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Elias Oikarinen – Henri Asposalo

HOUSING PORTFOLIO DIVERSIFICATION POTENTIALS IN THE HELSINKI METROPOLITAN AREA IN THE SHORT AND LONG HORIZON

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ABSTRACT

This study aims to examine housing portfolio diversification potentials in the Helsinki Metropolitan Area in the short and long run. The data used in the analysis consist of all the flat sales in the area from 1985 to 2002. The region is divided into 13 submarkets based on geographic and housing market factors. The risk diversification potentials inside the Helsinki Metropolitan Area and across the country are analysed based on quarterly return time series constructed for each submarket and 13 major Finnish cities. Quarterly correlation analysis implies that it is possible to gain relatively large diversification benefits by diversifying housing investments inside the Helsinki Metropolitan Area. However, analysis based on quarterly returns may be misleading because housing is typically long-term investment. Longer-horizon capital return correlations indicate equally negligible long-horizon geographical diversification potentials inside the Helsinki Metropolitan Area and across Finland. This unexpected result is studied further by employing cointegration analysis. According to the cointegration analysis housing prices are, in the long run, much more tightly linked in the Helsinki Metropolitan Area submarkets than in the major cities across the country. Hence, the long-term diversification potentials inside the Helsinki Metropolitan Area are weaker than across the country.

Keywords: Housing, investment, diversification, cointegration, predictability

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1 INTRODUCTION

According to the modern portfolio theory (MPT) investors should select the best combination of investment media to either maximise return for a given level of risk or minimise risk for a given level of return. The MPT is based on the fact that by diversifying portfolio into multiple assets one can achieve the same expected return with lower level of risk or a higher expected return at the same risk level. This diversifying effect exists because the returns on different assets do not correlate perfectly with each other. This is due to the unsystematic factors that influence the returns of different assets.

The analogue of diversifying portfolio risk applies also to housing investments. One logical method for diversifying property portfolio is to invest in properties that are located in different geographical areas. This can be done by investing in different countries, different areas inside one country or different submarkets inside one metropolitan area. Naturally, all these geographical diversification methods can be used together as well. Diversification across national borders can be assumed to work because of exchange rate fluctuations and because of differences in economic structures that affect the business cycles. Regional differences in social and economic structures can make regional diversification obtainable also inside a country. The idea of diversification possibilities inside a metropolitan area is perhaps not as obvious. Nevertheless, one can expect that even in a geographically small metropolitan area changes in submarket factors such as reputation, services, employment and studying possibilities, traffic connections and crime level of the sub area may cause correlation of the housing returns between different submarkets to be sufficiently low for significant diversification possibilities. Intracity diversification is made attractive by the information and management efficiencies gained by concentrating investments in only one metropolitan area. However, there has still been very little study of real estate intracity diversification although researchers agree that the real estate market is a local market, and a metropolitan area contains many distinct markets. Major reason for the small number of studies in this area has been the lack of sufficient data to do such research.

From a Finnish property investor's point of view the Helsinki Metropolitan Area (HMA) is the most interesting area with respect to intracity diversification. In Helsinki and in its neighbouring cities, Vantaa, Espoo and Kauniainen there are altogether about one million inhabitants, which makes this area by far the biggest urban area in Finland. We may assume that this, in turn, makes the diversification possibilities inside the area much more significant than in any other urban area in Finland. Furthermore, a major part of Finnish housing investments is located in this area. The fact that the correlation coefficients of the housing property returns between the biggest cities in Finland have been relatively high makes the analysis of intracity diversification possibilities very interesting.

This study aims to examine from a Finnish real estate investor's point of view the attractiveness of concentrating housing investments in the Helsinki Metropolitan Area using data from 1985 to 2002. The short-term analysis is based on the basic methods of the MPT, namely the traditional mean-variance analysis with calculations of efficient frontiers. Direct housing investments, however, have certain restrictive characteristics with respect to the MPT. First, the MPT assumes that transaction or information costs do not exist. In reality these costs are substantial in housing investments. Second, the theory assumes that all the assets are perfectly dividable. However, dwellings are very large (expensive) and undividable units. Because of the lack of divisibility a large amount of capital is needed in order to diversify a housing portfolio properly. The large unit size together with the heterogeneity of housing makes housing a highly illiquid asset.

These problems do not eliminate the diversifying possibilities of housing portfolio as such. Nevertheless, the illiquidity and high transaction costs of housing make direct housing investments mainly long-horizon investments. The classic results of Samuelson (1969) and Merton (1969) showed that if asset returns are independently and identically distributed (i.i.d.), an investor with power utility who rebalances his portfolio optimally should choose the same asset allocation, regardless of investment horizon. More recent research, however, has shown that predictability in asset returns may lead to strong horizon effects (see e.g. Balduzzi - Lynch, 1999; Lynch – Balduzzi, 2000; Barberis, 2000; Campbell – Viceira, 2002). Due to the inefficiencies mentioned above it is likely that housing returns in Finland are, in fact, predictable so that a long-term investor should not make the same choices as a short-term investor. Furthermore, return predictability makes the traditional unconditional mean-variance analysis invalid both for short- and long-horizon investors. In addition, in a number of studies it has been found that despite relatively small short-term return correlations two return indices may have such long-run relationship that the long-horizon diversification potentials are negligible[1]. It is likely that housing returns between many areas, especially inside a geographically small area such as the HMA, exhibit long-term relationship. Consequently, major part of this study is especially devoted to examining the long-run interdependencies between different housing markets and evaluating their implications for portfolio diversification.

The long-term relationships are analysed employing cointegration tests. Cointegration between two markets implies that they are tied together by some common factor or factors so that the long-term diversification benefits gained by holding housing from both of these markets in the portfolio are reduced. For an investor interested in long-horizon diversification benefits it is therefore relevant to examine whether different markets are cointegrated or not. In this paper attention is given also the specification of deterministic variables to be included in the cointegration tests. This has not been done in similar studies before. We argue that neglecting careful selection of deterministic variables may lead to finding too few cointegrating relationships that are of significance to long-term diversification potentials.

The next section of the paper proceeds with a review of relevant literature. In the third part the data is described. This is followed by a section studying correlations and efficient frontiers. After this cointegration tests are applied to examine the long-run relationships between housing price movements in different areas. The implications of the long-run relationships for long-term diversification potentials and asset allocation are also discussed. In the end conclusions are derived from the analysis.

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[1] Among such studies are e.g. Grubel - Fadner (1971), Taylor - Tonks (1989) and Allen - MacDonald (1995) concerning equity markets, Smith (2002) concerning bonds, and Tarbert (1998), and Kleiman et al. (2002) concerning commercial real estate.

2 LITERATURE REVIEW

Due to the growth, integration and deregulation of the world financial markets, a growing interest towards international real estate portfolio diversification emerged in the 1990s. For example studies by Gordon (1991), Eichholtz (1996), Newell and Webb (1996), Pagliari et al. (1997) and D'Arcy and Lee (1998) have presented evidence in support of internationally diversifying portfolios composed of real estate only. Empirical research suggests, however, that the additional information and management costs associated with direct international property investments provide an important barrier to diversifying direct property investments across borders (see Worzala, 1994; Newell – Worzala, 1995).

The benefits of geographic diversification of property portfolio inside national borders have been systematically examined since the beginning of the 1980s. Miles and McCue (1982) divided the United States into distinct, yet arbitrary regions. They concluded that diversification by property type was more effective than geographic diversification. Follow-up research by Hartzell et al. (1986), which was based on longer time series and more robust sample of properties, however, reached the opposite conclusion. Later the use of eight regions produced only marginal improvement (see Hartzell et al., 1987).

The somewhat disappointing results regarding geographic diversification led to the so-called economic-base thinking. Grissom et al. (1987) claimed that while property returns are different in various geographic regions of the country, the reason is due to the fundamentally different economies of the regions as opposed to arbitrary drawn lines on a map. Since then the effectiveness of economic-based diversification has been tested in a number of articles. Mueller and Ziering (1992) were the first to completely remove arbitrary geographic boundaries in their analysis. The results have been encouraging. Economic-based diversification has been found to be a superior diversification strategy (e.g. Mueller – Ziering, 1992; Mueller, 1993; Williams, 1996). Furthermore, Ziering and Hess (1995) showed that the use of a broad-based, socio-economic approach to defining market groups for diversification purposes may make the property portfolio diversification even more effective.

The encouraging results concerning diversification based on economic and social factors opened a question of whether diversification within even more narrowly defined areas can produce significant reduction in real estate portfolio risk. Early work examining the market segmentation and diversification potentials on an intra-region basis was done by Grissom et al. (1987). They studied industrial real estate market segmentation and valuation using the Arbitrage Price Theory and concluded that a submarket orientation, rather than an integrated perspective, is more appropriate in predicting returns on industrial property. Grissom et al. (1991) demonstrated potential benefits for spatial diversification across intra-regional markets using variance and regression analysis to analyse data from Austin, Houston, Dallas and San Antonio in the United States. They did not, however, examine the main factor determining the diversification potentials, i.e. correlations between the sub areas. More recently the subject has been studied by Rabianski and Cheng (1997), Wolverton et al. (1998) and Brown et al. (2000). Rabianski and Cheng found low vacancy rate correlations for office and industrial properties in intracity submarkets in Atlanta, Boston, Chicago and Dallas. The results of Wolverton et al. based on vacancy and rental data implied significant risk reduction opportunities from investing in apartments located in different parts of Seattle. The paper by Brown et al. was one of the first studies to examine the intracity diversification possibilities outside the United States. Using transactional panel data for office and housing property in Hong Kong their evidence was only mildly encouraging. However, the authors noted that using more narrowly defined submarkets and constructing such submarkets that the economic homogeneity within and heterogeneity between the submarkets are increased could produce stronger results.

All the studies reported above are based on short-term fluctuations in real estate returns and thus investigate diversification benefits for relatively short-horizon investors. However, Grubel and Fadner (1971) already showed that asset return correlation can be an increasing function of holding period. In addition, correlations exhibit instability over time and are therefore problematic for investors with longer investment horizons. Consequently, cointegration analysis has been utilized in many studies to analyse long-term diversification potentials. The basic idea is that the existence of cointegration between two asset markets suggests that in the long run their returns will be highly correlated, even though they may diverge in the short run. An early study using cointegration techniques to investigate long-term diversification potentials was done by Taylor and Tonks (1989). Since that cointegration analysis has been employed to examine long-horizon diversification possibilities by e.g. Chan et al. (1992), Kasa (1992), Allen and MacDonald (1995), DeFusco et al. (1996), Markellanos and Siriopoulos (1997), Kanas (1998), Neih and Tsangyao (2003), and Rutledge and Karim (2004) concerning stock markets, Smith (2002) concerning bond markets, Tarbert (1998), and Kleiman et al. (2002) concerning commercial property markets, and Glascock et al. (2000) incorporating multiple asset classes in the analysis. Research on the long-run diversification of real estate portfolio has so far been limited even though this kind of research is particularly important concerning real estate — after all, direct real estate investment is typically long-horizon investment due to its characteristics. This study contributes to this area by studying the long-horizon housing portfolio diversification potentials inside the HMA and across Finland.

To sum up, only a little is still known about intracity real estate diversification. Further research is necessary for several reasons. First, knowledge of the possibilities of intracity diversification is important because of the potential benefits gained by reducing both information and management costs by concentrating investments in smaller and fewer geographical areas. Exploring the diversification possibilities within metropolitan areas may enable property investors to achieve the same goal at a lower cost. Second, viewing metropolitan areas as homogeneous property markets may result in misdirected investment strategy. This is because relying on solely aggregated data ignores the heterogeneity of different sub areas. Third, it seems clear that the benefits of intracity diversification are likely to vary widely across cities. Fourth, property is typically long-term investment, which gives rise to the need to analyse long-horizon diversification opportunities more carefully. This paper brings further evidence on this area.

3 DATA

As in the study by Brown et al., only transactional data is used in the analysis. This is due to lack of rental and cost data for different sub areas in the HMA. We believe, however, that price movements work as a good proxy for analysing diversification potentials of housing. This view is supported by the fact that price movements have been by far the most significant factor causing geographical differences in residential property returns in Finland during the sample period. Indeed, the total return correlations between 13 major Finnish cities have been almost exactly the same since 1985 as the capital return correlations.

