[4] The reported rents are "face" rents rather than "effective" rents: that is, they do not incorporate adjustments for differential packages of tenant incentives such as rent free periods or capital allowances. Such tenant incentives vary over time (and increase in value in over-supplied markets). The rental series thus understate the true volatility of rents in the investment market. No local market data on incentive packages or effective rents are available.

Two sets of data were provided. First, published indices were available for the three main property types (retail, offices and industrials) and for ten standard regions of the UK (excluding Northern Ireland). The data exclude shopping centres, mixed use buildings and business space. The South East region is divided into various London sub-regions (depending on the property type) and the 'rest of the South East'. Second, rents and yields for the individual points from which the published series are constructed were provided.

In each case, a hypothetical real returns series was constructed from the rent and yield data.[5] The available data are annual from May 1972, biannual from May 1977 and quarterly from May 1990. In order to construct the longest possible time period covering two complete property cycles, annual May to May series were used.

Five levels of aggregation were used in the returns data:

- the three property types;
- three broad geographical regions[6] as suggested by Key *et al*. (1994);
- a nine group classification comprising the three property types and three regions above;
- a 39 group classification comprising the three property types and the standard regions, with divisions of London;
- and 157 local markets covering the three property types.[7]

In each of the first three cases, the series were constructed from the 39 group classification using constant weights as set out in Hillier Parker (1994). The 157 markets are combined into

[5] CB Hillier Parker produces separate rental value and yield (capitalisation rate) series. The number of points in the indices has changed over the years (Hillier Parker, 1994). To accommodate an expansion of rent points, the method of construction of the rent index was changed in May 1984. Since then, the number of rent points has fallen. The yield series is constructed differently but information is not published.

[6] These are London, the South (the rest of the South East, East Anglia and the South West) and the North (East Midlands, West Midlands, Wales, North West, Yorkshire & Humberside, the North and Scotland).

[7] This is the largest possible number of markets for which a full data series can be constructed for 1972-97.

a variety of groupings (see below) using weights derived from capital values at May 1994 and constrained by the weights used by CB Hillier Parker for the 39 property type/region indices.[8]

3.2 Methodology

Initially, cluster analysis is used to determine relatively homogenous groupings for the various levels of aggregation. For the nine group (three sector by three 'super' regions) and the 39 group (three sectors and a geographical split that is based on the UK standard regions but with more disaggregation for London markets) classifications, cluster analysis is undertaken using the returns data. Separate cluster analyses are carried out using returns, yields and rental data for the 157 local markets. From these a variety of groupings are generated. Some of these are actual cluster groupings, others are simplified versions which conform more to conventional property type and regional definitions. The key cluster solutions are tested for temporal stability by repeating the analysis for the period 1973-1985, covering half the total period and one major property cycle. Any stability between the results for the whole and partial period would provide strong evidence of the importance of the identified dimensions.

The preferred method for the cluster analyses is hierarchical agglomerative clustering which produces nested solutions. The amalgamation rule is Ward's method which uses an analysis of variance approach to evaluate the distances between clusters (see, for example, Everitt, 1974). This distinguishes the empirical analysis from previous property studies. Ward's method attempts to minimise the sum of squares of any two (hypothetical) clusters that can be formed at each step. It is regarded as a very efficient method and, although it has a tendency to produce clusters of small size, no such problem was found in this analysis.

[8] There is no easy way to produce a returns index from the rent and yield data available. A pragmatic approach was adopted of constant weights based on capital value. Actual capital values were adjusted in two ways. First, within each property type, the capital values in each geographical division were scaled so that the total contribution to the property type was the same as in the Hillier Parker Rent Index. Second, the total contribution of each property type was scaled to ensure that the property type contribution was equal to that of the Hillier Parker Rent Index.

The metric used for distance between groups is 1 - Pearson's 'r'. This is used as the objective of the analysis is to combine markets which are most strongly correlated. In concentrating on correlation, the analysis discards information on average historic returns and volatility. This makes it more difficult to generate solutions that, *ex post*, are superior to conventional classifications in constructing efficient frontiers. However, portfolio analysis is forward-looking and expectations based. Sharpe's dictum that historic data are '*reasonably useful for correlations and virtually useless for expected returns*' (Sharpe, 1990) needs to be borne in mind. The optimum number of clusters is assessed using the 'scree' method: when the linkage distance between clusters joined at each stage starts to increase substantially, the clustering is stopped. Although this inevitably involves a degree of subjectivity, no problems of interpretation were encountered.

The investment characteristics of the groupings generated by the clustering procedure are then examined. The indices constructed for the groups (the asset classes) are used as inputs into a Modern Portfolio Theory (MPT) analysis.[9] In this procedure, the means and risks (standard deviations of returns) for each index are used to identify all possible combinations of return and risk for portfolios containing different amounts of these asset classes.[10] For most of these return/risk points, it is possible to increase return for the same risk, or to decrease risk for the same return. So, from the set of all *possible* combinations, the *optimum* combinations are extracted. These points offer the highest return for any given level of risk or the lowest risk for any given level of return. The locus of the optimum points is known as the *efficient frontier*.

Efficient frontiers are constructed for the cluster groupings and the results compared to the conventional portfolio allocation classifications: three sectors, three 'super regions', the nine sector-region grouping and the thirty-nine group sector-region grouping. *A priori*, it is expected that classifications with a large number of groups will dominate those with a smaller number of groups. However, the clustering procedure may enable parsimonious groupings to generate investment returns for a given level of risk that are close to those of conventional classifications with larger numbers of groups.

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[9] This is, in essence, an optimisation problem with a quadratic objective function.

[10] Strictly, MPT requires expected return and risk but it is conventional to use historical measures as proxies.

4. Results

4.1 Cluster analyses

The nine group data

The first cluster analysis was undertaken on the nine group classification produced from the three property types and the three 'super' regions. The preferred four cluster solution is shown in Table 1. For the whole period, 1973-1997, all retail markets are in a single cluster, the northern industrial and office markets are together and the London office market is separate from the other office and industrial markets of southern England. When the analysis is repeated for the first half of the period (1973-1985), the clusters are more sectoral in nature, with retail and industrial markets forming separate clusters and the office markets split into London and the rest. This provides tentative evidence for the growing importance of a north-south divide in property market performance from the 1980s, leading to a stronger geographical component.

< TABLE 1 ABOUT HERE >

This growing importance of a north-south dimension is consistent with research findings in other economic areas, notably unemployment (for example, Brown and Sessions, 1997) and regional income (for example, Johnston *et al.* 1996). This latter study on household incomes concludes that, even allowing for house prices, '*the North-South divide more than doubled over the period* [1979-1991]' (pages 574-5). With much occupational demand for office space in the 'North' coming from business and producer services, it is understandable that industrial and office performance are linked. Central London office performance is closely linked with (international) financial services demand and, hence, is not closely associated with the manufacturing sector. London suburban and southern office performance and the performance of high technology industrial firms in the south of the UK are more likely to move together.

Although consumer behaviour might be expected to be related to regional economic performance (and, therefore, retail markets to exhibit geographical patterns), there are over-arching national factors such as consumer confidence, national house price trends and the level of real interest rates that seem to dominate. The results of the analysis, then, seem to conform to our knowledge of the economic geography of the UK. Green *et al.* (1994) note that the timing of entry into the 1979/80 recession (measured by unemployment change) varied by urban function as much as by geography. Thus, while the north led the south generally, northern service towns entered the recession later than, for example, southern retails. By contrast, entry into the 1989/90 recession was strongly regional. Thus, we would expect the regional dimension to emerge more clearly in property performance in the latter half of our time period. The groupings obtained, then, may form the basis for portfolio strategy.

