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ABSTRACT

This study adds to the literature on mean aversion and mean reversion in housing prices. In contrast with the previous related literature, the persistence and reversion characteristics are studied by computing variance ratios using Kim's (2006) Wild bootstrapping and by investigating horizons up to 10 years. The variance ratios clearly indicate that housing prices do not follow random walk in any of the 15 Finnish cities included in the analysis. Instead, momentum in housing price growth is long-lasting and considerable in size. Since the eventual reversion is substantially weaker than the initial mean aversion, housing is notably riskier asset in the long term than suggested by variances computed from quarterly or annual price movements. The results also show that the momentum and reversion patterns may substantially vary between regional housing markets. These differences influence the optimal housing portfolio allocation and highlight one more reason why it is complicated to use country level housing price data when analyzing the optimal portfolio allocation or housing price dynamics.

JEL Classification: R31; G11

Keywords: housing prices; momentum; mean reversion; variance ratio; portfolio allocation

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1 Introduction

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. However, it has been known for long that housing price movements exhibit notable predictability. Importantly, the recent research has shown that predictability in asset returns may lead to strong horizon effects (see e.g. Balduzzi and Lynch, 1999; Lynch and Balduzzi, 2000; Barberis, 2000; Campbell and Viceira, 2002). In particular, due to mean aversion and mean reversion in asset prices, the relative riskiness of various assets and the optimal portfolio allocation are dependent on the planned investment horizon. Mean aversion, or "momentum", implies that high returns today predict high returns in the relatively close future as well. Mean reversion, instead, indicates that higher than average returns today are followed by lower than average returns in the future. Importantly, if asset prices are mean reverting, the returns are less volatile in the long horizon than in the short run. Hence, for a long-term investor mean-reverting assets are more attractive than suggested by the conventionally used short-run volatility measures. Mean aversion, in turn, signifies the opposite.

The early research on the time series properties of asset returns concentrate on the financial assets. Early studies on mean aversion and reversion in the stock market include DeBondt and Thaler (1985, 1987), Fama and French (1988) and Poterba and Summers (1988). Much of the empirical evidence suggests that even the financial asset returns are not i.i.d. Pioneering work regarding the housing market was conducted by Case and Shiller (1989, 1990). The results by Case and Shiller, which implied the existence of notable short-run persistence in housing price growth and showed somewhat weaker evidence for longer-horizon negative serial correlation, have been confirmed by numerous studies since that. While it is easy to explain the longer-horizon mean reversion theoretically, several potential reasons, including backward-looking expectations, liquidity constraints and housing market frictions, have been presented for the short-term momentum.

Housing, and direct real estate in general, is typically long-term investment due to its characteristics such as relatively low liquidity and high transaction costs. Collett et al. (2003) find that the median realized holding period for institutional real estate investors varies with property type and year of purchase, but is generally between 7 and 14 years. This is consistent with transaction costs making direct real estate a suitable investment only for investors with medium to long-term horizons. Therefore, the horizon effects of the time series properties of asset returns are outstandingly relevant to investors holding real estate in their portfolios. Nevertheless, the empirical literature regarding the mean reversion and aversion of housing returns typically studies horizons up to a couple of years at maximum. Investment horizon for direct housing investments is often substantially longer than that, however. Therefore, more research on the longer-horizon characteristics of housing returns is needed.

Importantly, the magnitude and length of mean aversion and subsequent reversion of housing prices may well vary between regions and between dwelling types. A number of market characteristics, such as market size and liquidity, population density and growth, and supply constraints may influence the momentum and mean reversion patterns. The regional differences in the horizon effect may well have notable portfolio implications.

The main aim of this study is to examine empirically whether the horizon effects notably differ between distinct housing markets in Finland. Before the empirical analysis, the article discusses theoretically the potential reasons behind housing price momentum and mean reversion and behind differences in the price patterns between different housing markets. The previous related studies have employed econometric models to investigate the persistence in real estate price movements (Case and Shiller, 1989, 1990; Englund and Ioannides, 1997; Capozza, et al., 2004; MacKinnon and Al Zaman, 2009). These models cater for dynamics only up to a couple of years or less. In contrast with the previous articles, in this paper the housing market horizon effect is analyzed by computing variance ratios and by investigating horizons up to 10 years. The variance ratios enable a detailed examination of the shapes and durations of momentum and mean reversion, and easily allow for comparison between distinct markets. Moreover, the computed variance ratios cater for the potential serial correlation in housing price movements up to the whole ten year horizon.

The results show that, expectedly, housing prices do not follow random walk in any of the markets. Instead, momentum effect in housing prices is long-lasting and considerable in size. The variance ratios peak at the horizon of 4-5 years after which mean reversion starts. The reversion is substantially weaker than the initial mean aversion, however. That is, housing is notably riskier asset in the long term than suggested by variances computed from quarterly or annual price movements. Since the stock and bond returns do not appear to exhibit similar strong momentum, the relative attractiveness of housing investments is weaker for a long-horizon investor than suggested by the conventional portfolio analyses that employ short-term variances and assume i.i.d. returns. This justifies, at least partly, the relatively small share of direct real estate investments in institutional portfolios.

The results also show that the horizon effect may substantially vary between regional housing markets and between flats and single-family housing. There appear to be notable regional differences in the duration and, in particular, the magnitude of momentum. The results also indicate that the long-term mean reversion greatly varies between markets. These differences influence the optimal housing portfolio allocation and highlight one more reason why it is complicated to use country level housing price data when analyzing the optimal portfolio allocation or housing price dynamics. The variance ratios generally imply that in more liquid markets, in terms of the turnover rate, the momentum effect is somewhat weaker and shorter than in more illiquid markets. Somewhat surprisingly, the estimated correlation between momentum and market size and density is positive.