The data used to examine the intracity diversification effectiveness consists of all the flat sales in the HMA from 1985 to 2002. There are about 245 000 observations altogether. Some exceptional sales are withdrawn from the data. These Finnish social housing sector sales and sales that are significantly undervalued (often sales between relatives) are less than one percent of the whole data, nevertheless. The prices are measured as euros per square meter. The data has been gathered by Statistics Finland and is based on stamp duty information. Similar data is also used to form house price time series for the biggest cities in Finland. These cities, however, are not divided into several submarkets — each city is viewed as one market in the analysis.

There are three reasons for using only flats in the analysis. First, flats are in general more homogenous group in their characteristics than row houses or detached houses. This decreases the heterogeneity problem associated with housing. Second, Finnish housing investors mostly invest in flats. This is mainly because of better liquidity and easier maintenance of flats compared to row houses or detached houses. Third, using all the sales might give us a wrong picture about the correlations between the areas: there are significant differences in the composition of the total housing stock in different areas — in some sub areas almost all the sales consist of flats but in some other areas the housing stock mainly consists of row houses and detached houses. Thus, big part of the differences in returns might actually be explained by property type diversification, not by geographical diversification, which is the interest in this study.

There are several alternative methods for defining submarkets. A submarket is typically defined as a set of dwellings that are reasonably close substitutes for one another, but relatively poor substitutes for dwellings in other submarkets (Grigsby et al., 1987). This definition leads to a difficult question about identification of close substitutes. In practice, the splitting of larger market into smaller submarkets is often carried out in an *ad hoc* manner, using predefined or otherwise convenient geographical boundaries. There is no reason, however, to be confident that the resulting submarkets are defined in an optimal or even satisfactory way. An alternative way is to use more systematic methods using the data available. Such methods used for defining submarkets are, for example, the principal component analysis and cluster analysis. (Bourassa et al., 1999.) Furthermore, Bourassa et al. (1999) have used the principal component analysis, cluster analysis and hedonic pricing techniques together to construct, test and analyse submarkets.

In this study we define submarkets for diversification purposes. This means that the target is to construct geographically continuous areas that exhibit as low capital return correlations with the other areas as possible. In addition, the house price movements inside each submarket should be as uniform as possible. Thus, similarly to the study by Wolverton et al., correlations have a crucial role in constructing the submarkets in this research. The HMA area is divided into 13 submarkets based on geographic and housing property market factors as described below.

The location of each sale in the database is measured by postcode. There are some postcode districts in the HMA where there have been no flat sales at all or only a few sales per quarter. These areas were left outside the analysis. The total number of postcode areas included in the analysis is 126. To begin with, areas that consist of a couple of neighbouring postcode districts are formed in order to get areas with sufficient number of sales per period for more reliable correlation analysis. This is necessary because in quite a few of the postal districts there have been only a small number of sales per quarter. Next, the eventual submarkets were formed by combining these areas based on their location and correlations with the other areas ignoring administrative boundaries (other than postcode boundaries). These larger areas are needed for the analysis in order to have sufficient number of quarterly observations in each submarket to offset the heterogeneity problem associated with housing. Unfortunately, hedonic price indices, which would enable better separation of true price development from qualitative changes in the data at different time periods, are not readily available for the submarkets. Therefore, we have formed large enough areas to eliminate the heterogeneity problem as much as possible but still to have enough areas to be able to test the diversification effects properly. The total number of observations in the 13 submarkets we have defined vary from 10 581 to 35 427. Also the use of flats in the analysis decreases the heterogeneity problem as mentioned earlier.

The objective is to identify intracity geographic subsets that exhibit relatively homogeneous within-subset price movements and that exhibit as low correlations as possible with remaining intracity subsets. Compromises are necessary, partly due to the need of sufficiently large areas, and it is clear that there still exists some heterogeneity inside the submarkets. The geographical division into submarkets is presented in Figure A1 in the Appendix and the postal districts together with the total number of observations in each of the submarkets are reported in Table A2 in the Appendix.

After defining the distinct submarkets quarterly real return time series were constructed for each submarket and city. Quarterly returns were estimated as:

$$R_t = \ln(P_t / P_{t-1}) \qquad (1),$$

where R_t is the real return in quarter t, and P_t is the deflated price level during the quarter. Cost of living index has been used to deflate the prices. Price levels are averages of all the sales in the area during the period. Descriptive statistics concerning the real capital returns in each of the areas are presented in Table A1 in the Appendix. According to the Jarque-Bera test the assumptions of normality can be rejected only in three of the 26 series. None of the series exhibits seasonal variation but most of the series are strongly serially correlated.

4 EFFICIENT FRONTIER AND CORRELATION ANALYSIS

Based on the return time series described above, in this section correlation matrices are counted and efficient frontiers are constructed using quadratic non-linear programming with a short-selling constraint using several different observation windows.

To get a benchmark for intracity diversification attractiveness the diversification possibilities gained by investing in 13 major Finnish cities are at first analysed. These cities include three cities in the HMA, i.e. Helsinki, Vantaa and Espoo[2]. Correlation coefficients between quarterly real house price movements in the sample period are presented in Table 1. The correlations between Helsinki, Espoo and Vantaa are high (from .79 to .84), which indicates that the diversification potentials within the HMA are very limited. Furthermore, the correlations between these three cities and most of the other cities are relatively high. This suggests that one cannot obtain remarkable diversification benefits by introducing housing in other cities to a portfolio that consists of housing in the HMA, either. Pori seems to be an exception to this and also Rovaniemi and Lappeenranta have somewhat lower figures than the other seven cities.

The efficient frontier consisting of these 13 cities is shown in Figure 1. All the three cities located in the Helsinki metropolitan area have a zero weight in the minimum variance portfolio[3]. The fact that Rovaniemi has got a 20 percent weight in the minimum variance portfolio even though its variance has been high and average real price growth negative shows the central role of correlations in portfolio diversification.

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[2] The considerably smaller town, Kauniainen, located inside Espoo is included in the Espoo figures.

[3] Weights in the minimum variance portfolio formed by the 13 cities: Lappeenranta .350, Rovaniemi .199, Oulu .170, Turku .134, Pori .095, Tampere .027, Kuopio .024 and zero for Helsinki, Espoo, Vantaa, Kouvola, Lahti and Jyväskylä. Annualised standard deviation and return for the minimum variance portfolio: 6.25% / 1.19%

Table 1 Correlations between real quarterly housing price changes in 13 major Finnish cities

	Helsinki	Espoo	Vantaa	Turku	Tampere	Kouvola	Lahti	Pori	Lappeenranta	Jyväskylä	Kuopio	Oulu	Rovaniemi
Helsinki	1												
Espoo	.84	1											
Vantaa	.84	.79	1										
Turku	.69	.67	.67	1									
Tampere	.75	.69	.76	.49	1								
Kouvola	.63	.58	.54	.40	.60	1							
Lahti	.75	.75	.68	.66	.63	.48	1						
Pori	.39	.41	.46	.35	.46	.40	.34	1					
Lappeenranta	.52	.45	.61	.36	.56	.46	.47	.27	1				
Jyväskylä	.74	.64	.78	.68	.66	.54	.59	.42	.51	1			
Kuopio	.67	.64	.67	.53	.65	.57	.52	.37	.49	.55	1		
Oulu	.66	.60	.66	.48	.64	.56	.67	.39	.66	.63	.52	1	
Rovaniemi	.52	.49	.42	.57	.35	.37	.56	.26	.13	.57	.42	.40	1
Average	.67	.63	.66	.55	.60	.51	.59	.38	.46	.61	.55	.58	.42

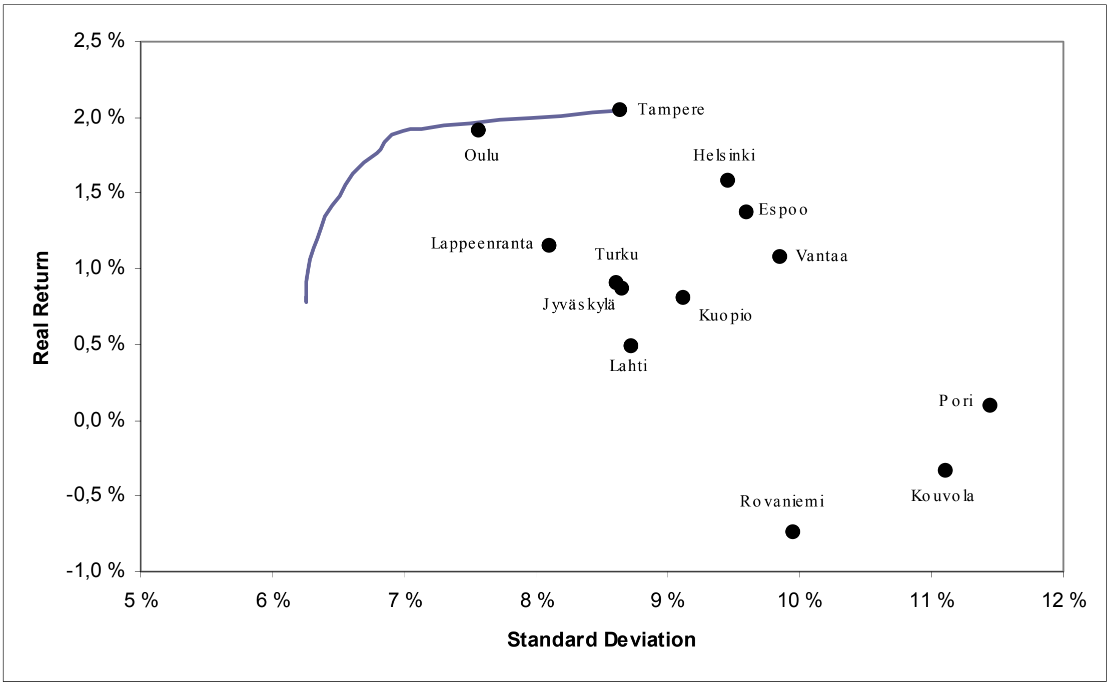

Figure 1 Efficient frontier for housing portfolio consisting of 13 major Finnish cities based on quarterly returns[4]

[4] Standard deviations and expected returns annualised.

It is somewhat strange that the relationship between risk and return is not in accordance with the MPT — higher risk has not meant higher return. In fact, in Oulu the average rise in housing prices has been second highest and volatility the lowest. This phenomenon is, at least partly, explained by the extraordinary large housing market bubble at the end of the 1980s and the beginning of the 1990s. In the areas where the prices rose the most during the bubble they also dropped the sharpest after the bubble burst. The volatility at that time was so extensive that those few years play a significant role in the overall volatilities reported in the sample period. This has probably biased the risk-return relationship somewhat. In Oulu the increase in housing prices was mild compared to the other cities and as a result the decrease was also much smaller. Thus, in Oulu the standard deviation of housing prices was smaller in the sample period than in the other cities.

Table 2 reports the quarterly correlations between the submarkets in the HMA. Not surprisingly, the correlations between the submarkets are on average higher than those between different cities — after all the submarkets are located geographically very close to each other. The difference, nevertheless, is not large. The average correlation coefficients for the HMA submarkets and the cities are .62 and .56, respectively. This indicates that taking account of the information and management efficiencies that can be gained by concentrating investments in only one metropolitan area, concentrating housing investments only in the HMA might be an attractive strategy for a Finnish real estate investor at least in the short run, despite the relatively high correlations between the submarkets.

Examining the correlation matrix in Table 2 more closely reveals that the Isle and the City Core have had, on average, the lowest correlation coefficients with the other submarkets. For the Isle the correlations vary from .36 to .48 and for the City Core from .30 to .61. All these figures are lower than the average for all the submarkets. For the City Core this might seem a bit surprising at the first sight. It is quite logical though that particularly in the City Core housing price development deviates from the other areas. This is because in the City Core housing supply is more inflexible than in the other areas due to the lack of free space. The areas in the east (East 1, 2, and 3 plus North 2) on the other hand have had high correlations with each other (from .73 to .83). These high correlations together with Figure 2 suggest that the defined submarkets in the east may, in fact, be part of one larger submarket. This differs from the western submarkets, which seem to be much less tightly linked to each other in the short run.