The thirty-nine group data

The thirty-nine groups are produced by a three sector by thirteen areas (approximately the standard regions but with a finer breakdown of London offices) disaggregation. Once again a four cluster solution appeared to offer the most effective homogenous groupings. However, to provide a direct comparison with the conventional nine group sector-super region classification, the nine factor solution is shown in Table 2. These results refine the broad pattern emerging from the nine groups analysis above.

< TABLE 2 ABOUT HERE >

For the full data series, all retail markets except those in Scotland are in two clusters, which quickly fuse. Office and industrial markets are divided on a north-south basis, although the boundary differs between sectors. For offices, the division is between London and the South East and the rest of the country; East Anglian, East Midland and South Western industrial markets cluster with southern office and industrial, perhaps reflecting their different industrial structures and the spread of high-tech industry and distribution along the communications corridors around London. City offices form a separate cluster which, at the four cluster level, merges with Scottish retail. This cluster merges with the southern office/industrial cluster at

the next step. The grouping of Scottish retail and City offices occurs throughout the analyses with no obvious explanation. Both share high volatility of returns.

Examining the four cluster solution for the first half of the time period, retail markets once again form a separate cluster. Scottish industrial and office markets are distinct; no north-south divide in industrial markets is seen. Office markets in the traditional 'Northern' manufacturing regions of the North, North West, Yorkshire and Humberside and also the East Midlands are clustered with the industrial markets while all other offices form a separate cluster. The substantial UK industrial restructuring which occurred at the end of the 1973-1985 period preceded the major impacts of financial deregulation on the central London office market. Thus, only the office markets of the regions that are still dominated by traditional manufacturing cluster with the industrial markets, while the industrial markets themselves are undifferentiated. In the second half of the analysis period, there has been a north-south divergence in the nature of industrialisation and regional performance, reflected in the cluster analysis. Differentiation may result from the growing divergent performance of traditional manufacturing (peripherally located) and high technology production (concentrated in the radial transport corridors around London) and from the impact of growth in trade with mainland Europe with the Single European Market and the opening of the channel tunnel. At the same time, the City of London office market has separated from other markets, its occupational demand driven by international financial markets, particularly following financial deregulation in the mid-1980s.

Local market cluster analysis

The 157 local markets were clustered using three performance measures: estimated total return, percentage change in yield and percentage rental change. In this paper, the results from the returns-based analysis are reported below. Full results of all three analyses are available from the authors. The yield-based clusters are broadly sectoral in nature. Many of the factors leading to yield shifts are national in nature (interest rates, bond yields, anticipated inflation) or have a property-type component (anticipated growth related to industrial sector performance). By contrast, the rental change solutions are more locally driven, reflecting the importance of supply-side factors: as a result the solutions are more 'noisy'. Some broad regional and local

factors may be discerned (for example, City and West End offices form distinct clusters). The rental and yield analyses point to the very limited value of standard regions in defining a portfolio allocation strategy.

Table 3 sets out the nine cluster solution for the 157 local markets based on returns. The eight cluster solution might be preferred on the basis of scree analysis and a strong case could also be made for a four cluster solution. The clusters have a strong sectoral dimension, reflecting the importance of yield shifts in determining returns. The bulk of retail markets are found in two clusters (clusters 8 and 9) with no obvious geographical, functional or size factors separating them. The two retail clusters fuse at the next step. City offices form a distinct cluster (cluster 3), as do other central London offices (cluster 5). There is a predominantly Scottish retail cluster (cluster 4) and there are two clusters of markets arranged in a ring around the London metropolitan area (clusters 6 and 7). These are split on a sectoral basis between industrial and offices but fuse at the next step to give the eight cluster solution. The remaining industrial and office markets are split into two groups: a northern industrial cluster (cluster 1) which includes the office markets of major industrial cities and a mixed office-industrial cluster in a ring beyond the London fringe (cluster 2).

< TABLE 3 ABOUT HERE >

As these clusters fuse, the sectoral character becomes more clear:

- the London metropolitan fringe office and industrial markets join together (clusters 6 and 7);
- the two retail markets join (clusters 8 and 9);
- the peripheral industrial/office markets fuse (clusters 1 and 2);
- the central London office and fringe London markets combine (clusters 5, 6 and 7); and
- the City of London office and Scottish retail markets fuse (although the cluster is dominated by the City offices) (cluster 3 and 4).

Thus, at the level of detail provided by the 157 separate local markets, a clear pattern emerges showing the dominant effect of property type, the existence of broad north-south divides in

industrial and office markets and evidence of distinct City office and Scottish retail factors. However, there is no evidence of the importance of standard regions nor any obvious differences that relate to town size or function.

To test cluster stability, the returns analysis was repeated for the period 1973-1985. The preferred solution contained five clusters, although a strong case could be made for three. The clusters are:

1. a Scottish, predominantly retail, cluster;
2. a central London office cluster;
3. an industrial cluster (which includes a small number of office markets in towns dominated by manufacturing);
4. a mixed cluster of retail markets and outer fringe offices; and
5. a large retail cluster.

As these fuse:

- the retail cluster remains distinct;
- the central London office markets and the Scottish retail clusters merge; and
- the industrial and mixed clusters merge.

Table 4 shows the relationship between the results for the 1973-1997 (eight cluster) and 1973-1985 (five cluster) solutions. It can be seen that there is considerable stability across the cluster solutions, particularly where the four cluster (1973-1997) and three cluster (1973-1985) solutions are compared. Of the differences between the full solution and the sub-period solution, the most notable is the separation of the City office market from the rest of the central London office market in the full period. This may be attributed to financial deregulation in the second half of the study period. The north-south split in industrial and office markets becomes more clear and is more important than functional splits by city size or type. Thus, for example, the industrial markets of Bristol, Swindon and Northampton emerge as clearly part of the Southern group in the full period analysis: their fortunes linked to high tech production and warehousing along the motorway corridors radiating from London. Retail markets remain distinct and cluster together, with the possibly anomalous exception of Scottish shops which, throughout, group with City offices.

< TABLE 4 ABOUT HERE >

The stability of the broad patterns and the clear links to the changing economic geography of the UK suggest that the classifications, combined with an understanding of the trajectory of the changing pattern of economic activity can substantially contribute to future portfolio construction. The results of the classifications derived from the cluster analyses are now used to construct efficient frontiers and the results compared to those obtained from use of the conventional, heuristic classifications.

4.2 Efficient frontiers

Frontiers using traditional heuristics

Figure 1 shows efficient frontiers based on the returns for classifications using traditional heuristics:

- a three sector classification;
- a three 'super' region classification;
- a nine group classification based on the three property types and three 'super' regions (3x3); and
- the thirty-nine group classification.

As would be expected, the thirty-nine group solution dominates the other three. However, as noted above, most funds would be unable to pursue a diversification strategy based on such a level of disaggregation due to the capital costs involved. The super-regions exhibit little variation in return (implying that sector type is the more important dimension for risk diversification). The three-by-three sector-region solution dominates both sector and region efficient frontiers.

<FIGURE 1 ABOUT HERE >

It should be noted that the 'super' region boundaries produce groupings that are more heterogeneous than those constructed using cluster analysis. The average correlations between

assets (markets) in the 'super' regions are lower than in the more homogenous clusters. As a result, this reduces the measured risk level for each region-sector group due to diversification effects. However, an individual investor is unlikely to be able to diversify fully within a group and hence would face higher levels of specific risk. Thus, the reported risk and return profile is somewhat artificial.

Frontiers using clusters based on the three-by-three sector-regions

Figure 2 shows efficient frontiers for the three-by-three (3x3) sector-region data, and the four cluster solution derived from it. Here, the diversification effects from the large combined groupings result in the frontier for the cluster solution lying very close to the conventional classification efficient frontier, despite the smaller number of groups. However, investors using either the conventional or cluster solution as a basis for fund allocation would face considerable specific risk.