The paper proceeds as follows. The next section reviews empirical findings on housing market momentum and mean reversion, and discusses potential theoretical explanations for the empirical findings. The third section presents the data used in the empirical analysis. The variance ratio analysis is conducted in section four after which the paper is summarized and concluded.

2 Theoretical considerations and previous empirical findings

Short-run persistence and long-run mean reversion in housing price growth has aroused great interest since the empirical findings of Case and Shiller (1989 and 1990). The result by Case and Shiller (1989), which implied the existence notable persistence in housing price growth, has been confirmed by numerous studies since that (e.g. Meese and Wallace, 1994; Englund and Ioannides, 1997; Englund et al., 1999; Capozza et al., 2004; Roed Larsen and Weum, 2008; Beracha and Skiba (2010) just to name a few). Similarly, a number of empirical examinations (e.g. Cappozza and Seguin, 1996; Englund and Ioannides, 1997; Meen, 2002; Capozza, et al. 2004; Glaeser and Gyourko, 2006) have supported the findings of Case and Shiller (1990) that showed evidence for longer-horizon negative serial correlation in housing price changes.

The basic rational expectations theory can predict the mean-reverting tendency of housing prices. According to the conventional rational expectations stock-flow model of housing market, after a shock in the fundamentals housing prices overshoot first because of the inability of the housing stock to respond immediately, i.e., because of the construction lag. After the single overshot, price level gradually adjusts towards its new long-run level, i.e., mean reverts, as the housing supply responds to the changed housing price level (see DiPasquale and Wheaton, 1996, pp. 242-256). This theory suggests that the price level peaks immediately after the shock so that short-run mean aversion does not take place. At lower frequencies, in turn, autocorrelations should be close to zero if the adjustment process is reasonably fast.

Glaeser and Gyourko (2006) introduce a dynamic rational expectations model that can relatively well explain the perceived long-horizon mean reversion of housing prices in the US. In the model, mean reversion is not only a result of the construction lag, but also of the mean reversion in economic shocks to local productivity.[1] While the model of Glaeser and Gyourko is not able to explain the shorter-term mean-averting tendency, the liquidity constraints faced by households together with the positive interaction between housing prices and credit availability may create self re-enforcing cycles that lead to mean-averting housing prices in the relatively short term (Goodhart and Hofmann, 2007; Oikarinen, 2009a).

Several studies on housing price dynamics report significant positive parameter estimates on the lagged housing price growth even if fundamental variables are included in the estimated model (e.g. Case and Shiller, 1990; Englund and Ioannides, 1997; Capozza et al., 2004). Some of these estimations also include credit variables that are likely to cater for the interaction between credit and housing prices (Oikarinen, 2009a, 2009b). These results suggest that the short-run persistence in housing price growth cannot be wholly explained by the short-term persistence of changes in the economic fundamentals and by the interaction between credit availability and housing prices. Nevertheless, irrational features are not necessary to explain even this finding, since given the heterogenous product and time-consuming search in the housing market, rapid price adjustments may not be rational (DiPasquale and Wheaton, 1994). That is, the notable frictions in the housing market, such as information asymmetry due to high information costs, high transaction costs, absence of short selling, and infrequent trading, may well induce short-term mean aversion even if market participants are rational.

In addition to the rational expectations considerations, the literature presents several potential behavioral features that may cause short-horizon persistence in housing price growth and may therefore explain the above mentioned findings at least partially.[2] In particular, the feedback effect, caused by backward-looking expectations, can cause momentum in asset prices (Cutler et al., 1990). If expectations are backward looking, current rapid housing price growth induces positive expectations regarding future housing appreciation. These expectations, then, may fulfill themselves in the relatively short run. Early empirical evidence of backward-looking expectations in the housing market was provided by Case and Shiller (1989) and Mankiw and Weil (1989), and more recently the existence of backward-looking expectations has been confirmed by numerous empirical articles. If backward-looking expectations are assumed, the

[1] Similarly, Malkiel (2003) argues that the tendency of interest rates to be mean reverting may cause mean reversion in the asset returns.

[2] An overview of the irrational features suggested and documented in the behavioral finance literature is given e.g. by Stracca (2004).

short-term mean averting tendency of housing prices can be explained in the context of the housing market stock-flow model. Moreover, based on the search model by Piazzesi and Schneider (2009) even a small fraction of optimists ("momentum traders") can drive up the average transaction price of housing. Piazzesi and Schneider also report empirical support for the existence of backward-looking expectations in the housing market regarding the recent housing boom in the US. According to Black et al. (2006) and Fraser et al. (2008) "momentum trading", caused by the feedback effect, has notably contributed to housing price bubbles in the U.K. and New Zealand.

Similarly, a tendency for investors and households to underreact to new information, another explanation offered by the behavioralists, could explain the short-run momentum. If the full impact of new important information is only grasped over a relatively long period of time, housing prices will exhibit momentum. The feedback effect may also strengthen the longer-run mean reversal of housing prices. Because of feedback, prices may substantially overreact upwards after a positive shock before the mean reversion starts. Then, the feedback effect may cause the price level to overreact downwards (see e.g. Shiller, 2003). Indeed, DeBondt and Thaler (1985) argue that investors are subject to waves of optimism and pessimism which may add to short-run momentum and longer-run mean reversion.