Table 2 Correlations between real quarterly housing price changes in the Helsinki Metropolitan Area submarkets

	City Core	Center 1	Center 2	Isle	West 1	West 2	West 3	North 1	North 2	North 3	East 1	East 2	East 3
City Core	1												
Center 1	.62	1											
Center 2	.56	.77	1										
Isle	.54	.37	.50	1									
West 1	.50	.64	.62	.41	1								
West 2	.51	.67	.72	.37	.54	1							
West 3	.51	.64	.67	.39	.54	.58	1						
North 1	.51	.71	.83	.45	.63	.69	.67	1					
North 2	.32	.64	.71	.44	.59	.57	.53	.75	1				
North 3	.48	.70	.78	.37	.65	.73	.65	.77	.68	1			
East 1	.52	.71	.79	.46	.56	.67	.64	.76	.73	.71	1		
East 2	.42	.67	.72	.50	.64	.64	.50	.72	.77	.73	.73	1	
East 3	.47	.70	.83	.43	.54	.65	.67	.79	.77	.71	.83	.78	1
Average	.50	.65	.71	.44	.57	.61	.58	.69	.63	.66	.67	.65	.68

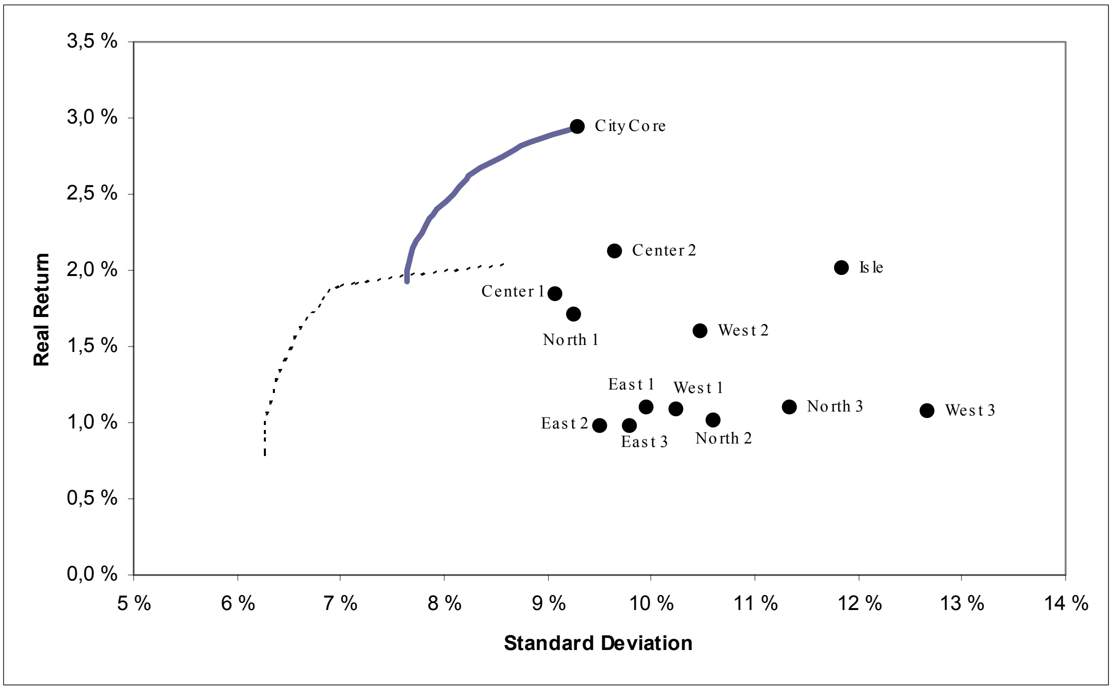

Figure 2 Efficient frontier for housing portfolio consisting of 13 submarkets inside the Helsinki Metropolitan Area based on quarterly returns [5]

[5] Standard deviations and expected returns annualised.

In Figure 2 the continuous thick curve shows the efficient frontier for the HMA submarkets. The dotted line is the efficient frontier for the 13 cities that was already presented in Figure 1. We can see that lower risk level can be gained by investing in cities across the country[6]. However, according to our historic data, investing in different sub areas in the HMA yields new risk-return possibilities to an investor — it enables the investor to invest in portfolios with higher expected return. As a matter of fact, a substantial volume of new efficient risk-return possibilities is made available by adding only the City Core to a portfolio consisting of housing in cities outside the HMA.

Interestingly we can see the same phenomenon in Figure 2 that we saw earlier in Figure 1: there has not been "the right kind of" relationship between risk and return. For example there are quite a few areas that have been dominated by the three center areas during the sample period. It is rather surprising that the center areas have had lower volatility than most of the other submarkets. One might have expected that housing prices in these submarkets are particularly volatile because housing supply is typically more inflexible in center areas. A partial explanation for the observed higher volatility in some areas might be the smaller number of observations in these submarkets. The two areas with the smallest number of observations (Isle and West 3) have also the highest reported standard deviations. However, also these areas have substantial number of observations per quarter. Hence, we believe that the number of observations explains only a small part of the difference in volatility between the submarkets.

In any case, Table 2 and Figure 2 together show that there are significant differences in housing price movements in different areas of the HMA in the short run. This suggests that viewing the HMA as one homogeneous market is misleading and may result in misdirected investment strategy at least for relatively short-term investors. This is further illustrated by Figure 3. The efficient frontier consisting of the 10 cities outside the HMA together with the submarkets in the HMA is presented by the continuous black curve. The other efficient frontiers are for the 13 cities and the 13 submarkets alone. The figure shows how dividing the HMA into more than three areas allows short-term investors to reach substantially higher expected returns with the same level of risk. Furthermore, in this case the areas in the HMA have, in total, a weight of

[6] Weights in the minimum variance portfolio formed by the HMA submarkets: City Core .331, East 2 .176, Center 1 .124, North 1 .118, West 1 .085, Isle .058, North 2 .058, West 2 .030, East 1 .019, and zero for Center 2, East 1, and North 3. Annualised standard deviation and return for the minimum variance portfolio: 7.63% / 2.38%.

about 23 percents in the minimum variance portfolio[7]. As told earlier, the weight of the HMA is zero in the minimum variance portfolio when aggregated measures from the three cities are used. Thus, the use of aggregated data underestimates the weights the HMA areas should have in the efficient frontier.

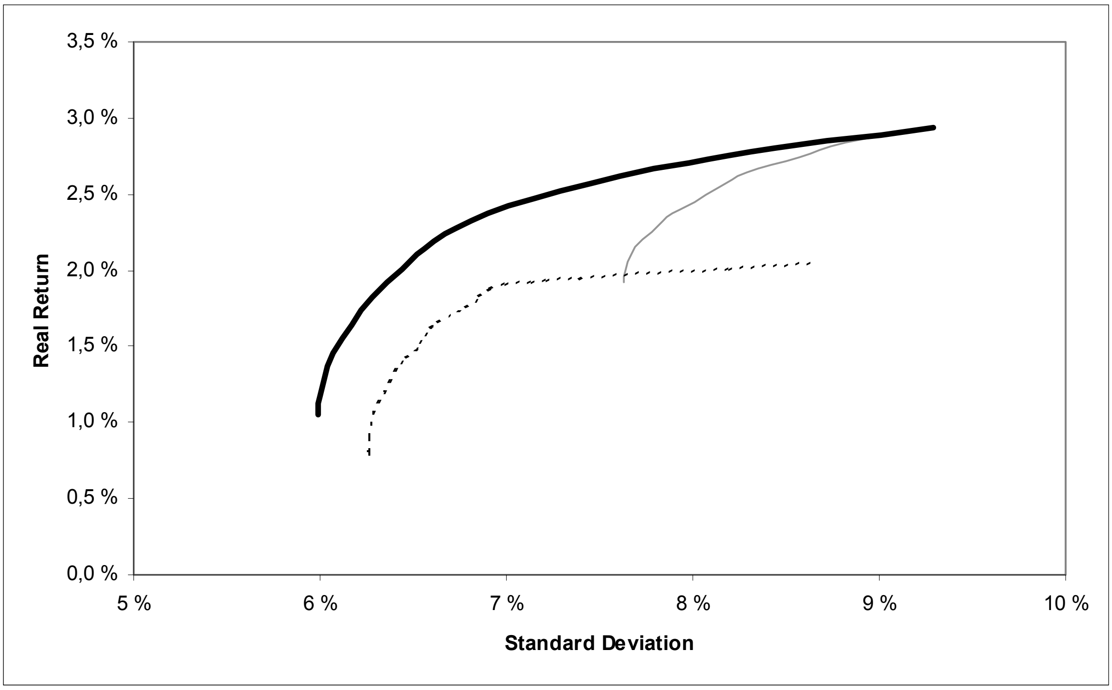

Figure 3 Efficient frontier for portfolio consisting of 10 cities outside and 13 submarkets inside the Helsinki Metropolitan Area[8]

The analysis above is based on relatively short-term deviations in price movements. Direct real estate investments, however, are typically extremely long-term investments. The fact that buy-and-hold strategy is employed rather than rebalancing strategy when direct real estate investments are concerned is mainly due to the low liquidity and high transaction costs involved in direct real estate investments. For example, in Finland institutional housing investors typically hold their investments for more than ten years. Quarterly return correlations can significantly exaggerate the diversification opportunities concerning housing investments that are held even for decades. This is due to the fact that in longer horizon housing prices in different geographical areas may be much more tightly linked than the quarterly correlations indicate.

[7] Weights in the minimum variance portfolio formed by the 10 cities outside the HMA together with the HMA submarkets: Lappeenranta .303, Rovaniemi .204, City Core .167, Pori .100, Turku .078, Oulu .074, Isle .059, Kuopio 0.015 and zero for the rest of the areas. Annualised standard deviation and return for the minimum variance portfolio: 5.97% / 1.48%.

[8] Standard deviations and expected returns annualised.

Thus, there is a need to analyse the long-run relationships between housing prices in different areas more carefully. Nevertheless, in most of the studies so far this fact has not been considered seriously.

One option to explore longer-horizon diversification possibilities is to use longer observation windows. Due to the relatively short sample period that is done in this study by employing rolling correlations i.e. using overlapping observation windows. Even the use of six-month returns increases the average correlations notably: the average correlations are .79 and .77 for the HMA submarkets and the cities across Finland, respectively. When employing annual returns the average correlations are as high as .91 and .89. The same phenomenon continues when the observation period is lengthened even further. Biannual average correlations are .95 and .93 and five-year correlations .98 and .96 for the submarkets and the cities, respectively. The annual and five-year correlations are reported in Tables A3 and A4 in the Appendix.

Of course, also the appearances of the efficient frontiers change as the investment horizon is lengthened because correlations and variances change substantially as observation window is varied. The efficient frontiers based on annual returns are presented in Figures A2 and A3 in the Appendix. According to Figure A3 diversifying inside the HMA does not seem useful — taking account of efficiencies gained by investing in one small area it would seem attractive to invest only in the City Core. For the cities the amount of new risk-return possibilities gained by diversification seems much larger. Comparing these efficient frontiers with those in Figures 1 and 2 also shows that the relative riskiness of different areas changes as the observation window is changed.

The correlation figures highlight a couple of interesting observations. Firstly, the correlation coefficients grow substantially when the investment horizon is prolonged. Similar findings have been reported in many studies concerning stock market data starting from Grubel and Fadner (1971). The result implies that long-run diversification potentials are much worse than suggested by quarterly correlations. Secondly, the correlations between the cities across the country are almost as large as the correlations between the sub areas inside the HMA. This implies that when taking account of the management and information efficiencies it may be worthwhile for a Finnish investor to concentrate all his housing investments in the HMA or some other city. Thirdly, the correlation coefficients get extremely close to one as the investment horizon is lengthened suggesting that benefits gained from geographical diversification of housing portfolio are negligible in the long run. Fourthly, the variation in the correlation coefficients between different areas decreases considerably as the observation periods get longer.

The growth of the return correlations and the decrease of the variation of the correlations as the investment horizon is extended are illustrated in Figure 4. The fact that correlations are smaller and their standard deviations are larger for the cities than for the HMA submarkets is expected. After all, the HMA is a geographically small area where one does not expect to see as large deviations in the housing market conditions as across the whole country. The differences between the HMA and the cities are surprisingly small, nevertheless.