< FIGURE 2 ABOUT HERE >

Frontiers using clusters based on the 39 sector-regions

Figure 3 compares frontiers for the three-by-three sector-region classification and for two nine group cluster solutions derived from the 39 sector-region breakdown. The first grouping is that based on the actual cluster solution; the second is an adjusted grouping where, to conform more with sector groupings, Scottish retail was moved from the London offices cluster to the retail cluster. This adjustment provides a more coherent and intuitive set of groups for portfolio allocation purposes. The actual and adjusted groupings generate very similar frontiers. These dominate the three-by-three sector-region classification for low risk portfolios but are dominated at higher returns.

It should be noted that both risk and return have small ranges, so that the difference between solutions is very small. This relates to the averaging effect of the regionalisation. The group weightings for portfolios on the efficient frontier are similar with a strong bias towards

industrial property. The cluster solutions for low to medium levels of risk split investment between Scottish industrial and office markets, peripheral industrial and office markets and the two retail clusters.

< FIGURE 3 ABOUT HERE >

Frontiers using clusters based on the 157 local markets

Figure 4 examines the efficient frontier for three-by-three sector-region classification compared to the frontiers obtained from the cluster analysis of the 157 local markets. Four cluster-derived frontiers are shown, based on the actual four cluster solution, the actual eight and nine cluster solutions and a simplified six cluster solution. This last is based on the eight cluster solution but reclassifies 'rogue' markets to create a more practical framework for investment. The actual four, eight and nine cluster solutions are set out in Table 3. The simplified six group solution consists of:

1. Scottish retail markets;
2. all remaining retail markets;
3. all City offices (with some South East offices);
4. all other London and South East offices;
5. industrial markets in London, the South East and South West; and
6. all other 'peripheral' industrial and office markets.

The risk axis in the figure has been truncated to the right: for the six, eight and nine cluster solutions, the maximum return portfolio has a high level of risk.

< FIGURE 4 ABOUT HERE >

The eight and nine cluster solutions produce portfolios that are superior to those of the conventional three-by-three sector-region classification at low levels of risk; at higher risk-return levels, the nine group cluster solution extends beyond the conventional classification. In the middle range of risk and return, the three-by-three sector-region classification dominates.

The simplified, practical six group classification is dominated by the conventional solution. The nine, eight and six cluster frontiers are somewhat distorted by the highly volatile behaviour of the Scottish retail markets which make up the maximum return portfolio.

Away from the maximum return portfolio, the nine group cluster solution has high weightings in northern industrial and office markets, in southern (non-London) office and industrial markets and in retail markets (see Table 5). It thus has a wider spread of investment than the conventional nine group solution, according more with intuitive concepts of diversification. The conventional classification, as expected, dominates the four cluster solution.

< TABLE 5 ABOUT HERE >

Figures 5 and 6 examine the local market solutions for two sub-periods, 1973-1985 and 1986-1997 with the same groupings as above. In the first half of the study period, the conventional three-by-three sector-region classification produces a short efficient frontier by comparison to the various solutions based on cluster analyses. Thus, although the frontier is generally to the 'north west' of the cluster solution frontiers, these generate both lower risk portfolios (albeit at low levels of return) and high risk portfolios with far greater average returns. For the less risk-averse investor, the higher return portfolios of the nine-cluster solution might be preferred.

In the second half of the study period, the various frontiers are much more similar in nature. The frontier of the conventional classification is dominated by those of both the eight and nine cluster solutions, but dominates the simplified six cluster and actual four cluster solution. This may suggest that the changing economic geography noted above is reflected in property performance in the latter half of the study period. The cluster analysis has captured these changes and hence offers a more efficient framework for diversification than the conventional three-by-three sector-region basis.

< FIGURE 5 ABOUT HERE >

< FIGURE 6 ABOUT HERE >

Frontiers using revised sector three-by-three sector-region groupings

Based on the cluster results, and their impact on efficient frontiers, two revised three-by-three sector-region classifications were devised.[11] In these cases, the regional groupings differ by sector, reflecting both similarities in performance and changing spatial patterns of economic activity. The classifications are shown below. They differ in their treatment of the office sector. The first classification shows City offices as a distinct category, reflecting the unique nature of the City office market (where occupational and, to an increasing extent, investment demand is a function of international financial activity, distinct from the fortunes of the UK economy). The remaining offices are split into southern and peripheral categories. The second classification groups all London and South Eastern offices together, then separates the office markets of the more prosperous non-south east regions from those of more peripheral regions.

Revised Sector Super-Region Classification 1

1 Shops/London
2 Shops/SE
3 Shops/Other
4 Offices/City
5 Offices/Other London and SE
6 Offices/Other
7 Industrials/London and SE
8 Industrials/Southern and EM
9 Industrials/Northern

Revised Sector Super-Region Classification 2

1 Shops/London
2 Shops/SE
3 Shops/Other

[11] As with the original three-by-three sector-region classification, these are aggregated from the 39 sector region groupings.

4 Offices/London and SE

5 Offices/EA, EM and SW

6 Offices/Other

7 Industrials/London and SE

8 Industrials/Southern and EM

9 Industrials/Northern

Efficient frontiers for these two new classifications were compared to the conventional nine group classification. Figure 7 shows the results for the whole study period, Figures 8 and 9 for the 1973-1985 and 1986-1997 periods, respectively. For the full period, the frontiers are near identical for low to average risk-return portfolios. However, both the two revised classifications extend above the conventional frontier, offering superior high risk-return portfolio performance. All solutions have high weightings in industrial property. The two revised classifications show substantial weightings in London shops in the mid-range risk-return portfolios. Offices only appear in the low risk, low return portfolios, providing some additional diversification gain.

< FIGURE 7 ABOUT HERE >

Dividing the data into two sub-periods produces quite distinct results. In the 1973-1985 period, the frontiers are relatively similar, with the exception of the revised classification 1 at high risk, high return levels, where weightings in the volatile City office market increase towards 100%. Revised classification 2 dominates the standard classification throughout. In the second half of the study period, both the revised classifications dominate the standard classification until they tend toward the highest return portfolio - southern and East Midland industrial (group 8). At this high risk end of the portfolio, there is a wholesale switch from northern industrial (group 9) to southern and East Midland industrial (group 8): the latter group has a zero weight in all other portfolios. In the mid-range portfolios, the weightings of the three classifications are similar to the largest weightings being for northern industrials (group 9) and other shops (group 3). The revised classifications also have relatively high weightings in London shops (group 1). As might be expected, office markets have zero or low weightings.

These are *ex post* groupings: investors would have based their allocations on expectations of performance. Many would not have forecast the poor office returns of the early 1990s. In general, however, these revised three by three groupings offer better performance than the conventional classification, particularly in the second half of the study period. Given that they are informed by the changing economic geography of the UK, they are likely to prove more robust in the future than the conventional three-by-three sector-region classification.

< FIGURE 8 ABOUT HERE >

< FIGURE 9 ABOUT HERE >

5. Conclusions

The analyses presented in this paper shed light on the drivers of commercial property performance in the UK. In structuring commercial property portfolios, property type generally dominates conventional region in diversifying away risk. A geographical dimension does emerge in office and industrial markets; central London office markets (and, in particular, the City office market) behave in a distinct fashion and there is a broad geographical split between office and industrial markets in the immediate fringe of London and all other 'peripheral' markets. Furthermore, the boundaries between London fringe and "peripheral" industrial markets change over time: the edges of the southern area expand reflecting the growth of high technology manufacturing and distribution along the motorways and the importance of accessibility to mainland Europe.