The magnitude and length of mean aversion and subsequent reversion may well vary between regions and between dwelling types. Clapp et al. (1995) suggest that higher population density should foster more, better and prompter information concerning housing markets, since information production is subject to positive scale economies. Moreover, in markets with greater number of transactions, information costs are lower and, therefore, prices should respond more rapidly to changing fundamentals (Capozza et al., 2004). Another informational factor is the existence of both informed and uniformed agents in the housing market.[3] Uninformed refers here to agents who do not have even publicly available information or at least do not know how the information should affect housing prices. If all the agents in the market are informed and rational, the price level should adjust to the new information set immediately. For the uninformed agents, however, it takes time before they perceive the change in the market conditions and consequently increase asking prices or are willing to pay more for dwellings. Moreover, the uninformed agents are more likely to base their expectations on recent historical housing price development than the informed agents. Therefore, the bigger the share of the uninformed agents in the market the longer the adjustment process is likely to last and the longer the short-run momentum is likely to be. If there are notable differences in the share of informed agents of all the agents between housing markets, the mean aversion stage is likely to extend for a longer period of time. Generally, it may be assumed that the best informed actors are mainly professional investors. In Finland institutional and other professional investors concentrate their housing investments on flats located in a few largest cities in the country (this is likely to be the case also in a number of other countries and states). Thus, it seems probable that the share of informed agents of all the active agents is larger in the market for flats and in the housing markets of the largest centres. Provided that this is true, the short-run momentum effect is expected to be more persistent in small towns than in the main economic centres.

[3] The idea of informed and uninformed agents was introduced originally by Grossman and Stiglitz (1976). Clapp et al. (1995) present the population density and Oikarinen (2006) the share of informed investors also as a potential reason for lead-lag effects between regional housing markets.

Altogether, the informational factors suggest that in larger and more densely populated metropolitan areas with more liquid housing markets housing demand should more rapidly adjust to shocks and therefore the momentum in housing prices should last for a shorter time period and the mean reversion should start sooner. In smaller cities, in turn, the persistence in housing prices is expected to be longer. Nevertheless, there may also be other reasons than the informational factors that affect persistence and reversion in housing prices. Capozza et al. (2004) hypothesize that higher real construction costs are correlated with slower mean reversion and more serial correlation. Construction costs vary between regions because of material and labor costs and also due to unpriced supply restrictions. Moreover, in less densely populated areas supply may be able to adjust more rapidly than in areas with greater scarcity of land.

There may be notable variation between dwelling types as well. As construction of a multi-storey apartment generally lasts longer than that of a single-family house, the adjustment of housing supply will be faster in the single-family housing market than in the flat market, at least if expectations formation is rational to the same extent in both markets. However, the informational factors would suggest just the opposite, i.e., that the momentum effect in single-family housing prices might last longer: flats are generally more homogenous than singe-family houses, and flats are typically located in more densely populated areas. Moreover, in the Finnish case the persistence in the single-family housing prices may be enhanced by the fact that single-family housing market is typically more illiquid and thin and incorporates greater transaction costs than the market for flats.[4] Hence, it might take longer for single-family housing prices to fully absorb all relevant information.

Since there are both informational and other factors that are likely to influence housing price dynamics at the market level, it is essentially an empirical question to study the variation in persistence and mean reversion between housing markets. Given the above discussion, it is not surprising that a number of studies report regional differences in the short-run mean-averting and longer-term mean-reverting tendency of housing prices. Capozza et al. (2004) find that housing prices mean revert faster in larger than smaller metro areas and that the serial correlation of housing prices is greater in metro areas with higher real incomes, population growth and real construction costs. Malpezzi's (1999) analysis indicates that housing price adjustment is faster in less stringently regulated environments. Abraham and Hendershott (1996), in turn, find that momentum is stronger in coastal cities, which generally exhibit greater land supply restrictions, than in inland cities. Also Case and Shiller (1989, 1990) report differences in the dynamics between cities. On the other hand, the results of Englund and Ioannides (1997) suggest that the autocorrelation structures are strikingly similar across countries.

Note that short-term mean aversion and long-term mean reversion have been documented also in the financial asset returns (see e.g. Fama and French, 1988; Lo and MacKinley, 1988; Cutler et al., 1991; Chan et al., 1996; Campbell and Viceira, 2005) although there are no similar structural reason (i.e. the sluggish adjustment of supply, high transaction costs) for momentum and mean reversion as in the housing market. The response speed of housing prices to shocks has been

[4] For instance, during 1987-2009 the annual number of single-family house sales in Finland was only 0.8% of the single-family housing stock, while the corresponding value for flats was 4.4%. The total number of transaction per year was 41 800 in the flat market and 7 800 in the single-family housing market. Furthermore, generally the transfer tax is 4% for single-family houses, while it is only 1.6% for flats.

typically found to be slow relative to stocks, however. Even regarding the financial asset returns, it is hard to state with certainty whether the mean aversion and reversion is due to informationally inefficient markets: the observed time-series patterns might be due to time-varying expected returns or the potentials gains from the predictability might not be enough to overcome the costs of trading (Fama, 1991). The latter is particularly relevant in housing markets that exhibit large transaction cost and relatively low liquidity. In any case, the time series properties of asset returns are of importance regarding, for instance, optimal portfolio allocation and economic policy decisions.