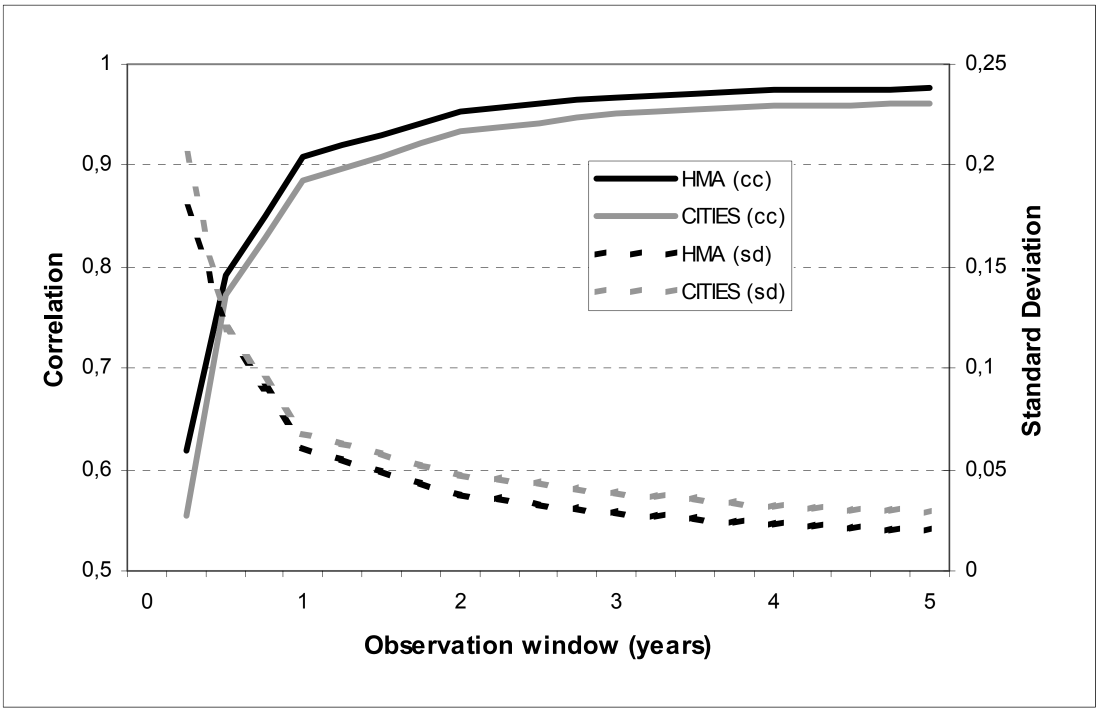

Figure 4 Average real return correlation and standard deviation of correlation using different observation windows

The observed relationship between the correlations using different observation windows implies that price changes in one area follow price changes in another area with lag. Hence, quarterly correlations are well below one even though the series are closely related in the longer run. The idea originally introduced by Grossman and Stiglitz (1976) could carry one explanation for lagged relationships. The idea is based on the fact that there are both informed and non-informed actors in the market. It is likely that in the housing market the share of informed (i.e. mainly institutional) investors is substantially larger in central areas than in more peripheral areas[9]. Therefore, housing prices in central areas are likely to react faster to a shock than prices

[9] In this paper the focus is not on examining whether price changes in central areas lead price movements in surrounding areas. This will be studied in a forthcoming paper, however.

in surrounding areas. With lag the non-informed actors in the market perceive the price change and the prices react accordingly in the areas dominated by the non-informed agents. The significance of this phenomenon may be weakened by the large role of real estate agents (i.e. informed agents) in the market, however. In addition, thin trading may also contribute to lagged relationships. It is possible that in the areas with most transactions the price changes are observed earlier than in the areas with thinner trading. Also according to this it would be expected that the central areas lead the surrounding areas. Furthermore, the correlation structure can be partly due to highly inflexible supply of housing in the short run. When the demand for housing rises in one area more than in some other areas, also the price level is likely to rise more in the short horizon due to the inelastic supply. In the longer horizon, however, the supply adjusts and the price level returns to its long-run equilibrium.

It is also possible that the fact that hedonic indices have not been used in the analysis explains some part of the contradiction between quarterly and annual return correlations. Between two successive quarters (in any area) there may have been differences in the average quality of the flats transacted. This may have caused the perceived quarterly returns to differ slightly from the true price changes. Consequently, the observed quarterly correlations may be somewhat smaller than the actual ones. During a longer time period the possible quality differences even out more. Nevertheless, the number of observations in each area in each quarter is substantially large. Therefore, we claim that the problem that is caused by the heterogeneity of housing explains, at its most, only a part of the growing trend of correlations as observation window is lengthened.

The fact that longer-term correlations are very close to one suggests that in the long run there are no decent geographical diversification benefits obtainable either by diversifying inside the HMA or by diversifying in cities across the country. Furthermore, the finding suggests that there may be long-run relationships between housing prices in different areas. Hence, the prices may be predictable. In fact, the variance ratio statistics[10] suggested by Poterba and Summers (1988) confirm that the housing price indices are predictable. For the returns to be i.i.d. the variance ratio statistics should not be different from one, i.e. the variance should grow in proportion with the horizon. Variance ratios below one indicate mean-reverting returns. Variance ratios for all the 26 housing price series studied in this paper, however, are well above one for all horizons from one to five years implying mean-averting returns.

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[10] Variace ratio (k) = 1/k * variance ($r_{t\rightarrow t+k}$) / variance (r_{t+1}), where variance ($r_{t\rightarrow t+k}$) = variance ($r_{t+1}+r_{t+2}+\ldots+r_{t+1}$) and k stands for the length of the horizon in quarters and r_t denotes return in quarter t.

Predictability means that the investment opportunity set is not stable. Instead, it is conditional on previous returns. Therefore, the unconditional efficient frontier analysis presented above is no longer efficient — ignoring the predictability causes utility costs (see e.g. Balduzzi – Lynch, 1999). Furthermore, the existence of long-term equilibrium relationship between two return indices would suggest that the long-horizon diversification benefits are likely to be very small.

5 LONG-HORIZON DIVERSIFICATION POSSIBILITIES BASED ON COINTEGRATION ANALYSIS

It seems worthwhile to study the existence of long-term interdependencies further by employing cointegration analysis. This is motivated by the inference in the previous section that housing prices in different areas may exhibit long-run relationships together with the fact that such long-term relationships have implications for portfolio diversification. Furthermore, correlation analysis has got its lacks when studying long-run diversification possibilities.

It is well known that correlations exhibit instability over time and are therefore problematic for investors with longer investment horizons. Another problem with correlation analysis is that a great number of observations is lost by using long observation windows even if overlapping returns are employed. From a very long-horizon investor's viewpoint even a couple of years observation windows used in correlation counting may be too short. Thus, longer observation windows may be needed. In this study, for example, there are 71 quarterly return observations. However, when analysing five-year correlations there are only 52 return observations, which is more than one fourth less than when using quarterly observations.

In addition, the results in the previous section concerning geographical diversification potentials in the long horizon are somewhat surprising. One would have thought that the relationships between housing prices in different cities across the country are much looser than inside the geographically small HMA. If it really is the case that long-term diversification possibilities across the country are as negligible as across the HMA, then it would be worthwhile for an investor to concentrate all his investments in the HMA or in some other city. However, we are not ready to accept this straight away, especially after visually inspecting graphs of the price time-series in different areas. The graphs suggest that there have been much more differences in housing price movements between different cities than between the submarkets in the HMA in the long run.

Due to the reasons mentioned above we find it necessary to study the long-run diversification potentials further by employing cointegration analysis. Of course correlation between different areas is still the factor determining the diversification potentials. The point is that the existence of cointegration between two series that are integrated of order one means that in the long run correlation between their differences must approach one, even though they may diverge in the short run (see e.g. Cochrane, 2001, 423). Cointegration therefore indicates that the markets are moving together in the long run and diversifying between them over the long horizon is not likely to lead to large benefits in risk reduction. Cointegration does not prevent the possibility of long-horizon diversification benefits totally, of course, although some authors have claimed otherwise. Diversification gains are made obtainable by the possibility of temporary deviations from the long-run equilibrium. However, the longer the holding period is the smaller the relative significance of the temporary deviations is and the smaller the diversification benefits are likely to be. Also the possibility of structural changes in the long-term relationship in the future may create some diversification possibilities between two cointegrated markets. The speed of adjustment parameters (alfas) have got an important role concerning long-horizon diversification potentials. The bigger the alfas are in absolute value, the faster the prices converge back to their long-run equilibrium. That is, the bigger the alfas, the harder it is to obtain notable long-horizon diversification benefits. If, however, two return indices are not cointegrated the diversification potentials are in general better considering long-term investments.

Regarding the data in hand an illustrative example concerning the discrepancy between the long-run diversification prospects and the annual correlations is offered by comparing the relationship between price levels in submarkets North 2 and East 2 with the relationship between the prices in Espoo and Oulu. Annual correlation coefficients have been practically the same (.96 and .94) in the sample period, implying equally faint diversification opportunities. Contrary to the price series of North 2 and East 2, the price indices of Espoo and Oulu have not been cointegrated, however, and there have obviously been better diversification potentials between these cities than between the two submarkets mentioned. This can be seen by comparing Figures A4 and A5 in the Appendix. Hence, even though the annual return correlations are equal in these two cases the actual long-run diversification potentials differ.

We perform pairwise cointegration test for all possible submarket pairs and all possible city pairs using the Johansen procedure. Multivariate cointegration tests are not applied. This is because we want to find out if there exist notable long-term diversification potentials between any two areas. Furthermore, carrying out multivariate cointegration tests might lead to mistaken inferences being drawn as illustrated by Allen and MacDonald (1995).

If two price series are cointegrated, then they can be presented in a vector error-correction form. According to preliminary graphical and statistical investigation of the data four different vector error-correction models (VECM) can realistically be considered:

Model 1
$$\Delta x_{i,t}=\sum_{s=1}^{p-1}\gamma_{i,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\psi_{i,s}\Delta x_{j,t-s}+\alpha_i(x_{i,t-1}-\beta x_{j,t-1})+u_{i,t} \qquad (2)$$
$$\Delta x_{j,t}=\sum_{s=1}^{p-1}\psi_{j,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\gamma_{j,s}\Delta x_{j,t-s}+\alpha_j(x_{i,t-1}-\beta x_{j,t-1})+u_{j,t}$$

Model 2
$$\Delta x_{i,t}=\sum_{s=1}^{p-1}\gamma_{i,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\psi_{i,s}\Delta x_{j,t-s}+\alpha_i(x_{i,t-1}-\beta x_{j,t-1}-\pi)+u_{i,t} \qquad (3)$$
$$\Delta x_{j,t}=\sum_{s=1}^{p-1}\psi_{j,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\gamma_{j,s}\Delta x_{j,t-s}+\alpha_j(x_{i,t-1}-\beta x_{j,t-1}-\pi)+u_{j,t}$$

Model 3
$$\Delta x_{i,t}=\mu_i+\sum_{s=1}^{p-1}\gamma_{i,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\psi_{i,s}\Delta x_{j,t-s}+\alpha_i(x_{i,t-1}-\beta x_{j,t-1})+u_{i,t} \qquad (4)$$
$$\Delta x_{j,t}=\mu_j+\sum_{s=1}^{p-1}\psi_{j,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\gamma_{j,s}\Delta x_{j,t-s}+\alpha_j(x_{i,t-1}-\beta x_{j,t-1})+u_{j,t}$$

Model 4
$$\Delta x_{i,t}=\mu_i+\sum_{s=1}^{p-1}\gamma_{i,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\psi_{i,s}\Delta x_{j,t-s}+\alpha_i(x_{i,t-1}-\beta x_{j,t-1}-\phi t)+u_{i,t} \qquad (5),$$
$$\Delta x_{j,t}=\mu_j+\sum_{s=1}^{p-1}\psi_{j,s}\Delta x_{i,t-s}+\sum_{s=1}^{p-1}\gamma_{j,s}\Delta x_{j,t-s}+\alpha_j(x_{i,t-1}-\beta x_{j,t-1}-\phi t)+u_{j,t}$$

where $\Delta x_{i,t}$ is $x_{i,t}$-$x_{i,t-1}$, $x_{i,t}$ is the log of the value of the housing price index in area *i* in period *t*, *p* is the number of lags included in the corresponding VAR model, *α* is a speed of adjustment parameter, the term in parenthesis is the long-run equilibrium relationship between the two price indices in question[11], *u* is the error term, *μ* is a constant, and *γ* and *ψ* are coefficients for own lagged observations and for the lagged observations of the other index, respectively. Furthermore, in some cases it is necessary to include either a constant (*π*) or a time trend (*t*) in the long-run equilibrium relationship. The interpretation of each of these four models is discussed later as well as the determination of the right model.