As a result of these sector-specific and local factors, conventional UK administrative and statistical regional classifications do not provide useful information in structuring a portfolio strategy. Nor, it would appear, do typologies of towns by function or size. This finding goes against conventional wisdom in the property market but confirms insights from the new regional science literature emphasising the importance of local institutions and competition between places. Global, national and regional economic and financial forces may thus produce distinct spatial outcomes. Nonetheless, there appear to be strong links between economic activity, location and property market that would enable refinement of a forward-looking portfolio strategy.

Analysis indicates that a heuristic nine group classification of property markets by three property types and three 'super regions' (London, the South East and the Rest of the UK) provides a useful framework for portfolio allocation. However, the resultant groupings are heterogeneous within each group. This generates results which understate the amount of volatility that would be faced by an investor with limited funds. Cluster analysis permits identification of more homogenous groups, clarifies the location of geographical divisions between groups (which differ for office and industrial activity) and enables parsimonious investment strategies to be developed, suited to smaller funds.

The efficient frontiers generated by the cluster groupings are close to, and, in some cases, superior to, those derived from the conventional nine group classification. Since the conventional classification contains more groups than the cluster solutions, the conventional frontiers would be expected to dominate, all things being equal. Using the cluster results to derive revised sector-super region groupings results in superior results and a classification that reflects changes in the economic-geographical factors that drive property markets.

While the results suggest that the cluster-based approach offers a practical route to developing a portfolio strategy, there are limitations that should be stated. As in most commercial property studies, the data are problematic. Rents and yields are based on valuations, not transactions and the rental data omit the impact of tenant incentives. The returns calculated for markets are synthetic and would not be equivalent to those experienced by an investor due to the contractual form of leases. Furthermore, although the 157 markets provide wide coverage, there may be other property markets of interest to investors (a problem in any classification). The generated clusters are not completely stable, although this reflects the changing economic geography of the UK. The study omits property types that are outside the main three sectors. Within the main sectors, finer gradations may be necessary, for example, between town centre offices and business parks, between manufacturing, high-tech and distribution-based industrial space or between town centre and mall shops. Such developments are hampered by lack of data. Finally, it should be emphasised that the analysis has been carried out *ex post*, while portfolio allocation should be expectations-based. This was the reasoning behind concentration on correlation rather than risk and return in the clustering process. Shape's dictum (cited above) suggests that historic returns are of little value in predicting future

returns, but that *ex post* correlations do convey information about the future. The aim is to produce classifications that are useful for structuring future investment decision-making, that aid the construction of efficiently diversified property portfolios and that can be interpreted in terms of the economic structure of the UK.

Further research could seek to explore rental change using urban classifications, in particular, this might enable separation of markets in the retail sector. More detailed study of change in the London office market might help to produce improved divisions in that area. Similarly, the classification of market areas in the South East could be further refined. There appear to be differences between industrial and office market boundaries which may relate to the diffusion of high tech R&D based industrialisation along the motorway corridors out of London. By incorporating the changes in the urban economic system into the classifications of property markets, it may thus be possible to generate frameworks for property investment which reflect the underlying dynamics and drivers of real estate performance.

The study has implications that go beyond the development of effective property portfolio strategies. As Turok (1992), Leitner (1994), van der Krabben & Boekema (1994) and Ball & Wood (1996), amongst others, have noted, there are strong relationships between real estate investment and local economic performance. The results reported here reflect not only the relationship between local supply of and demand for space but also investment flows. As Henneberry notes, property investment has become 'dislocated from users' requirements'. He suggests that, since finance capital is 'far from fully attuned to the behaviour of regional property markets', the timing and amplitude of development cycles do not result from the structure, performance and occupational needs of local industries, but rather the preferences and decisions of major institutional investors and providers of finance and funding. Thus he detects a sequential pattern in the 1980s office boom with London (and, to a lesser extent, Scotland) leading the boom with other regions peaking later.

This investment-led transmission mechanism finds an echo in the work of Martin and Minns (1995), who suggest, in relation to pension funds, that the concentration of economic power in and around London transfers wealth disproportionately to the South East. Martin and Minns attribute this core-periphery tendency to institutional requirements for liquidity, discouraging long-term regional investment. This helps *explain* the results presented here: the clear

emergence of a division in industrial and office markets between core Southern and peripheral areas based on returns reflecting the scale and timing of investment flows and their interaction with local and regional economic performance. However, the efficient frontiers presented here suggest that there are diversification gains to be obtained by a spread of investment across the clusters. Thus, a regionally dispersed investment strategy has both risk-return and policy advantages.

References

Amin A and Thrift N, Eds, 1995a, *Globalisation, Institutions and Regional Development in Europe* (Oxford University Press, Oxford)

Amin A and Thrift N, 1995b, "Globalisation, 'Institutional Thickness' and the Local Economy" in P Healey, S Cameron, S Davoudi, S Graham & A Madani-Pour, *Managing Cities: The New Urban Context* (John Wiley, Chichester, Sussex) 91-108.

Ball M and A Wood, 1996, "Does building investment affect economic growth?" *Journal of Property Research* **13** 115-130.

Brown S and Sessions J, 1997, "A Profile of UK Unemployment: Regional versus Demographic Influences" *Regional Studies* **31** 351-366.

Clarke G, 1998 "Why convention dominates pension fund trustee investment decision making" *Environment and Planning A*, **30**, 997-1015.

Cooke P, Uranga M and Etxebarria G, 1998, "Regional Systems of Innovation: An Evolutionary Perspective" *Environment and Planning A*, **30**, 1563-1584.

Cullen I, 1993, "Cluster analysis and property risk" in The Cutting Edge*: Proceedings of the RICS Property Research Conference*, 1993, pp 21-36 (RICS: London).

Eichholtz P, Hoesli M, MacGregor B and Nanthakumaran N, 1995, "Real estate portfolio diversification by property type and region" *Journal of Property Finance*, **6** 39-59.

Everitt, B (1974) *Cluster Analysis* (Heinemann, London)

Goetzmann W and Wachter S, 1995a, "Clustering methods for real estate portfolios" *Real Estate Economics*, **23** 271-310.

Goetzmann, W and Wachter S, 1995b, "The global real estate crash: evidence from an international database", in *Proceedings of the International Congress on Real Estate*, Volume 3, Singapore, University of Singapore, unpaginated

Green A and Owen D, 1990, "The development of a classification of travel to work areas" *Progress in Planning*, **34** 1-92.

Green A, Owen D and Winnett C, 1994, "The Changing Geography of Recession: Analyses of Local Unemployment Time Series" *Transactions, Institute of British Geographers*, **19** 142-162.

Hartzell D, Eichholtz P and Selender A, 1993, "Economic diversification in European real estate portfolios" *Journal of Property Research*, **10** 5-25.

Hartzell D, Shulman D and Wurtzebach C, 1987, "Refining the analysis of regional diversification for income-producing real estate" *Journal of Real Estate Research* **2** 85-95.

Healey P, 1998, "Building Institutional Capacity Through Collaborative Approaches to Urban Planning" *Environment and Planning A*, **30**, 1531-1546.

Healey P, Cameron S, Davoudi S, Graham S and Madani-Pour A, 1995, *Managing Cities: The New Urban Context* (John Wiley, Chichester, Sussex)

Henneberry J, 1999, "Convergence and Difference in Regional Office Development Cycles", *Urban Studies*, **36** forthcoming

Hillier Parker 1994, Hillier Parker Rent Index Digest, (Hillier Parker, London).

Hoesli M, Lizieri C and MacGregor B, 1997, "The spatial dimensions of the investment performance of UK commercial property" *Urban Studies*, **34** 1475-1494.