In contrast with the above mentioned studies on housing market momentum and reversion that typically use data for the U.S. and are based on econometric models that may exclude long-term autocorrelations in housing price movements, this study investigates the persistence and mean reversion in housing prices by conducting variance ratio tests and investigating investment horizons up to 10 years, and by using data for Finland. The variance ratio statistics enable a detailed examination of the shapes and durations of momentum and mean reversion, and easily allows for comparison between distinct markets. Furthermore, the computed variance ratios cater for the potential serial correlation in housing price movements up to the whole ten year horizon. Moreover, this study specifically focuses on detecting regional variations in the dynamics.

3 Data description

The empirical analysis is based on quarterly price indices of privately financed dwellings in a sample 15 Finnish cities. The cities incorporate the main growth centres in Finland, including the 10 largest cities in population, as well as some smaller and more peripheral cities such as Rovaniemi in Lapland and the contracting city of Kajaani with less than 40 000 inhabitants. Since vast majority of the privately financed rental housing, i.e., of the free-market investment housing, are flats, the analysis focuses on the flat markets. Moreover, the flat data are less complicated than the single-family housing data due to the more homogenous and liquid underlying asset. In fact, the only city for which Statistics Finland publishes hedonic price index for single-family housing is the Helsinki Metropolitan Area (HMA)[5]. The single-family housing data for HMA are used to compare the momentum and mean reversion patterns between flats and single-family housing.

This study uses the quarterly hedonic price indices constructed by Statistics Finland. The indices cover a period from 1987Q1 to 2009Q4 and are based on the transactions of privately financed dwellings in the secondary market. In addition, longer time series (from 1970 onwards) for four cities are used to investigate if the momentum and reversion patterns have changed over time. For the period 1970-1986 the indices are based on average transaction prices per square meter. In this paper only real indices and returns are used. Hence, the indices provided by Statistics Finland are deflated by the cost of living index. Furthermore, only log returns are used throughout the paper.

Only the capital returns are considered in the analysis, since there are no regional level rental price or maintenance cost data at the quarterly frequency. In general, it is the price movements

[5] HMA, as defined here, consists of Helsinki and the three nearest surrounding municipalities Espoo, Kauniainen and Vantaa.

that cause the volatility in housing returns. Therefore, it is reasonable to assume that the time series patterns of housing returns are driven by price movements, not by net rental cash flows. Indeed, data at annual frequency confirms that the autocorrelation structure (at least up to four lags) is practically identical between capital returns and total returns in all the markets. Hence, it is concluded that it is reasonable to use the capital returns to study momentum and mean reversion in housing returns.

The empirical analysis also includes construction cost, stock price and bond price data. The construction cost index that is used to study momentum and mean reversion in construction cost changes is based on tender prices of new multi-storey housing construction in HMA. The index is reported by Rapal Ltd. The OMX Helsinki CAP index (OMXHCAP) over 1987-2009 presents the measure for the Finnish stock market performance. Finally, the Datastream all maturities Finnish government bond index for the period 1989-2009 is used to examine the bond return patterns.[6] Also all of these indices are in real terms and in the log form. Figure 1 shows all the indices used in the analysis.

[Figure 1 around here]

The overheating of the Finnish housing markets in the end of the 1980s can be well seen in the Figure. In the turn of the decade the bubble burst causing a sharp drop in the housing price level. The decline in housing prices was strengthened by a severe recession of the Finnish economy. The bottom of the depression was reach in 1993 and eventually in 1996 housing prices started to rice again together with the overall Finnish economy. Since the mid 1990s real housing prices have increased substantially all over the country.

Table 1 presents summary statistics of housing market variables and of general market variables and conditions in each of the markets. Due to the greater value of land, and thereby greater “land leverage” (Bostic et al., 2007), housing price volatility is expected to be greater in larger and more densely populated cities. However, the hedonic price indices suggest that housing price volatility is greatest in small cities. This is most likely due to the relatively thin housing markets in the smaller cities. For instance, in Seinäjoki the average number of quarterly transactions in the sample period is 67, while it is over 3400 in HMA. Because of the relatively small number of observations per period in the smaller markets, the hedonic housing prices indices are not able to track the actual price development as well in the smaller cities as in the larger cities. In other words, the price indices of the small markets include more “noise”, i.e., variation that is due to the heterogeneity of housing rather than due to actual price changes, than those of the larger markets. Similarly, the autocorrelation coefficients are likely to be substantially downwards biased in the case of the smaller markets. Therefore, the standard deviations and autocorrelations that are reported in Table 1 are based on Hodrick-Prescott (H-P) filtered housing price indices that should extract, to a notable extent, the “noise” in the price series. These values are likely to give a better indication of the relative magnitudes of the quarterly volatilities and autocorrelations between the cities. As small lambda as 0.5 is used in the filtering in order to not lose actual short-term dynamics. It is reasonable to believe that the H-P

[6] Total return index for bonds is available only since 1995. The variance ratios differ only slightly between the price and total return indices over the 1995-2009 period. Therefore, the price index that covers a notably longer sample period, 1989-2009, is used in the analysis to get more reliable results.

filtered series give a good approximation of the actual volatilities and autocorrelations. While the smoothing parameter is small enough not to extract the actual short-run dynamics, at least to a significant magnitude, the filtered return volatilities of the smaller cities are notably lower than those based on the original series and than those of the larger cities (as expected by the theory). This supports the claim that the high volatility of the smaller markets in the original data is to a large extent due to additional noise in the price series. Also the correlation analysis conducted in section 4 suggests that the filtering is reasonable and works comparatively well. For comparison, the statistics that are based on the non-filtered data are reported in the parenthesis in Table 1.