The speed of adjustment parameter *α* and long-run equilibrium relationship together form the error-correction term. The alfas have got significance concerning the long-run diversification potentials as already discussed above. In general alfa should be negative for x_i and positive for x_j if the time series are cointegrated, i.e. if the series are to converge to the long-run equilibrium in case they currently deviate from it.

Before the cointegration analysis itself the order of integration is tested for all the housing price time series. This is because cointegration can occur between two time series only if they are integrated in the same degree. Furthermore, if the time series are stationary, testing cointegration is not

[11] The long-run equilibrium relationship is normalized with respect to x_i and equals zero when the price indices are in their long-term equilibrium.

sensible. We use natural logarithms of quarterly price indices in each of the distinct geographical areas in the cointegration analysis and hence naturally in unit root tests too. For each index the base quarter is I/1985 and the base value is 100, i.e. 4.61 in logarithmic scale. According to numerous studies[12] housing prices seem to be integrated usually in the first degree. This means that price indices are non-stationary but price changes, i.e. capital returns, are stationary. Visual inspection of the price indices and capital returns together with their autocorrelation functions imply that this is the case also with all the areas considered in this study.

To test the order of integration more formally augmented Dickey-Fuller (ADF) tests are employed for each of the 26 series and their differences. The number of lags in the ADF tests are decided based on Hall's general to specific method as suggested by Maddala and Kim (1998). However, longer lag lengths than suggested by the general to specific method are used if needed to extract significant autocorrelation in the residuals. Ljung-Box Q-test is utilised to detect the significance of autocorrelation in the residuals. When testing stationarity of the levels the need for deterministic regressors in the ADF tests is decided based on the ϕ_1, ϕ_2, and ϕ_3 statistics provided by Dickey and Fuller (1981)[13]. Expectedly, no trend was needed in any of the ADF regressions. Furthermore, drift was not found necessary in any of the tests. The unit root test results are reported on the HMA submarkets in Table A5 and on the cities in Table A6 in the Appendix. All the series were found to be I(1). Interesting is the observation that the ADF test for the City Core requires five lags, which is much more than the number of lags in any of the tests for the other submarkets. This is probably due to extremely inflexible supply in the City Core.

The low power of various Dickey-Fuller tests is well known. However, in this study we saw no reason to use more powerful procedures to examine the existence of unit roots. There are several reasons for this. Firstly, the power is not a problem when studying the capital returns because unit root can be rejected in five percent level of significance in all the differenced series even by the ADF test. Secondly, as it can be seen from Tables A1 and A2, the value of test statistics is so close to zero in all the level series and actually even above zero in many cases that the power problem of the ADF test is very unlikely to have caused the acceptance of a false null of a unit root in any of the series. Thirdly, the results are expected and consistent with results in many other studies. Furthermore, the fact that housing prices seem to be I(1) is in

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[12] Studies implying that housing prices in Finland are I(1) are e.g. Suoniemi (1990), Kosonen (1997) and Barot and Takala (1998).

[13] According to the graphs and theory it is obvious that deterministic regressors are not needed when testing the stationarity of the differences.

accordance with the efficient market hypothesis. Thus, we conclude that all the series are integrated in the first degree and it is sensible to proceed to the cointegration tests using the Johansen method.

In the cointegration tests the choice of both deterministic factors and the number of lags is a vital step. Cointegration test statistics may be highly sensitive to the specification of lag length. In this study lag length is chosen according to the "Gonzalo approach", i.e. the lags are selected so that autocorrelation in residuals is eliminated but the VECM is still as parsimonious as possible. The presence of residual autocorrelation is checked employing three different tests: a multivariate Ljung-Box test based on the estimated auto- and crosscorrelations of the first T/4 lags where T is the number of usable observations, and LM tests for the first and fourth order autocorrelation.

The choice of the deterministic components to be included in the VECM, i.e. the choice between different VEC models, is important for two reasons. Firstly, one can obtain misleading parameter estimates if the deterministic components are incorrectly formulated. Secondly, the asymptotic distributions of the cointegration tests are dependent upon the presence of trends and/or constants in the VECM. Nevertheless, in most of the papers applying cointegration analysis to study long-horizon diversification potentials the selection of the deterministic factors has not been done properly. In this study the selection of the deterministic components is based on the Schwartz Bayesian information criteria (SBC), using *a priori* assumptions based on visual inspection of graphs and economic arguments so that only sensible models are considered in each case. However, when necessary to decide between models two and three, the choice is done using the statistics proposed by Johansen (1991):

$$-T\sum_{i=1}^{2}\left[\ln\left(1-\lambda_i^*\right)-\ln\left(1-\lambda_i\right)\right], \tag{6}$$

that has a χ^2 distribution with two degrees of freedom and where T is the number of usable observations, λ_1^* and λ_2^* are the eigenvalues of the model that includes an intercept term in the cointegration space (model 2), and λ_1 and λ_2 are the eigenvalues of the model with a drift term in the short-run model (model 3).

Our *a priori* starting point for the HMA submarket indices is that they exhibit growing trend[14]. Thus, models 1 and 2 are not considered as options

[14] Although for none of the return series except for the City Core the hypothesis that Δx equals zero can be rejected (one-tailed t-test, 10 percent level of significance) the assumption of growing trend in

when testing the cointegration between different submarkets because a drift term is needed in the VECM. Considering model 4 requires strong *a priori* arguments and in many cases it is clear from a graph representing two indices that also model 4 is invalid. This means that cointegration is tested using model 3 in these cases.

We suggest that the existence of cointegration even with the deterministic trend term in the long-run equilibrium relationship (model 4) implies very small long-horizon diversification potentials. Model 4 is a valid possibility if one of the indices seems to be growing faster than the other because then a trend term may be needed in the cointegration space. In this case, as in the case where two series are growing equally fast, the correlation is likely to be close to one in the long run even though the average return is not equal in the both areas. If this kind of cointegrating relationship exists a long-horizon investor is naturally more willing to invest in the area where the mean return is higher. The reason for this kind of relationship may be for example population growth together with differences in the flexibility of housing supply between different areas. As supply is less flexible in inner city areas, population growth of a metropolitan area is likely to raise prices more in central districts than in the suburbs[15]. Hence, it would not be surprising if model 4 was needed at least in some cases concerning the HMA submarkets because population has grown significantly in the area during the sample period. Illustrative examples of cases where only model 3 seems to be valid and where also model 4 may be valid are shown in Figures A6 and A7, respectively, in the Appendix.

Contrary to the Helsinki area, there are many urban areas in Finland where the number of inhabitants has decreased. Therefore, in some of the cities real prices have risen much less than in any of the HMA submarkets. In Kouvola and Rovaniemi real housing price level has even slightly decreased during the sample period. When cointegration between real housing prices in two of the cities where real housing price level has changed only slightly from 1985 to 2002 is examined, also models 1 and 2 are considered as options because drift term is not necessarily needed. Although model 1 occurs rarely in practice, it is possible here because of the use of indexed time series in the analysis, i.e.

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real housing prices in the HMA submarkets can be supported by theory and the data in hand. The number of households as well as the level of real disposable income per household has been growing fast in the HMA during the sample period. According to the theory this should have caused the real value of land and the real value of housing to increase. In all the submarkets real housing prices were considerably higher in IV/2002 than in I/1985, which supports the theory. Because of the deep slump in the beginning of the 1990s the real price growth from 1985 to 2002 just has not been high enough relative to its volatility in many submarkets to be able to statistically reject the hypothesis that Δx equals zero.

[15] It has to be noted, however, that if for some reason the population growth of the HMA turned negative a structural change in the long-term equilibrium relationship might occur. That is, the coefficient ϕ might change.

the starting point and units of measurement for all the series are the same. In this analysis model 2 is thinkable in very rare cases. These are the cases where it seems that in the base quarter of the indices the relationship between the indices has deviated substantially from their (possible) long-run equilibrium but still neither of the series have grown or decreased notably.

In general we have accepted cointegration of two series if the small sample corrected value of λ-max is significant in ten percent level of significance according to the Osterwald and Lenum (1992) tables. However, in cases relatively close to ten percent significance level also the eigenvalues of the companion matrix and the value of the Trace statistics together with a plot of the Trace statistics based on recursive estimation are used to support the decision because in general cointegration tests are not powerful. The λ-max values are reported in Tables 6 and 7 for the HMA submarkets and the cities, respectively. The cases where cointegration is accepted are bolded.

According to the cointegration analysis the HMA submarkets have been much more interdependent than the cities. Of all the 78 submarket pairs we conclude that 47 are cointegrated. For the cities corresponding figure is only 13. In fact, 46 out of 56 submarket pairs are cointegrated if the City Core and the Isle are not taken into account. Hence, except for the City Core and the Isle the submarkets seem to be tightly linked to each other over the long run.

The results show that inside the HMA the long-term diversification possibilities are very limited as already suggested by the annual correlation analysis. In line with the results implying strong interdependency between the HMA submarkets is the fact that housing prices between the three cities in the HMA, Helsinki, Espoo, and Vantaa, are cointegrated. Nevertheless, the analysis indicates some slight opportunities for long-term geographical diversification inside the HMA too: the City Core and the Isle seem to be more independent than the other areas and thus exhibit some long-horizon risk diversification prospects. Major reason for the differences between the City Core and the other areas may be the fact that housing supply is more inelastic in the City Core than in the other submarkets as mentioned earlier.

Table 3 λ-max values of the pairwise cointegration tests for the HMA submarkets[16]

	CC	C1	C2	Isle	W1	W2	W3	N1	N2	N3	E1	E2
C1	12.3 (cd,5)											
C2	9.13 (d,5)	8.55 (d,2)										
Isle	12.6* (d,5)	5.83 (d2)	9.72 (d,3)									
W1	17.1* (cd,5)	22.6** (cd,2)	29.1*** (cd,2)	7.72 (d,3)								
W2	13.4 (cd,5)	10.6 (d,3)	30.4*** (d,2)	7.98 (d,3)	21.7** (cd,3)							
W3	14.1 (cd,5)	20.0*** (d,3)	32.8*** (cd,2)	10.5 (d,3)	18.7* (cd,3)	34.6*** (d,3)						
N1	14.3 (cd,5)	11.8 (d,3)	23.4** (cd,2)	7.73 (d,3)	25.6*** (d,2)	14.9* (d,2)	12.1* (d,3)					
N2	15.7 (cd,5)	16.2 (cd,3)	25.3*** (cd,2)	7.30 (d,3)	15.95** (d,3)	22.0** (cd,2)	12.5* (d,3)	17.2* (cd,2)				
N3	12.8 (cd,5)	17.8** (d,2)	23.3** (cd,2)	9.59 (d,3)	20.4*** (d,3)	32.8*** (cd,4)	10.2 (d,2)	19.3*** (d,2)	26.2*** (d,3)			
E1	14.2 (cd,5)	12.8* (d,3)	40.2*** (cd,2)	5.77 (d,3)	14.1* (d,3)	7.70 (d,3)	17.1** (d,2)	20.2*** (d,3)	10.1 (d,2)	9.71 (d,3)		
E2	16.1 (cd,5)	12.6* (d,2)	26.7*** (cd,2)	5.81 (d,3)	18.3** (d,2)	27.0*** (cd,2)	17.2** (d,2)	18.3** (d,2)	13.7* (d,2)	13.9* (d,3)	21.7*** (d,2)	
E3	15.2 (cd,5)	10.8 (d,2)	20.1** (cd,2)	6.32 (d,3)	16.1** (d,2)	20.8** (cd,3)	10.1 (d,2)	12.3* (d,2)	19.1*** (d,2)	18.9*** (d,2)	10.8 (d,2)	16.6** (d,2)

Housing prices in the major Finnish cities are not as tightly linked. This result suggests that although the five-year correlations between the submarkets and between the cities are almost equal and the long-term gains obtainable through diversifying across the country seems to be quite modest they, nonetheless, are bigger than the gains obtainable through diversifying only inside the HMA. However, the possible information and management efficiencies gained by concentrating investments in only one metropolitan area have to be kept in mind. After taking account of these efficiencies it might seem attractive to an investor to concentrate Finnish housing investments in the HMA or in some other city.

The speed of adjustment parameters naturally support the conclusions made above. For the submarkets average size of the alfas is .24. The figure is only .08 for the cities. All the alfas are reported in Tables A7 and A8 in the Appendix. The afhas should be interpreted with caution because also all the statistically insignificant alphas and all the alphas from the non-cointegrating relationships are stated in the table.