IPD 1998, *IPD Monthly Index*, March 1998, (Investment Property Databank, London)

Jackson C, 1997, Establishing a classification of traditional local retail centres, paper presented at the RICS "Cutting Edge" Conference, University of the West of England, Bristol, September 5-6. Available from the Royal Institution of Chartered Surveyors (www.RICS.org,uk/research)

Jackson C, 1998, Classifying local markets on the basis of retail rental growth rates, paper presented at the ARES 14th Annual Meeting, Monterey, California, April 15-18.

Johnston R, McKinney M and Stark T, 1996, "Regional Price Level Variations and Real Household Incomes in the UK 1979-1993" *Regional Studies*, **30**, 567-578.

Key T, MacGregor B, Nanthakumaran N and Zarkesh F, 1994, *Understanding the property cycle* (RICS, London)

Lee S and Byrne P, 1998, "Diversification by sector, region or function? A mean absolute deviation optimisation" *Journal of Property Valuation and Investment*, **16** 38-56.

Leitner H, 1994, "Capital markets, the development industry and urban office market dynamics: rethinking building cycles" *Environment & Planning A* **26** 779-802.

Malizia E, 1996, "Economic fundamentals and the performance of warehouse property in large U.S. metropolitan areas" *Journal of Real Estate Portfolio Management*, **2** 159-168.

Malizia E and Simons R, 1991, "Comparing regional classifications for real estate portfolio diversification" *Journal of Real Estate Research* **6** 53-77.

Martin R and Minns R, 1995, "The spatial structure and implications of the UK pension fund system" *Regional Studies*, **29** 125-144.

Massey D, 1997, "In what sense a regional problem?" *Regional Studies* **13** 233-243.

Massey D, Allen J 1984, G*eography Matters!* (Cambridge University Press, Cambridge)

Miles M and McCue T, 1982, "Historic returns and institutional real estate portfolios" *AREUEA Journal* **10** 184-199.

Mueller G, 1993, "Refining economic diversification strategies for real estate portfolios" *Journal of Real Estate Research* **8** 55-68.

Nijkamp P, 1993, "Towards a Network of Regions; the United States of Europe" *European Planning Studies*, **1**, 149-168.

Rabianski J and Cheng P, 1997, "Intrametropolitan spatial diversification" *Journal of Real Estate Portfolio Management* **3** 129-140.

Raco M, 1998 "Assessing 'institutional thickness' in the local context: a comparison of Cardiff and Sheffield" *Environment and Planning A*, **30**, 975-996.

Sharpe W, 1990, Asset Allocation, in *Managing Investment Portfolios*, Eds J Maginn and D Tuttle, (Warren, Gorham and Lamont, Boston) 7-1 – 7-71

Shulman D and Hopkins R, 1988, Economic diversification in real estate portfolios, *Bond Market Research: Real Estate*, (Salomon Brothers Inc., New York)

Storper M and Scott A, 1992, *Pathways to Industrialisation and Regional Development* (Routledge, London)

Storper M and Scott A, 1995, "The wealth of regions; market forces and policy imperatives in local and global context" *Futures* **27** 505-526.

Turok I, 1992, "Property led urban economic regeneration: Panacea or Placebo" *Environment & Planning A* **24** 361-379.

Van der Krabben E and Boekema F, 1994, "Missing links between urban economic growth theory and real estate development processes" *Journal of Property Research* **11** 111-129.

Table 1: Preferred cluster solution from the nine group classification

(a) (1973-97)

Cluster 1	Industrials/North Offices/North
Cluster 2	Industrials/South Industrials/London Offices/South
Cluster 3	Offices/London
Cluster 4	Retail/North Retail/South Retail/London

Note: the cluster amalgamation proceeds as follows: 2 fuses with 3; then 2&3 with 4.

(b) (1973-85)

Cluster 1	Industrials/North Industrials/South Industrials/London
Cluster 2	Offices/London
Cluster 3	Offices/North Offices/South
Cluster 4	Retail/North Retail/South Retail/London

Note: the cluster amalgamation proceeds as follows: 3 fuses with 4; then 1 fuses with 2.

Table 2: Cluster solutions from the 39 group classification

(a) Nine group (1973-97)

Cluster 1	Industrials & Offices/Scotland
Cluster 2	Industrials West Midlands Industrials Wales Industrials Yorks and Humberside Industrials North West Industrials North
Cluster 3	Offices Yorks and Humberside Offices North Offices North West Offices Wales Offices West Midlands
Cluster 4	Offices/South West Offices/East Anglia Offices/East Midlands
Cluster 5	Offices/Suburban London Industrials/London Industrials & Offices/South East Industrials/South West Industrials/East Anglia Industrials/East Midlands
Cluster 6	Offices/West End Offices/Holborn & Marylebone
Cluster 7	Offices/Central City, London Offices/Fringe City, London Retail/Scotland
Cluster 8	Retail / South East Retail / Inner Suburban London Retail / Outer Suburban London
Cluster 9	All Remaining Retail

Note: the cluster amalgamation proceeds as follows: 3 & 4 fuse; 5 & 6 fuse; 2 joins with 3&4; 8 & 9 fuse; 1 joins with 2,3 & 4; 7 joins with 5 & 6; 5, 6 & 7 join with 1,2,3 & 4. The preferred four cluster solution, then, is A: clusters 1,2,3; B: clusters 4 & 5; C: cluster 7; D: clusters 8 & 9.

(b) 1973-85 four cluster solution

Cluster 1	Industrials & Offices/Scotland
Cluster 2	All Industrials except Scotland Offices/East Midlands Offices/Yorks and Humberside Offices/North West Offices/North
Cluster 3	All other offices Retail/Scotland
Cluster 4	All retail except Scotland

Note: the cluster amalgamation proceeds as follows: 1 fuses with 2; then 1&2 fuses with 3.

Table 3: Preferred cluster solution from the 157 local markets using percentage return

Cluster 1 Northern Industrial & Office	Industrials/North West (Liverpool; Manchester) Industrials/Yorkshire and Humberside (Leeds; Sheffield) Industrials/North (Middlesbrough; Newcastle Upon Tyne) Industrials/Scotland (Dundee; Edinburgh; Glasgow; Offices/East Midlands (Leicester) Offices/North West (Liverpool) Offices/Yorkshire and Humberside (Sheffield) Offices/North (Middlesbrough; Newcastle Upon Tyne)
Cluster 2 Peripheral Office & Industrial	Industrials/South East (Southampton) Industrials/East Anglia (Norwich) Industrials/East Midlands (Nottingham; Northampton) Industrials/West Midlands (Birmingham; Leamington) Industrials/Wales (Cardiff) Offices/South East (Maidstone) Offices/South West (Bristol) Offices/East Anglia (Cambridge; Norwich) Offices/East Midlands (Nottingham) Offices/West Midlands (Birmingham) Offices/Wales (Cardiff) Offices/Yorkshire and Humberside (Leeds) Offices/North West (Manchester) Offices/Scotland (Edinburgh; Glasgow; Shops/North West (Runcorn)
Cluster 3 City Offices	Offices/Fringe City of London (City Road South; Fleet Street; Holborn Viaduct; Minories; Southwark (Prime); Offices/Central City of London (Bishopsgate; Cannon Street; Cheapside; Fenchurch Street; Leadenhall Street; Lombard Street; Moorgate; Queen Victoria East)
Cluster 4 Scottish	Industrials/Scotland (Aberdeen) Offices/Scotland (Aberdeen) Shops/Scotland (Aberdeen; Ayr; Dundee; East Kilbride; Edinburgh;