Expectedly, the H-P filtered price volatility is notably greater in HMA than in the other areas – after all, HMA is by far the largest and most expensive regional market in Finland and in HMA land leverage is the highest in the country. The filtering also substantially changes the autocorrelation figures in the smaller markets. That is, due to the measurement error in the indices, the original series would hide the strong autocorrelation in housing price movements in the small cities and would notably exaggerate the standard deviation at the quarterly frequency. Moreover, the filtered price changes generally appear to be approximately normally distributed. Anyhow, the large estimated first and second order autocorrelations, the first order being 0.81-0.92 and the second order 0.53-0.74 across the cities, suggest that there is a strong momentum effect in housing prices regardless of the region.

In addition to the basic information regarding housing price movements, Table 1 reports information on several market characteristics that may notably affect momentum and mean reversion in housing price movements according to the theory. These variables are related to the market size and liquidity as well as to the market growth. Since the cities vary greatly in the size of their administrational geographical boundaries and some cities include notable peripheral areas within their boundaries, population may not give the right picture of the actual “size” of the urban housing market – a notable fraction of the population may live in agricultural areas that are not part of the core housing market of the city. Hence, in addition to population and population growth Table 1 includes information on the share of population that lives in the urban areas

Note that while the housing and construction cost indices are H-P filtered, stocks and bond indices are not. The stock and bond markets do not have the same asset heterogeneity complications as the housing market. Therefore, the price series cannot be assumed to include similar additional noise that is due to measurement errors as the housing price series and the construction cost series do.

Table 1 Descriptive statistics of the markets over 1987-2009

Market	Pop. (growth)	Urban share (%)	Avg. price level (€/m²)	Trans. vol. (turnov.%)	Mean %	S.D. %	Jarque-Bera	1st order autocorr	2nd order autocorr
HMA	921 (27%)	99.6	1826	3433 (3.6%)	2.7	7.2 (8.1)	.07 (.04)	.91 (.70)	.71 (.51)
Tampere	190 (24%)	98.5	1209	811 (4.0%)	2.9	6.5 (7.5)	.84 (.15)	.92 (.61)	.74 (.52)
Turku	168 (10%)	98.4	1078	761 (3.8%)	2.0	6.1 (7.5)	.54 (.07)	.90 (.47)	.72 (.44)
Oulu	119 (37%)	94.7	1067	341 (3.3%)	2.0	5.1 (6.5)	.11 (.22)	.88 (.39)	.67 (.39)
Jyväskylä	114 (28%)	92.6	1123	282 (3.6%)	1.6	5.6 (7.4)	.26 (.07)	.89 (.30)	.71 (.42)
Lahti	96 (8%)	98.7	941	392 (4.1%)	1.9	6.2 (7.4)	.79 (.15)	.92 (.57)	.75 (.48)
Kuopio	88 (14%)	91.8	1117	289 (4.1%)	2.0	5.9 (8.0)	.11 (.00)	.88 (.27)	.69 (.33)
Kouvola	92 (-7%)	86.6	769	123 (3.4%)	0.7	6.1 (9.1)	.38 (.04)	.86 (.11)	.66 (.27)
Pori	83 (-1%)	95.2	845	181 (4.2%)	1.5	5.4 (8.6)	.27 (.49)	.84 (.02)	.63 (.21)
Joensuu	70 (10%)	87.2	1096	148 (3.1%)	1.9	4.9 (7.4)	.53 (.42)	.85 (.08)	.65 (.24)
Lappeenranta	70 (5%)	89.4	1078	157 (3.5%)	1.3	5.1 (7.6)	.48 (.11)	.87 (.07)	.68 (.34)
Rovaniemi	57 (15%)	87.7	869	111 (3.5%)	1.4	5.5 (8.5)	.42 (.02)	.84 (.05)	.62 (.24)
Vaasa	56 (10%)	98.8	1020	175 (3.1%)	1.9	4.2 (6.9)	.02 (.32)	.84 (-.01)	.65 (.19)
Seinäjoki	51 (25%)	87.9	883	67 (3.7%)	1.4	5.8 (9.3)	.03 (.00)	.81 (-.04)	.53 (.29)
Kajaani	39 (-3%)	88.9	1164	85 (3.9%)	1.5	5.0 (8.1)	.91 (.14)	.83 (-.02)	.59 (.29)
HMA, single-family	921 (27%)	99.6	1698	98 (0.4%)	1.7	9.1 (20)	.19 (.70)	.68 (-.34)	.38 (.22)
Constr. costs					-0.6	5.3	.00	.89	.68
Stocks					2.8	22.9	.31	.39	.09
Bonds					-1.0	5.0	.22	.29	.01

Mean is the annualized average log change in the price level, S.D is the annualized standard deviation of the log price changes, and Jarque-bera is the p-value for the null of normally distributed price changes in the Jarque-Bera test. Regarding these variables that summarize the housing price movements, the value in the parenthesis is based on non-filtered index, whereas the value above the parenthesis is computed from the H-P filtered price index. The Table also shows the average population of the cities (pop.) as thousands of inhabitants during the sample period and the population growth during the period in parenthesis, the share of population that lives in urban areas, average transaction price (per square meter) of privately financed flats (single-family housing in the two last rows) in 1987-2009, as well as average quarterly transaction volume in the market during 1987-2009 and the turnover rate (annual transaction volume / total stock, 2009) in the parenthesis. There have been several changes in the geographical boundaries of the cities during 2008-2009. The housing market figures correspond to the city boundaries prior to the changes whereas the population growth figures correspond to the population growth in the whole area with the new (wider) boundaries. The use of the wider area population growth is reasonable, since typically the whole region belongs to the same commuting area. Due to the changes in the boundaries, only the latest turnover rate figures are reliable and reported.