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[16] In the parenthesis n, c, d, and cd denote for no deterministic regressors, constant in the cointegrating relationship, drift term, and a drift term plus a trend in the cointegration space in the VECM, respectively; the figures in parenthesis denote for the number of lags included in the VECM; *, **, and *** signify significance in 10%, 5%, and 1% level, respectively.

Table 4 λ-max values of the pairwise cointegration tests for major Finnish cities

	He	Es	Va	Tu	Ta	Ko	Lah	Po	Lap	Jy	Ku	Ou
Es	21.1** (cd,2)											
Va	13.3* (d,3)	21.0** (cd,3)										
Tu	11.6 (d,3)	9.23 (d,3)	11.9 (d,3)									
Ta	9.58 (d,2)	14.3 (cd,2)	16.0 (cd,3)	9.06 (d,3)								
Ko	11.6 (cd,2)	11.8 (cd,2)	7.73 (d,3)	23.0** (cd,3)	22.9** (cd,2)							
Lah	8.77 (d,2)	5.24 (d,2)	8.26 (d,3)	21.0*** (d,3)	7.04 (d,3)	23.7** (cd,2)						
Po	8.16 (d,2)	6.95 (d,2)	9.29 (d,3)	7.77 (d,3)	8.77 (d,2)	1.78 (n,3)	4.78 (n,2)					
Lap	8.88 (d,2)	10.9 (d,2)	8.36 (d,3)	12.6* (d,3)	7.73 (d,3)	14.3 (cd,3)	16.8 (cd,3)	7.43 (d,2)				
Jy	6.35 (d,2)	8.60 (d,2)	10.9 (d,3)	7.08 (d,2)	4.63 (d,2)	19.3** (cd,2)	4.98 (d,2)	10.2 (d,3)	13.9* (d,3)			
Ku	7.58 (d,2)	9.24 (d,3)	11.3 (d,3)	7.53 (d,3)	8.24 (d,3)	9.07 (cd,4)	4.41 (d,2)	9.67 (c,3)	12.1* (d,3)	19.7*** (d,2)		
Ou	8.04 (d,2)	4.92 (d,2)	9.59 (d,3)	12.2 (cd,3)	9.38 (d,3)	15.8 (cd,2)	15.4 (cd,5)	6.80 (d,3)	19.8** (cd,3)	11.6 (cd,3)	7.49 (d,3)	
Ro	5.33 (d,2)	4.23 (d,2)	7.96 (d,3)	8.07 (d,3)	5.95 (cd,2)	3.56 (n,2)	4.93 (n,4)	5.44 (n,3)	8.06 (d,3)	4.86 (d,2)	5.97 (d,3)	6.58 (d,3)

The result that most of the housing price time series of the HMA sub areas are cointegrated with each other also implies that, despite the relatively low quarterly correlations, the HMA may after all form a single coherent housing market, at least if the City Core and the Isle are excluded. If we had found that the housing prices in different sub areas are not cointegrated, the analysis would have indicated that there are, in fact, several distinct submarkets inside the HMA. On the other hand, the existence of cointegrating relationship between many of the HMA submarkets and some of the cities implies that the Finnish housing markets are not fully efficient informationally[17]. Whether one can, taking account of the transaction costs, systematically reach higher than average returns based on the predictability is another question.

[17] Ferré & Hall (2002) showed that the existence of cointegration does not necessarily imply inefficiency. However, the dynamics in the models estimated in this paper are such that they indicate informational inefficiency.

6 CONCLUSIONS

The aim of this study was to examine the attractiveness of concentrating housing investments in the Helsinki Metropolitan Area from a Finnish real estate investor's point of view. For this purpose the HMA was divided into 13 sub areas based on geographic and housing market factors using transactional data consisting of all the flat sales in the area from 1985 to 2002. As a comparison the diversification possibilities across major cities in Finland was also studied.

The efficient frontier analysis based on quarterly returns indicated that dividing the HMA into several distinct areas creates substantial volume of new efficient risk-return possibilities. The analysis showed that relying solely on aggregate data is misleading and may result in misdirected investment strategy at least in the short run. Furthermore, the quarterly data implied that it is possible to gain relatively large short-term diversification benefits by diversifying housing investments inside the HMA.

We claimed, however, that the analysis based on quarterly returns might be misleading because housing is typically long-term investment. Therefore, correlations based on longer observation windows were also studied. It was found that longer-horizon capital return correlations have been close to one both between the HMA submarkets and between the cities across Finland. This implied that in the longer horizon geographical diversification possibilities are equally negligible inside the HMA and across the country.

We wanted to study this unexpected result further by employing cointegration analysis, however. The cointegration analysis showed that in the long run housing prices are much more tightly linked in the HMA submarkets than in the major cities across the country. Hence, long-term diversification potentials inside the HMA are weaker than across the country. This result is logical and expected. However, due to relatively high return correlations between cities across Finland it might seem profitable to some investors to concentrate Finnish housing investments in only one urban area due to the possibility of information and management efficiencies. The smaller the investor's portfolio the more attractive the concentration is because the information and management costs of including a new area to the portfolio are the bigger relative to the portfolio return the smaller the value of the portfolio is. The results of the long-term analysis are of particular relevance to institutional investors such as life insurance companies that would wish to hold long-term investment portfolios and may be adopting a policy of passive diversification.

Concerning portfolio allocation it is also noteworthy that each of the price series exhibit predictability at least in some degree. The utility costs of relying on unconditional mean-variance analysis and ignoring predictability can be substantial as shown by Balduzzi & Lynch (1999). Furthermore, to take advantage of predictability a dynamic investor is more inclined to trade. For direct real estate investors, however, the willingness to reallocate portfolio is decreased by high transaction costs and illiquidity of real estate. In addition, predictability has implications concerning the intertemporal hedging demand first explored by Merton (1973).[18]

The study was based only on transactional data — other factors determining the total returns of housing property, i.e. rents, maintenance costs, and vacancy rates were ignored due to the lack of data available. We claim, however, that capital returns give a good picture concerning housing portfolio diversification possibilities both in the short and long run. This view is supported by the fact that price movements have been by far the most significant factor causing geographical differences in housing returns in Finland.

For many investors, however, the smooth rental cash flows are a major reason to invest in real estate. Thus, considering rental cash flows, there may be attractive diversification possibilities between two areas even if the price levels in these areas are cointegrated. It is, nevertheless, likely that the correlations between rental cash flows in different areas are very high.

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[18] The effects of the predictability are studied in more detail in a forthcoming paper.

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APPENDIX ADDITIONAL TABLES AND FIGURES

Table A1 Descriptive statistics of quarterly real housing price changes in the major Finnish cities and in the 13 HMA submarkets from 1985 to 2002[19]

Area	Mean (annualised)	Standard deviation (annualised)	Jarque-Bera (p-value)	First order autocorrelation
Helsinki	.0158	.0946	.750	.628**
Espoo	.0137	.0960	.928	.555**
Vantaa	.0107	.0985	.020**	.577**
Turku	.0091	.0862	.505	.382**
Tampere	.0205	.0864	.492	.508**
Kouvola	.0034	.1112	.696	.042
Lahti	.0049	.0873	.296	.405**
Pori	.0009	.1144	.876	.053
Lappeenranta	.0115	.0810	.003***	.088
Jyväskylä	.0086	.0865	.370	.375**
Kuopio	.0081	.0912	.024**	.158
Oulu	.0198	.0758	.436	.297*
Rovaniemi	.0075	.0995	.463	.054
City Core	.0294	.0929	.627	.177
Center 1	.0184	.0907	.151	.435**
Center 2	.0212	.0965	.643	.575**
Isle	.0202	.1185	.083	.082
West 1	.0108	.1024	.209	.266**
West 2	.0160	.1047	.373	.264**
West 3	.0107	.1268	.441	.278**
North 1	.0171	.0926	.955	.471**
North 2	.0101	.1061	.924	.453**
North 3	.0110	.1135	.756	.383**
East 1	.0109	.0996	.521	.381**
East 2	.0097	.0951	.159	.487**
East 3	.0098	.0981	.793	.571**

[19] * and ** signify significance in 5% and 1% level, respectively.

Table A2 Total number of observations in each of the HMA submarkets

Area	Observations	Postal code areas
City Core	30 861	100, 120, 130, 140, 150, 160, 170, 180
Center 1	28 727	240, 250, 260, 270, 280, 300, 310, 320, 330, 350, 360, 380
Center 2	35 427	500, 510, 520, 530, 550
North 1	18 398	370, 390, 400, 410, 420, 430, 440, 610, 620, 630, 660, 670, 680, 690
East 1	15 949	560, 570, 600, 640, 650, 810, 820, 830, 840, 870, 900, 910, 930
Isle	10 581	200, 210, 340
East 2	14 620	700, 710, 720, 730, 740, 750, 760, 770, 780
West 1	11 331	1640, 1710, 2140, 2600, 2610, 2620, 2630, 2660, 2710, 2720, 2730
East 3	21 338	800, 920, 940, 950, 960, 970, 980, 990, 1200, 1230, 1280
West 2	16 782	2100, 2110,2120, 2130,2150, 2160,2170, 2180,2200, 2210,2230, 2240
North 2	13 723	1600, 1610, 1620, 1650, 1660, 1670, 1720, 1730
North 3	15 225	1300, 1350, 1360, 1370, 1390, 1400, 1450, 1480
West 3	11 778	2260, 2320, 2360, 2700, 2750, 2760, 2770, 2780
Total	244 740	

Table A3 Correlations between real annual housing price changes in the HMA submarkets and in the major Finnish cities

	City Core	Center 1	Center 2	Isle	West 1	West 2	West 3	North 1	North 2	North 3	East 1	East 2	East 3
City Core	1												
Center 1	.94	1											
Center 2	.89	.95	1										
Isle	.83	.80	.84	1									
West 1	.85	.91	.93	.78	1								
West 2	.84	.89	.92	.82	.92	1							
West 3	.81	.86	.91	.77	.92	.91	1						
North 1	.87	.94	.97	.84	.94	.94	.92	1					
North 2	.83	.91	.95	.80	.94	.93	.94	.96	1				
North 3	.86	.91	.95	.79	.95	.92	.93	.96	.96	1			
East 1	.86	.92	.96	.85	.93	.94	.94	.97	.96	.95	1		
East 2	.84	.91	.94	.82	.95	.94	.92	.96	.96	.96	.95	1	
East 3	.84	.91	.95	.80	.95	.94	.95	.96	.97	.96	.97	.97	1
Average	.85	.91	.93	.81	.91	.91	.90	.94	.93	.93	.93	.93	93

	Helsinki	Espoo	Vantaa	Turku	Tampere	Kouvola	Lahti	Pori	Lappeenranta	Jyväskylä	Kuopio	Oulu	Rovaniemi
Helsinki	1												
Espoo	.96	1											
Vantaa	.97	.97	1										
Turku	.92	.93	.94	1									
Tampere	.94	.94	.95	.89	1								
Kouvola	.93	.93	.93	.91	.93	1							
Lahti	.94	.94	.95	.94	.94	.92	1						
Pori	.76	.80	.78	.81	.79	.80	.80	1					
Lappeenranta	.88	.90	.92	.91	.90	.87	.91	.81	1				
Jyväskylä	.91	.92	.93	.92	.91	.91	.94	.83	.92	1			
Kuopio	.88	.91	.90	.93	.88	.90	.91	.89	.91	.92	1		
Oulu	.89	.94	.93	.89	.90	.89	.95	.78	.91	.92	.89	1	
Rovaniemi	.76	.78	.78	.83	.74	.76	.84	.78	.78	.86	.88	.84	1
Average	.90	.91	.91	.90	.89	.89	.92	.80	.88	.91	.90	.89	.80

Table A4 Correlations between real five-year housing price changes in the HMA submarkets and in the major Finnish cities

	City Core	Center 1	Center 2	Isle	West 1	West 2	West 3	North 1	North 2	North 3	East 1	East 2	East 3
City Core	1												
Center 1	.99	1											
Center 2	.98	.98	1										
Isle	.93	.92	.97	1									
West 1	.95	.96	.98	.94	1								
West 2	.96	.96	.99	.95	.99	1							
West 3	.94	.94	.98	.94	.99	.99	1						
North 1	.97	.97	.99	.97	.99	.99	.99	1					
North 2	.95	.96	.98	.94	.99	.99	.99	.99	1				
North 3	.95	.95	.98	.94	.99	.99	.99	.99	.99	1			
East 1	.97	.97	.99	.97	.99	.99	.99	.99	.99	.99	1		
East 2	.96	.96	.99	.96	.99	.99	.99	.99	.99	.99	.99	1	
East 3	.95	.95	.98	.95	.99	.99	.99	.99	.99	.99	.99	.99	1
Average	.96	.96	.98	.95	.98	.98	.98	.99	.98	.98	.99	.98	.98