Retail	Glasgow; Hamilton; Kirkcaldy; Paisley) Offices/South East (Brighton; Southampton)
Cluster 5 Central London Offices	Offices/Fringe City of London (Clerkenwell Road) Offices/West End of London (Belgravia; Berkeley Square House; New Bond Street; Oxford Street West; Regent Street; Victoria Street) Offices/Holborn and Marylebone (Baker Street; Bloomsbury; Euston Road; Great Portland Street; High Holborn; Kingsway; Marylebone Road; Theobalds Road; Tottenham Court Road; Offices/West End of London (Brook Street; Curzon Street; St. James)
Cluster 6 London Fringe Mainly Offices	Industrials/South East (Watford) Offices/Outer Suburban London (Bromley; Croydon; Ealing Broadway; Harrow; Romford) Offices/South East (Horsham; St. Albans; Watford) Offices/West Midlands (Solihull) Shops/Outer Suburban London (Bromley) Shops/South East (Watford) Shops/East Anglia (Bury St. Edmunds)
Cluster 7 London Fringe Mainly Industrial	Industrials/Outer Suburban London (Croydon; Enfield; Feltham) Industrials/South West (Bristol; Swindon) Industrials/East Midlands (Northampton) Industrials/South East (Basingstoke; Maidstone) Shops/Inner Suburban London (Peckham)
Cluster 8 Retail - I	Offices/Outer Suburban London (Kingston On Thames) Shops/Central City of London (Cheapside) Shops/West End of London (Kensington High Street; Kings Road - Chelsea; Victoria Street) Shops/Inner Suburban London (Wood Green) Shops/Outer Suburban London (Ealing Broadway; Hounslow; Ilford; Orpington; Ruislip; Wembley) Shops/East Midlands (Northampton; Nottingham)

	Shops/Wales (Cwmbran; Merthyr Tydfil) Shops/Yorkshire and Humberside (Hull) Shops/North West (Blackpool; Manchester)
Cluster 9 Retail - II	Offices/South East (Basingstoke; Guildford; Reading) Shops/West End of London (Brompton Rd and Knightsbridge; New Bond Street; Oxford Street West; Regent Street; Shops/Inner Suburban London (Lewisham) Shops/Outer Suburban London (Croydon; Kingston on Thames) South/South East (Ashford Kent; Basingstoke; Brighton; Colchester; Guildford; Horsham; Newbury; Southampton; Southend) Shops/South West (Bristol; Gloucester; Plymouth; Taunton) Shops/East Anglia (Norwich) Shops/East Midlands (Leicester) Shops/West Midlands (Birmingham; Shrewsbury; Tamworth) Shops/Wales (Cardiff) Shops/Yorkshire and Humberside (Dewsbury; Leeds; Sheffield; York) Shops/North West (Blackburn; Liverpool) Shops/North (Durham, Middlesbrough, Newcastle Upon Tyne)

Note: Cluster 6 and cluster 7 fuse at the next stage to give the preferred eight cluster solution. Thereafter, clusters 8 & 9 fuse; clusters 1 & 2 fuse, cluster 5 joins with 6 & 7; clusters 3 & 4 fuse; 3 & 4 join with 5, 6 & 7; 1 & 2 join with 3,4,5,6 & 7. Finally, the two retail clusters, 8 & 9 join with the other clusters.

Table 4: Comparison of market return cluster membership, 1973-1997, 1973-1985

		1973-85					
		3	**4**	**2**	**1**	**5**	**Total**
1973-97	**1**	12	1		1		14
	2	7	6	2	3	1	19
	3			12	1		13
	4	1			12		13
	5			19			19
	6	8	10	3		1	22
	7		5	1		13	19
	8		2	1		35	38
	Total	28	24	38	17	50	157

The clusters are:

1973-1997:

1. Northern Industrial and Office
2. Peripheral Office & Industrial
3. City Offices
4. Scottish Retail
5. Central London Offices
6. Mixed London Fringe
7. Retail - I
8. Retail - II

1973-1985:

1. Scottish, Mainly Retail
2. Central London Offices
3. Industrial & Northern Offices
4. Mixed Fringe & Retail
5. Retail

Table 5: Portfolio weightings on the efficient frontier: nine cluster solution

RISK	RETURN	W[1]	W[2]	W[3]	W[4]	W[5]	W[6]	W[7]	W[8]	W[9]
0.147	0.165	36.4	0	0	0	0	0	28.0	35.7	0
0.148	0.173	42.9	5.3	0	0	0	0	36.0	15.8	0
0.152	0.180	47.4	7.8	0	0	0	7.6	37.2	0	0
0.158	0.187	50.5	10.5	0	0	0	14.3	19.3	0	5.4
0.166	0.194	51.9	12.7	0	0	0	15.9	4.1	0	15.4
0.175	0.202	51.5	12.8	0	7.2	0	0	0	0	28.5
0.193	0.209	38.2	0	0	23.3	0	0	0	0	38.5
0.219	0.216	12.3	0	0	40.1	0	0	0	0	47.6
0.256	0.224	0	0	0	65.9	0	0	0	0	34.1
0.319	0.231	0	0	0	100.0	0	0	0	0	0

Key: W[1] is weight (%) in Cluster 1, and so on.

The clusters are:

1. Northern Industrial & Office
2. Peripheral Office & Industrial
3. City Offices
4. Scottish Retail
5. Central London Offices
6. London Fringe, Mainly Offices
7. London Fringe, Mainly Industrial
8. Retail - I
9. Retail - II

Figure 1: Efficient frontiers based on heuristic classifications, 1973-1997

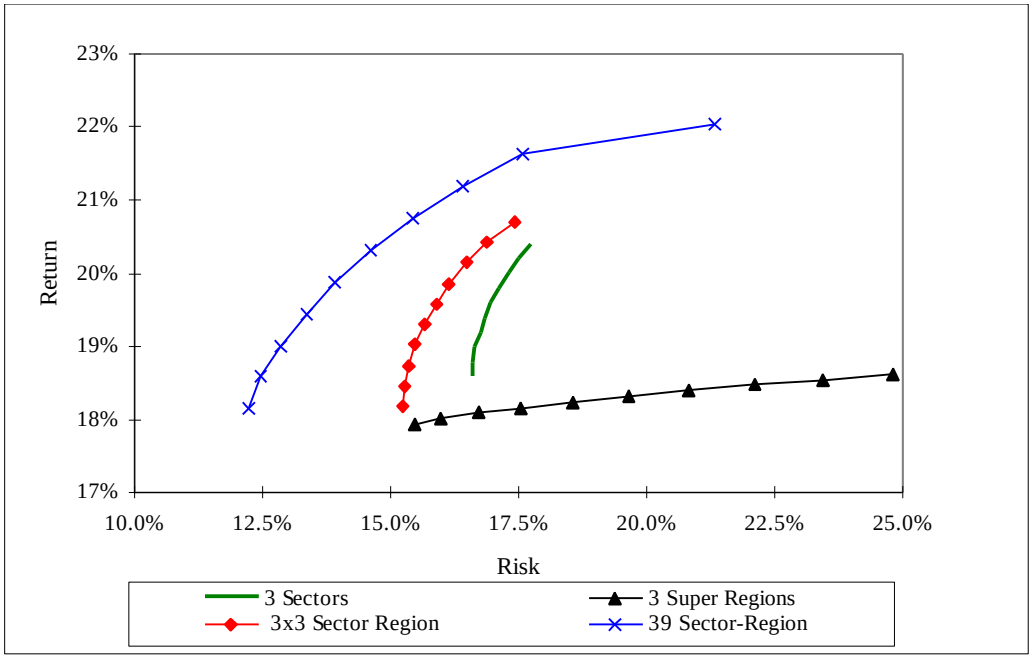

Figure 2: Efficient frontiers based on the 3 by 3 sector region classification and four cluster solution, 1973-1997