4 Variance ratio analysis

This study uses the variance ratio (VR) approach, suggested by Lo and MacKinley (1988, 1989), to examine if housing prices mean avert in the short run and mean revert in the long horizon. The VR statistics investigate the proportionality of the variance of k-differences of the returns with the variance of the first difference. For a random walk series, the variance of k-differences is k times the variance of the first difference. That is, for the returns to exhibit neither mean aversion nor reversion, the variance ratio statistics should not be different from one at any horizon. For example, if a housing price series follows a random walk, the variance of its one-year returns will be four times as large as the variance of its quarterly returns. If, instead, the variance increases more than proportionately to the horizon (k), VR exceeds one and indicates momentum in the returns. That is, whenever VR(k+1) is greater than VR(k) there is mean aversion and if VR(k+1) is smaller than VR(k) there is mean reversion.[7]

To get more observations concerning the longer horizon returns, overlapping returns are used to compute the VR statistics. The use of overlapping returns yields a more efficient estimator and a more powerful test (Campbell et al., 1997). Since even the number of overlapping observations is relatively small in this study, the conventional Lo and MacKinley (1988) variance ratio test that is based on an asymptotic normal distribution could show small sample deficiencies. Therefore, the reported variance ratio test results are based on the Wild bootstrap (Kim, 2006) with 1000 replications and normal error distribution.[8] Variance ratios up to 40 quarters are investigated in this study.[9].

Figure 2 pictures the VR values for flats in each of the markets. The vertical axis shows the VRs and the horizontal axis shows the investment horizon. Clearly, none of the housing price series follows the random walk. In all the markets the VR values are statistically significantly greater than one at almost all the horizons. Momentum lasts for a long time period regardless of the market. Even in Pori, where mean reversion starts the earliest, VR peaks at 15-quarter horizon. In Turku and Joensuu, in turn, VR peaks the latest, i.e., after 22 quarters. That is, the momentum effect appears to last for approximately four to five years. The long periods of mean aversion are in line with the empirical evidence from the U.S., although the momentum in housing prices generally seems to last even longer in Finland than in the U.S.: Glaeser and Gyourko (2006) find there to be momentum still over three year periods in the U.S. and according to the estimations of Capozza et al. (2004) housing price overshooting peaks at around four years after a shock in the fundamentals. Note that the filtering of the price series does not influence the timing of the peak in the VR curves.

The VR curves reveal notable differences in the momentum and mean reversion between the regional housing markets. While the maximum VR is 7.5 in Joensuu, it is only slightly over half of that in Seinäjoki. Moreover, housing prices do not show notable mean-reverting tendency in Joensuu even in the long horizon, whereas in most of the cities the VR curves drop substantially in the long run after peaking at the horizon of 4-5 years. The estimated mean reversion in most

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[7] For more about the variance ratio test, see Campbell et al. (1997).

[8] Kim's (2006) simulations indicate that the test results are generally insensitive to the choice of wild bootstrap distribution.

[9] Longer-horizon returns were not tested. This is because the number of observations gets overly small as the horizon is lengthened and because there are also other difficulties with inferences when the horizon is large relative to the total time span (see Campbell et al. 1997, pp. 57-59).

prominent in Rovaniemi where VR drops from 6.2, at four year investment horizon, all the way to 1.6 at the horizon of 37 quarters.

In each city, the filtered price indices naturally yield greater VRs than the original series. Generally, the smaller the market, the bigger this “correction” is. Nevertheless, the HMA curve is high compared to most other markets even after filtering. Note that the filtering appears to work well in the sense that the maximum VRs do not significantly correlate with the transaction volumes of the markets. In contrast, there is strong correlation (.67) between transaction volume and the VRs that are based on the non-filtered price series.

The high variance ratios indicate predictability in housing price movements. The shapes of the VR curves indicate that higher (lower) than average returns on housing today predict higher than average returns in the future. As the VRs stay substantially over one even in the long horizon, housing is a notably riskier asset in the long term than suggested by the quarterly or annual variance figures. Even the smallest VR is two at the 40 quarter horizon.

[Figure 2 around here]

Previous empirical evidence (Oikarinen, 2009a, 2009b) suggests that the financial market liberalization induced a structural change in the housing price dynamics in Finland in the late 1980s. In particular, the findings suggest that the interaction between housing prices and the availability of mortgage finance has notably increased after the liberalization. Since the interaction between housing prices and the credit availability may induce self-reinforcing cycles between housing and credit markets, the momentum effect may have become greater and the longer-run mean reversion stronger after the deregulation. To investigate whether this is the case, VR test is conducted to housing price series for HMA and Turku covering the 1970Q1-1986Q4 period and for Oulu and Tampere using data for the 1970Q3-1986Q4 period. For the rest of the cities as long housing price data is not available. The VR ratio statistics do not support the hypothesis of increased momentum and reversion. On the contrary, it seems that prior to the financial liberalization momentum was even stronger and the eventual mean reversion even greater than during the 1987-2009 period.

We conduct correlation analysis and estimate simple ordinary least squares (OLS) regression models to examine whether the regional differences in the dynamics can be explained by some of the regional variables suggested in the previous literature. The “regional” variables include measures of growth, housing price level, market liquidity, market size and population density. Table 2 reports the correlations between the momentum and mean reversion properties and the regional variables.