	Helsinki	Espoo	Vantaa	Turku	Tampere	Kouvola	Lahti	Pori	Lappeenranta	Jyväskylä	Kuopio	Oulu	Rovaniemi
Helsinki	1												
Espoo	.99	1											
Vantaa	.98	.99	1										
Turku	.95	.98	.98	1									
Tampere	.98	.99	.99	.98	1								
Kouvola	.98	.98	.98	.98	.99	1							
Lahti	.95	.97	.98	.99	.98	.98	1						
Pori	.91	.93	.92	.95	.93	.95	.95	1					
Lappeenranta	.94	.97	.98	.99	.98	.97	.99	.94	1				
Jyväskylä	.97	.97	.97	.98	.98	.98	.98	.97	.97	1			
Kuopio	.95	.96	.96	.98	.97	.98	.98	.98	.97	.99	1		
Oulu	.93	.96	.97	.98	.97	.96	.99	.94	.99	.97	.97	1	
Rovaniemi	.88	.89	.89	.91	.90	.91	.93	.95	.90	.95	.95	.92	1
Average	.95	.97	.97	.97	.97	.97	.97	.94	.97	.97	.97	.96	.92

Table A5 Augmented Dickey-Fuller test results for housing price indices of the HMA submarkets[20]

Submarket	Level (lags)	Difference (lags)
City Core	.377 (5)	-2.10** (4)
Center 1	.250 (2)	-3.32*** (1)
Center 2	.352 (1)	-4.30*** (0)
Isle	.684 (0)	-3.69*** (2)
West 1	.170 (2)	-3.31*** (1)
West 2	.406 (1)	-3.46*** (1)
West 3	.468 (3)	-3.34*** (2)
North 1	.232 (2)	-3.06*** (1)
North 2	.329 (1)	-3.30*** (1)
North 3	.243 (2)	-3.05*** (1)
East 1	.070 (3)	-2.61** (2)
East 2	-.011 (2)	-3.15*** (2)
East 3	.232 (1)	-4.37*** (0)

Table A6 Augmented Dickey-Fuller test results for housing price indices of major Finnish cities

City	Level (lags)	Difference (lags)
Helsinki	.409 (1)	-4.03*** (0)
Espoo	.343 (1)	-4.46*** (0)
Vantaa	.007 (2)	-2.33** (1)
Turku	-.031 (2)	-3.23*** (1)
Tampere	.644 (2)	-3.12*** (1)
Kouvola	-.011 (2)	-4.79*** (1)
Lahti	.165 (5)	-2.76*** (4)
Pori	.122 (3)	-5.30*** (1)
Lappeenranta	.253 (2)	-3.25*** (1)
Jyväskylä	.241 (1)	-5.58*** (0)
Kuopio	.216 (2)	-3.44*** (1)
Oulu	.585 (2)	-3.46*** (1)
Rovaniemi	-.344 (2)	-4.84*** (1)

[20] *, **, and *** denote for ten, five and one percent level of significance, respectively.

Table A7 Alphas in the error-correction models for the HMA submarkets[21]

	CC	C1	C2	Isle	W1	W2	W3	N1	N2	N3	E1	E2	E3
CC		-.189	.074	.131	.206	.244	.229	.286	.291	.245	.283	.309	.301
C1	.531		.170	.094	-.096	.006	.008	.156	.115	.066	.152	.080	.097
C2	-.039	.097		.189	-.150	-.199	-.247	.053	-.060	-.191	-.088	.053	-.110
Isle	.033	.104	.064		-.075	-.084	-.066	-.034	-.073	-.079	.022	-.053	-.055
W1	.307	.503	.771	.134		.418	.405	.856	.463	.429	.593	.568	.470
W2	.177	.297	.725	.219	.408		.415	.516	.439	.588	.379	.786	.579
W3	.242	.442	.887	.357	.452	.873		.372	.085	.256	.561	.437	.297
N1	.041	.052	.703	.151	-.231	-.029	.070		-.083	-.266	.424	.136	.004
N2	.186	.315	.616	.120	.321	.334	.209	.645		.216	.314	.343	.476
N3	.147	.189	.653	.152	.531	.499	.084	.781	.864		.459	.559	.604
E1	.095	.080	.991	.231	-.021	-.174	-.110	.601	.004	-.111		.252	.064
E2	.151	.140	.558	.096	.014	.135	.064	.512	.069	-.064	.447		.246
E3	.085	.076	.484	.093	.136	.179	.019	.391	.168	.077	.268	.366	

Table A8 Alphas in the error-correction models for the major cities in Finland

	He	Es	Va	Tu	Ta	Ko	Lah	Po	Lap	Jy	Ku	Ou	Ro
He		-.253	.035	-.040	-.060	-.117	-.023	-.054	-.019	-.089	-.092	.007	-.002
Es	.551		.659	-.081	.275	.010	-.052	-.046	.044	.008	-.097	.027	-.019
Va	-.016	.071		-.120	.139	.055	-.063	-.007	-.072	-.043	-.049	.023	.003
Tu	.020	.070	.116		.073	.671	.630	-.007	.373	.145	-.021	.274	-.044
Ta	.217	.188	.214	-.084		.194	.010	-.071	.010	-.044	-.079	-.025	-.024
Ko	.254	.320	-.061	-.250	.467		.054	-.003	.060	.157	-.092	-.068	.025
Lah	.008	.042	.039	.187	-.005	.522		.041	.550	-.025	-.034	.359	.100
Po	.092	.108	.007	.008	.176	.054	.123		.224	.338	.495	.123	.155
Lap	.130	.189	.057	-.011	-.005	.320	-.110	-.081		.150	-.056	-.045	-.028
Jy	.075	.185	.049	.071	.072	.393	.100	-.180	.333		.011	-.115	-.033
Ku	.086	.122	.057	.027	.102	.307	.140	-.132	.326	.628		.072	-.011
Ou	-.002	-.009	-.009	.164	.015	.301	-.001	-.066	.600	.091	-.028		.020
Ro	.001	.023	-.003	.063	.044	-.081	-.026	.054	.134	.145	.011	-.027	

[21] If i and j denote for the row number and the column number, respectively, then the value in cell i,j is the alfa of area i for the equilibrium relationship (x_j - βx_i – possible deterministic component). In general, if relationship between areas i and j is cointegrating then values in both i,j and j,i should be nonnegative and at least one of them significantly positive.

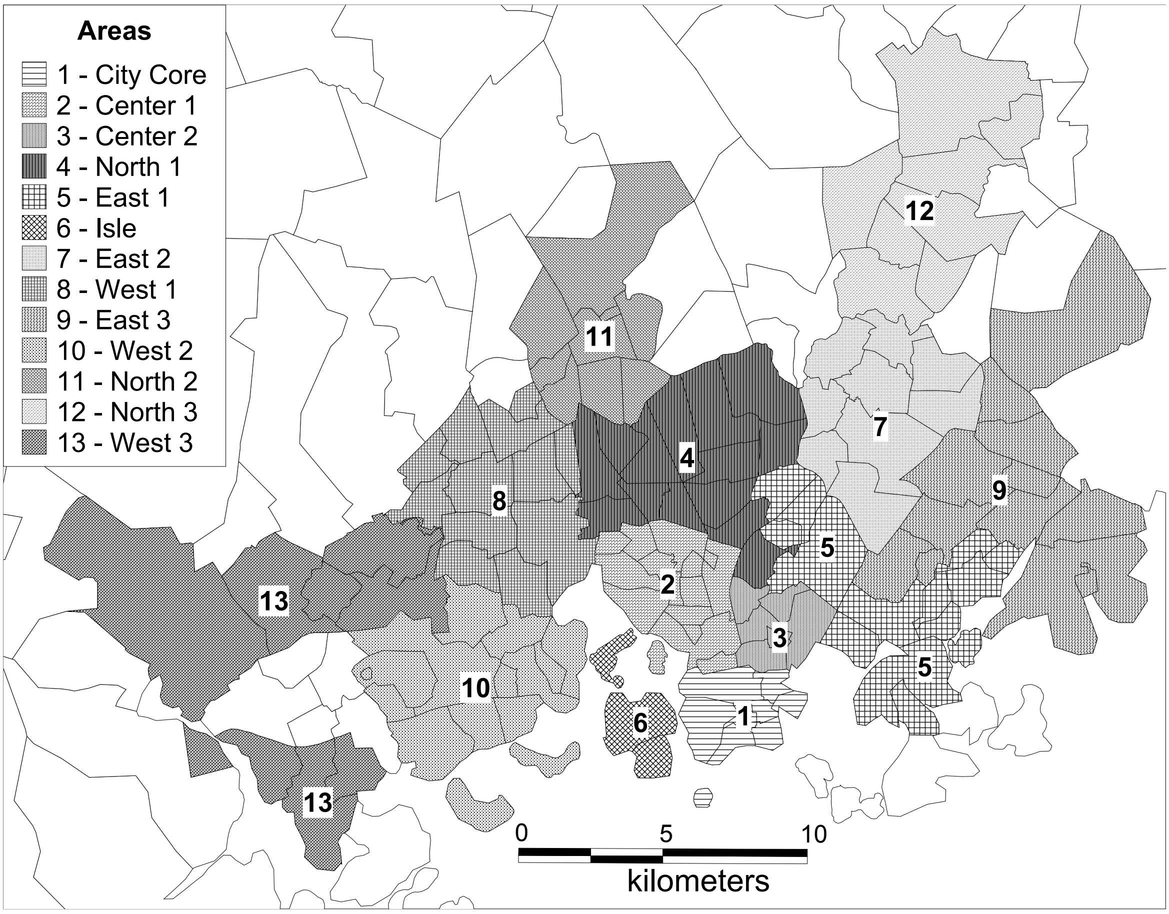

Figure A1 Geographical distribution of the 13 HMA submarkets

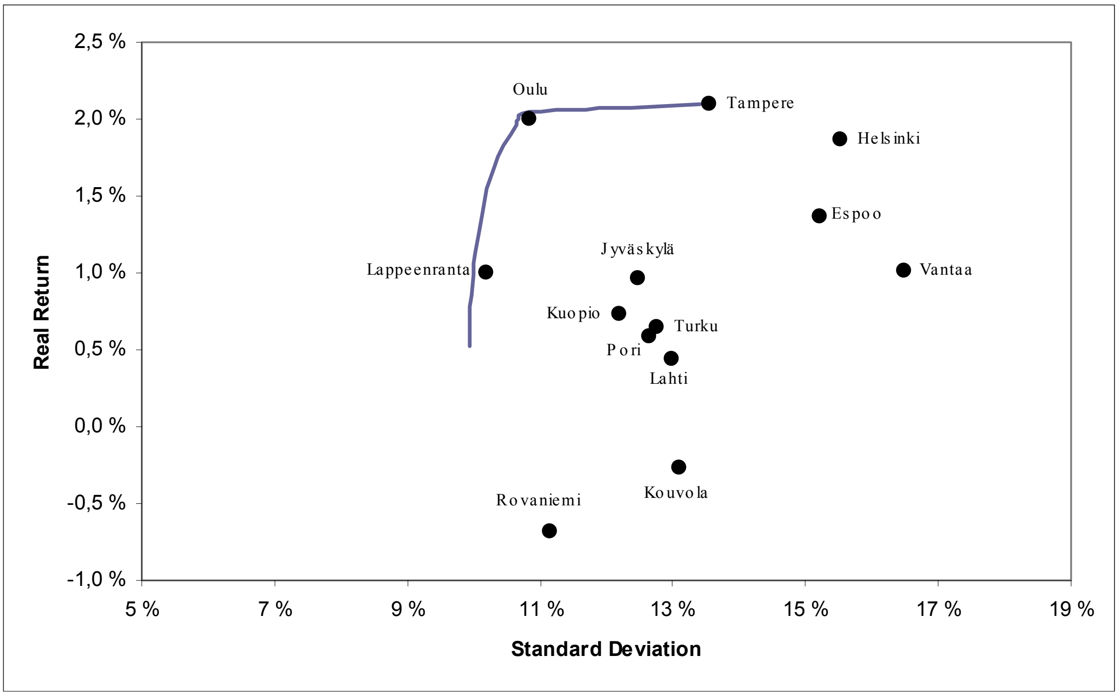

Figure A2 Efficient frontier for housing portfolio consisting of major Finnish cities based on annual returns