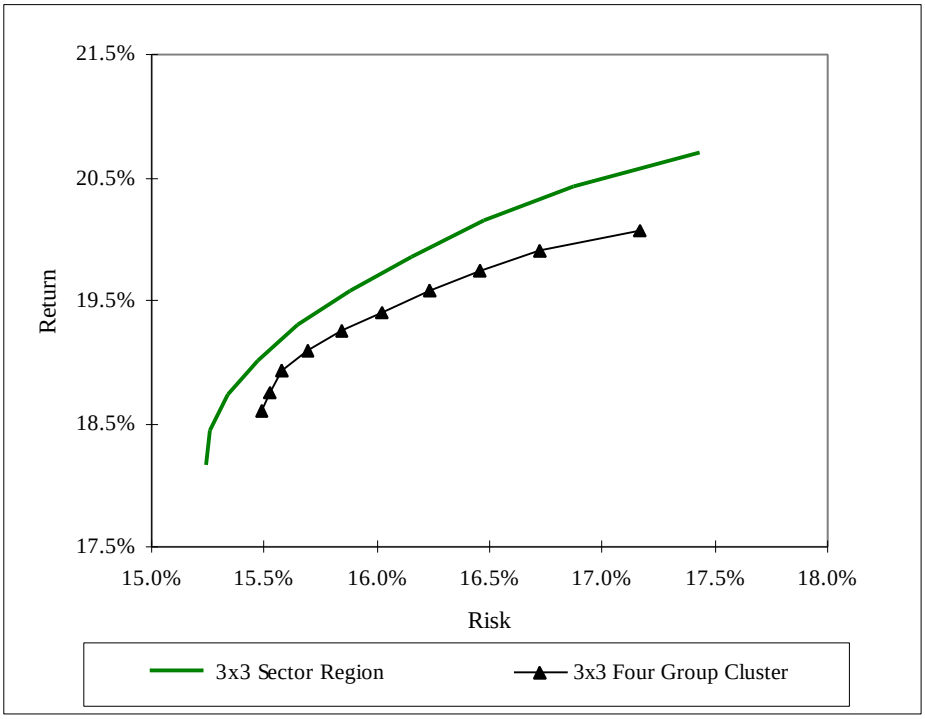

Figure 3: Efficient frontiers based on 3 by 3 sector region classification and two nine-cluster solutions, 1973-1997

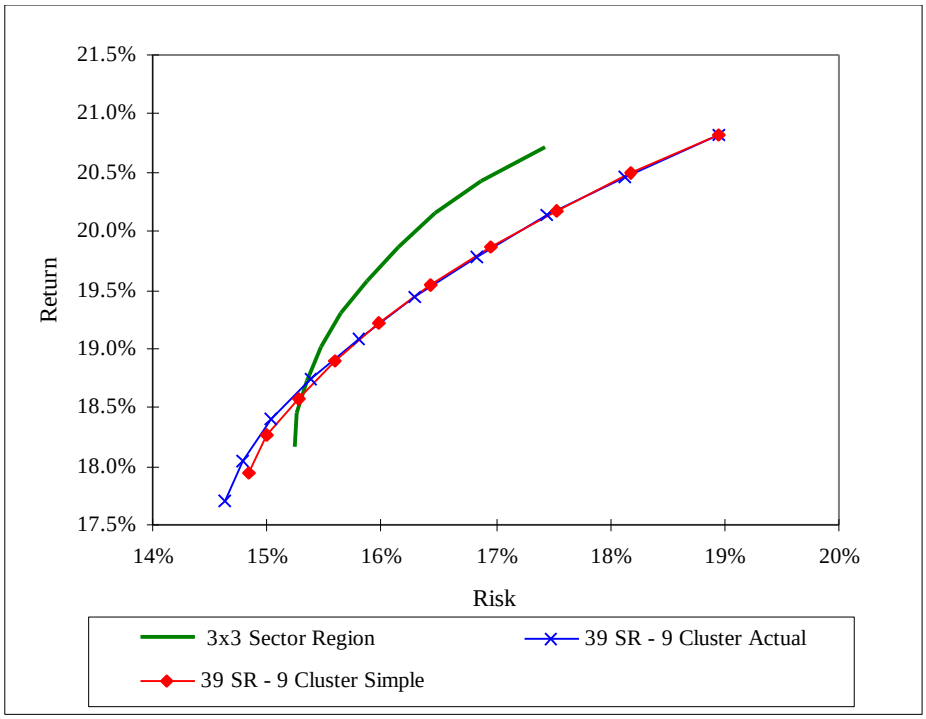

Figure 4: Efficient frontiers, 3 by 3 sector region classification and local market cluster solutions, 1973-1997