Table 2 Correlation coefficients between measures of mean aversion and reversion and regional market characteristics

	Dur.	*Max*	*Rev.*	*Vol.*	*T.o*	*Pop.*	*Growth*	*Price*	*Dens.*
Duration	1								
Max VR	0.72*	1							
Reversion	-0.71*	-0.27	1						
Volume	0.35	0.27	-0.18	1					
Turnover rate	-0.34	-0.38	-0.10	0.04	1				
Population	0.33	0.26	-0.16	0.99*	-0.01	1			
Growth	-0.08	-0.09	0.15	0.36	-0.15	0.36	1		
Price per m^2	0.27	0.21	-0.19	0.88*	-0.03	0.87*	0.43	1	
Density	0.47*	0.35	-0.26	0.87*	0.17	0.83*	0.24	0.70*	1
Urban share	0.15	0.20	-0.06	0.53*	0.27	0.47*	0.30	0.45	0.76*

Duration is the length of the momentum effect (the horizon at which VR peaks), *Max VR* is the VR value at the top, *Reversion* is the drop in VR from the top to the bottom after longer-run mean reversion, *Volume* is the average transaction volume in the market, *Turnover rate* is the transaction volume divided by the total stock in 2009, *Growth* is the population growth, *Density* is the population density (inhabitants per square kilometer) in 2009 and *Urban share* is the share of population living in urban areas. * denotes statistical significance at the 5% level.

In contrast with the hypothesis that the markets with greater number of transactions should be more informationally efficient than the smaller markets and with the empirical results of Capozza et al. (2004) regarding the U.S. housing markets, market size is not positively correlated with more rapid mean reversion of housing prices in Finland. Instead, the correlation coefficient between the length and magnitude of momentum and the market size (transaction volume, population) is positive, though not statistically significant. Moreover, the correlation between the magnitude of long-term mean reversion and market size is negative. Furthermore, in contradiction with the hypothesis that higher population density should foster more, better and prompter information concerning housing markets and, thereby, induce more rapid mean reversion and smaller momentum effect, correlation between the density variables and the momentum are positive while those between density and mean reversion are negative.[10] The correlation analysis also implies that long-term mean reversion is the weaker in the markets where the momentum lasts longer.

While mean reversion correlates significantly only with the duration of momentum, the regional variation in the duration and magnitude of momentum can be explained, to some extent, by the regional market characteristics. Table 3 presents simple linear OLS regressions for the momentum variables. The explanatory variables are selected based on the Schwartz Bayesian Information Criteria. It appears that the turnover rate is the most significant market characteristic in the regressions. Expectedly, greater turnover rate, i.e., greater liquidity in the market, shortens the duration of the momentum effect and lowers the maximum VR. In contrast with the prior assumptions and in line with the correlation analysis, the sing of population density is positive in both regressions. The signs of the coefficients are robust to the inclusion of additional variables in the models. Moreover, the coefficients appear to be considerably robust to the lambda selection in the H-P filtering at least as long as the lambda is reasonably small, i.e., as long as the H-P filter does not extract too much of the actual short-term variation in the

[10] Two density variables are included in the analysis. *Density* may be problematic, since there are notable differences between the geographical sizes of the cities – some cities contain a substantially greater share of agricultural land within their geographical boundaries than some other cities. Therefore, the other density variable, the share of population living in urban areas, is included in the analysis.

housing prices. That is, the estimated signs in the model for *Max VR* cannot be contributed to the possibility that the H-P filtered price indices (with the lambda of 0.5) for the smaller cities would still include much more noise than those for the larger cities.

The positive coefficient on population density may imply some sort of irrational behaviour that is reinforced by greater density. That is, maybe high housing price increases induce further increases for a longer time period in more densely populated areas because of a contagious feedback effect that is more likely to spread widely in a densely populated area. Much of the variation between the regional momentum variables remains unexplained and, due to the small number of observations, these regressions should be taken only as suggestive, though. In the future, the relationship between housing price momentum and the market characteristics could be studied more extensively employing larger datasets.

Table 3 Cross-section OLS regressions for the duration and magnitude of momentum

	Duration		*Max VR*	
Constant	26.8	(5.10)	9.59	(1.89)
Density	0.32	(0.13)	0.09	(0.05)
Turnover	-2.65	(1.40)	-0.97	(0.52)
R^2	.40		.32	
J-B	.49		.51	

Duration is the investment horizon at which the VR tops in a given city and *Max VR* refers to the VR value at that horizon. *Density* stands for the population density of the city (hundreds of inhabitants per square kilometer) and *turnover* for the transaction volume divided by the total stock in the market (%). Standard errors are reported in the parenthesis. J-B denotes the Jarque-Bera test for residual normality. The explanatory variables are selected based on the Schwartz Bayesian Information Criteria.

Another potential explanation to the apparently positive relationship between momentum and market size and density may be regional variations in land leverage, i.e., in the share of housing prices that is accounted for by the value of land upon which the dwellings are located. In general, the larger and more densely populated the market is, the greater is the value of land and the greater is the land leverage.[11] This applies at least in a relatively small and coherent country, such as Finland, where there are no substantial regional differences in the construction costs. Hence, if momentum is more pronounced in land prices than in construction costs, greater land leverage is expected to be associated with stronger momentum effect in housing prices. There is no data on the value of developed residential land, but the construction cost index can be used to estimate the momentum effect in the value of structure. The data provide evidence of shorter duration of momentum in construction costs than in flat prices. Momentum in construction costs appears to last for approximately three years. That is, regional variation in land leverage is a potential explanation for the positive correlation between momentum duration and market size and density. Another way to state the same is that in areas where land is more scarce resource housing supply can typically adjust more slowly due to which housing prices may be more serially correlated. Regarding the magnitude of momentum the data does not show evidence of notable difference between construction costs and flat prices, however.