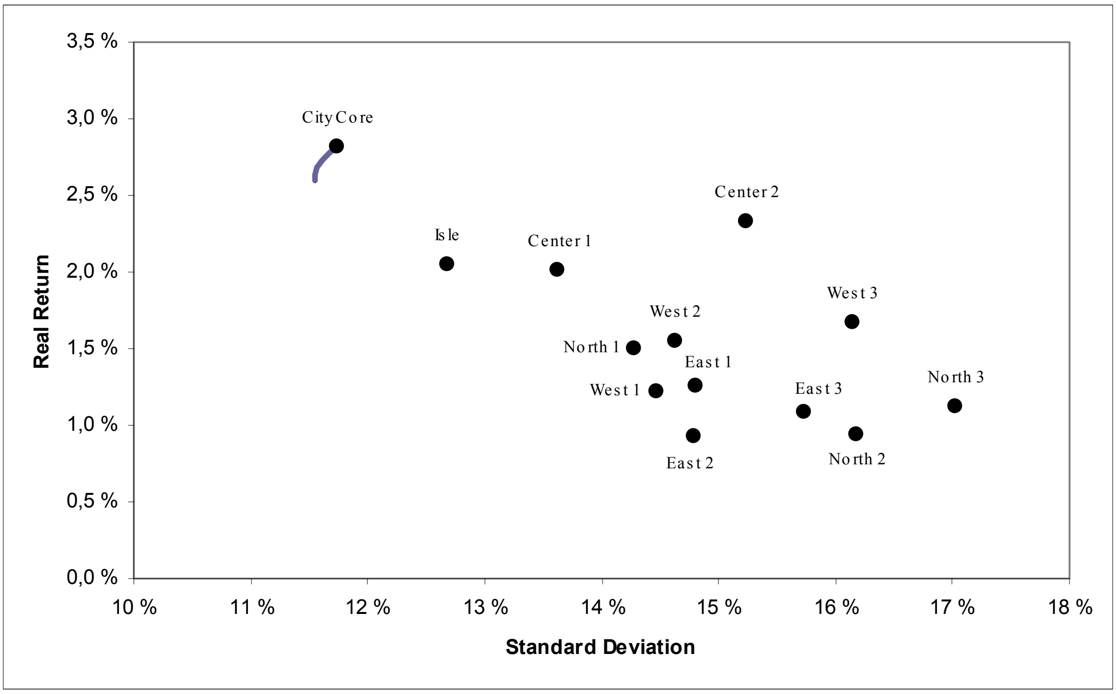

Figure A3 Efficient frontier for housing portfolio consisting of the HMA submarkets based on annual returns

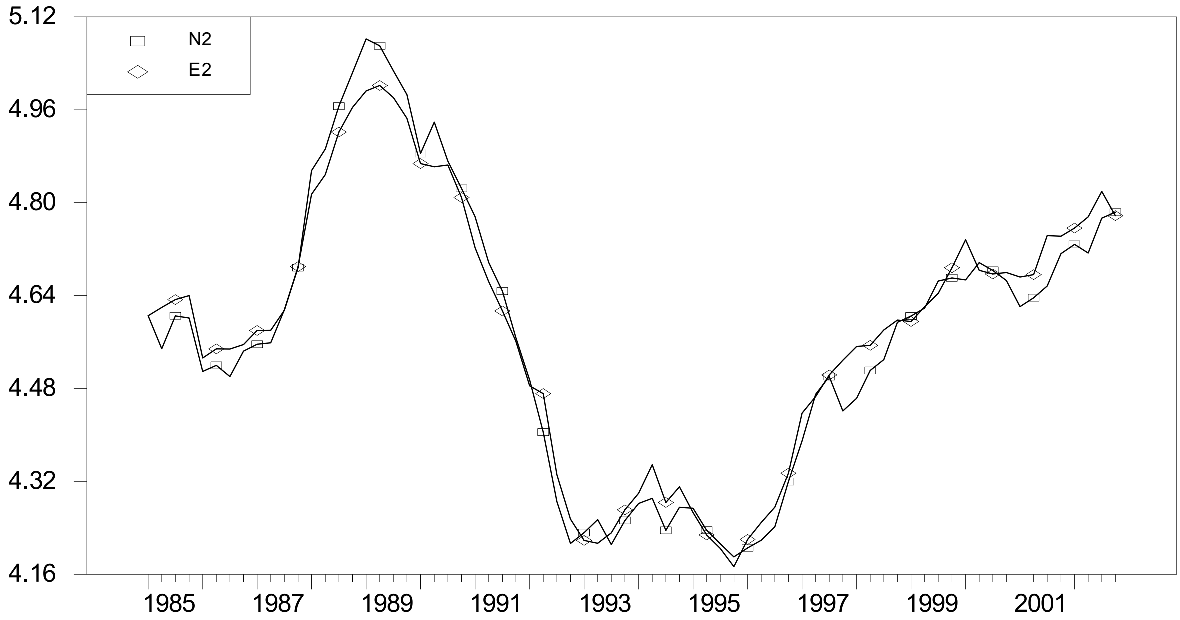

Figure A4 Housing price indices for the HMA submarkets North 2 and East 2

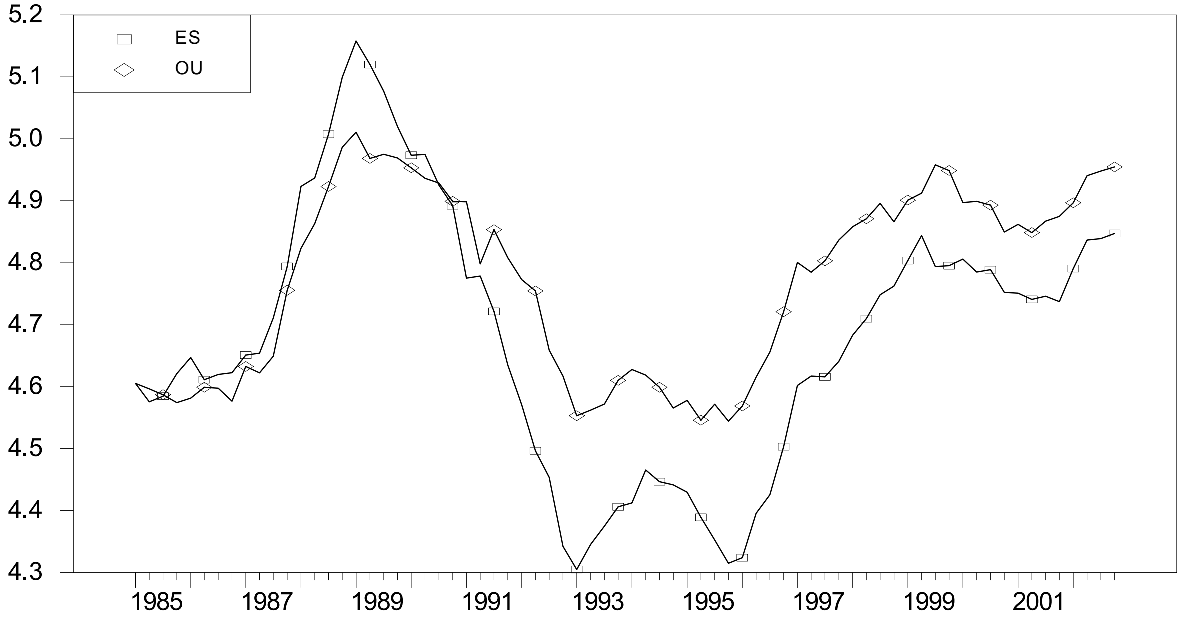

Figure A5 Housing price indices for Espoo and Oulu

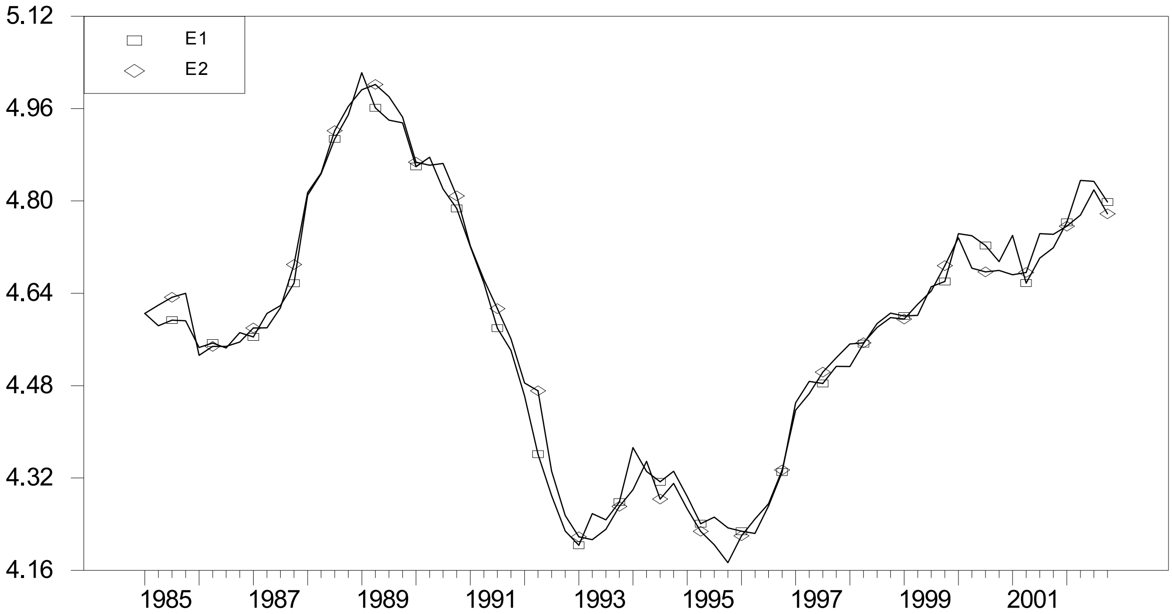

Figure A6 Housing price indices for the HMA submarkets East 1 and East 2

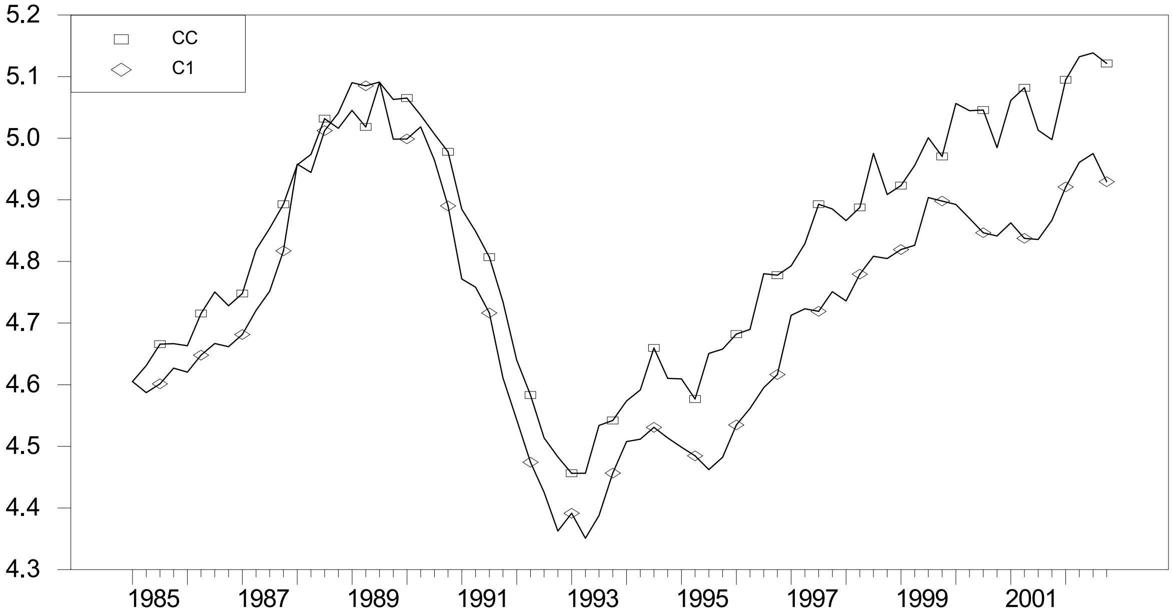

Figure A7 Housing price indices for the HMA submarkets City Core and Center 1