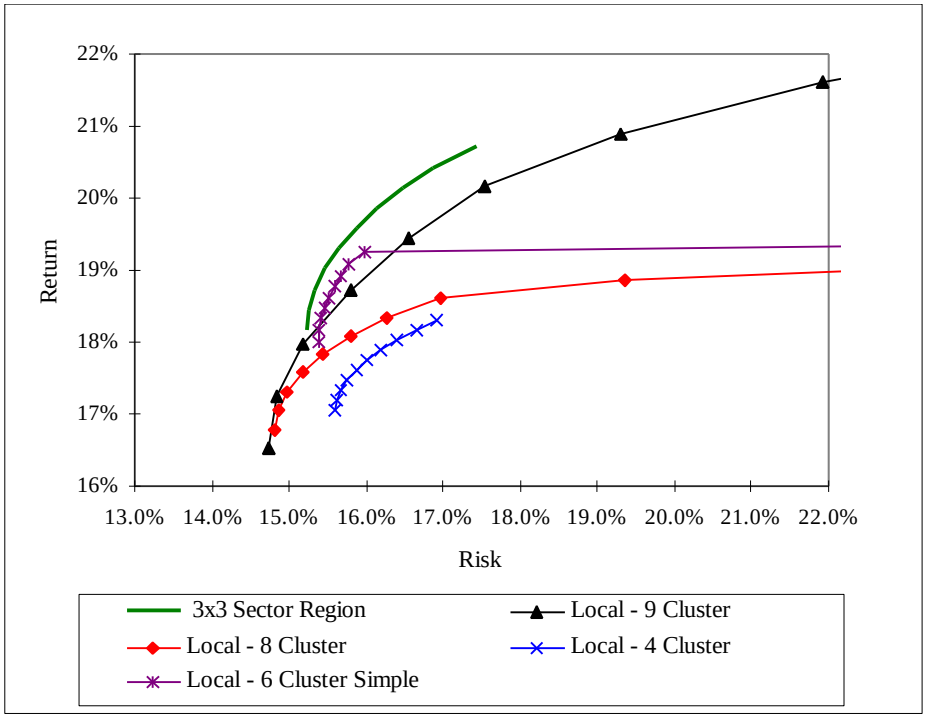

Figure 5: Efficient frontiers for local market solutions, 1973-1985

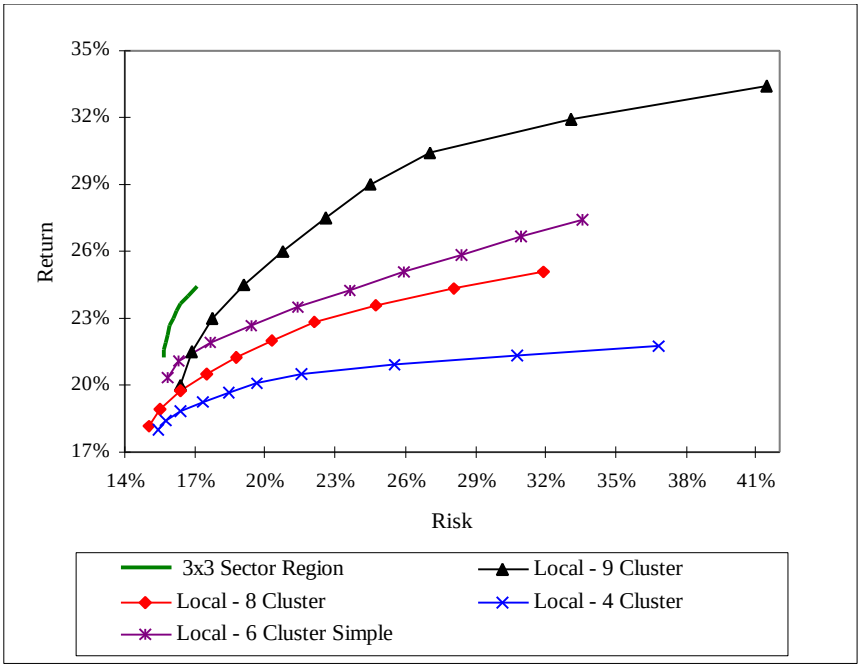

Figure 6: Efficient frontiers for local market solutions, 1986-1997

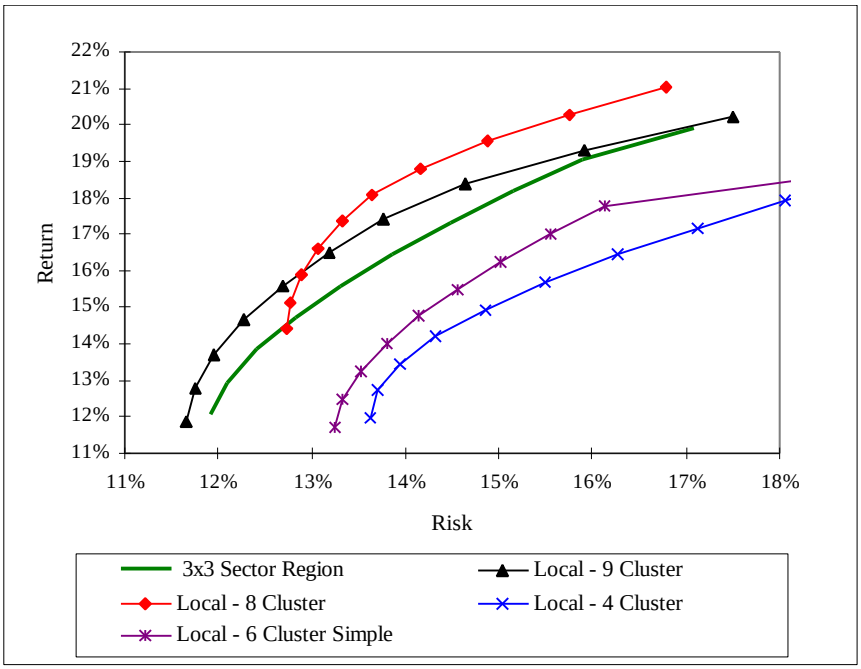

Figure 7: Conventional and revised 3 by 3 sector-region frontiers, 1973-1997

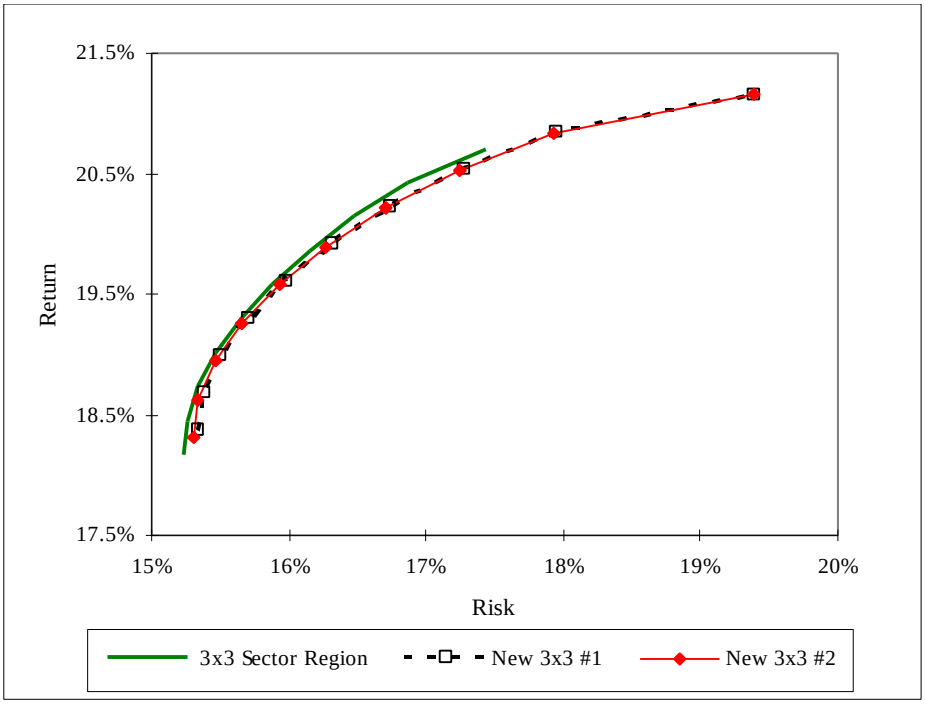

Figure 8: Conventional and revised 3 by 3 sector-region frontiers, 1973-1985

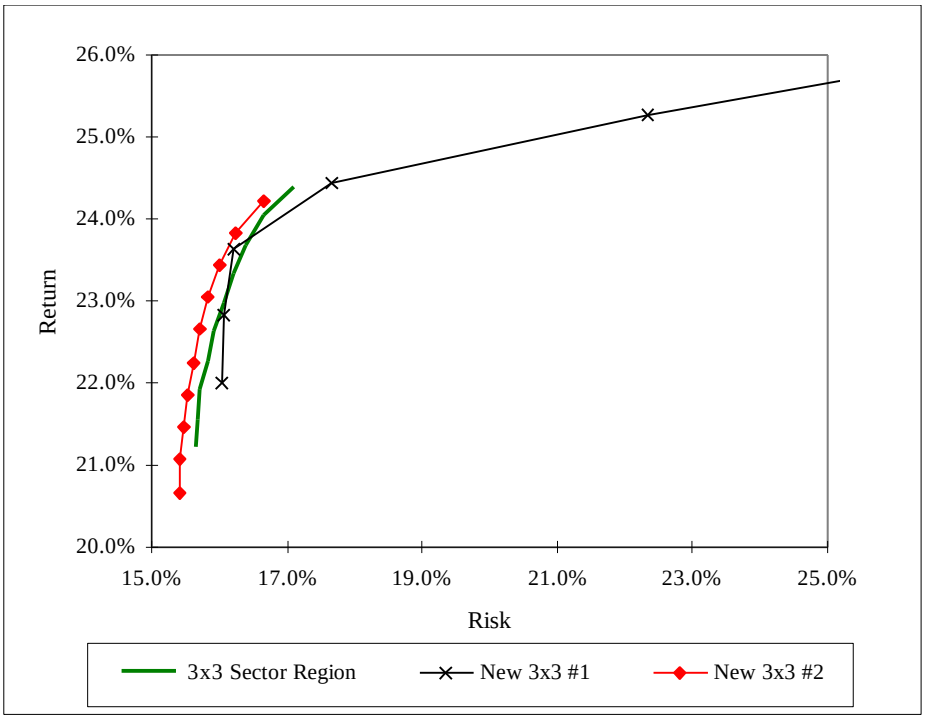

Figure 9: Conventional and revised 3 by 3 sector-region frontiers, 1986-1997