[11] This comes from the land pricing theory, see e.g. Capozza and Helsley (1990), and DiPasquale and Wheaton (1996).

Expectedly, mean reversion starts earlier in the flat market than in the single-family housing market. In the case of the whole country, this could be due to the different geographical distributions of flats and single-family houses. However, the difference also holds within the HMA, where mean reversion starts one year faster in the flat market than in the single-family housing market. In light of the results concerning the flat markets, the better liquidity in the flat market is likely to have a role in the difference between flats and single-family houses. Also the notably higher transaction costs in the single-family housing market probably contribute to the longer duration of momentum in the single-family housing market. The difference between the estimated magnitudes of momentum is not significant between the HMA flat and single-family housing markets, however. In fact, the gap in the maximum VRs shown in the top left corner in Figure 3 narrows fast if the lambda is slightly increased – it appears that at the initial lambda of 0.5 the HP filtered single-family housing price series still includes substantial noise. Given the high heterogeneity and small number of transaction in the single-family housing market, this is not surprising.

[Figure 3 around here]

Figure 3 also shows the VR curves for stocks and bonds and the overall Finnish flat market. The stock market exhibits only slight momentum compared with the housing market. Moreover, stock prices start to mean revert at around ten quarters, i.e., much more rapidly than flat prices, and in the long horizon stock market volatility does not appear to be any greater than in the short run: the long-horizon VRs are not significantly different from one. In the bond market mean reversion starts even faster and, with the exception of the three first quarters, there is no significant horizon effect in bond price movements.

The significant momentum and substantially smaller long-term mean reversion in housing prices together with the relatively small short-term momentum and relatively large longer-term mean reversion in stock and bond prices may explain at least part of the fact that the share of housing (and real estate in general) in institutional portfolios typically is considerably smaller than it should be based on unconditional portfolio analysis. It appears, however, that volatility in housing price movements does not reach the volatility in stock returns even in the long horizon. While the estimated annualized standard deviation at the quarterly frequency is 6.2% for country level flat price movements and 22.9% for stocks, the corresponding figures at the ten-year horizon are 13.4% and 20.6% for flats and stocks, respectively. This findings for the Finnish market is in contrast with the results of MacKinnon and Al Zaman (2009) for the U.S. Based on MacKinnon's and Al Zaman's analysis, real estate is just as risky as equity investment for long-term investors.

Mean aversion up to several years in housing prices can be seen somewhat surprising, since the supply typically reacts with a lag of approximately one year after a price shock. DiPasquale and Wheaton (1994) argue that, given the heterogenous product and time-consuming search in the housing market, rapid price adjustments may not be rational. However, it is questionable whether serial correlation up to 4-5 year horizon can be explained by the market frictions. A potential explanation for the strong and long-lasting mean aversion is offered by the price-to-price feedback theory (see e.g. Shiller, 2003). According to feedback theory price increase may create expectations for further price increases. This may happen because successes for investors who have benefited from the price increase may attract public attention and promote word-of-mouth enthusiasm. In housing markets there is also another factor working. People who are currently tenants but are planning to buy a dwelling for their own use in the future may fear that once prices have increased for a while they go further up. Thus, they may want to buy when prices have already started to rise creating further increase in prices. If the “feedback” is not interrupted, it may even produce a price bubble. The unearned increment in housing prices is made easier to occur because for most actors in the market it is almost impossible to judge what is the proper fundamental value for a given dwelling. Even for professional investors the judgement of fundamental value is often hard, not least because there has still been relatively little research on house price dynamics in Finland. Furthermore, the lack of short-selling possibilities makes it harder for the more pessimistic actors to prevent the prices from rising further. Hence, the optimists lead the market. The same mechanism can also cause negative price cycles.

5 Summary and conclusions

Extensive empirical literature shows evidence of substantial short-term mean aversion and longer-horizon mean reversion in housing prices. There are theoretical reasons to expect and some empirical evidence showing that the persistence and reversion patterns notably vary between distinct regional markets. However, the theory does not provide a clear answer as to which housing markets should exhibit the largest and most long-lasting momentum effects and in which markets the reversal should be the strongest. Therefore, it is essentially an empirical question to study the variation in momentum and mean reversion between housing markets.

The aim of this study is to discuss the causes of the time series patterns of housing prices and of regional differences in the patterns, and in particular to provide new empirical evidence on the momentum and mean reversion characteristics in regional housing markets. It is argued that, as the time series patterns of housing returns are dominated by the capital returns, it is reasonable to concentrate on the capital returns, i.e., on price movements, when studying the mean aversion and reversion in housing prices. In contrast with the earlier empirical literature on the subject, this study uses data from 15 cities in Finland and examines the persistence and reversion patterns by computing variance ratios and by investigating horizons up to 10 years. Even though hedonic housing price indices are used, the heterogeneity of dwellings together with thin trading induces complications when comparing the regional price patterns. Therefore, in this study the variance ratio statistics are computed based on Hodrick-Prescott filtered price indices that are expected to diminish the influence of the measurement error due to thin trading on the comparability of the variance ration statistics.

In line with previous empirical evidence for other markets, the results show that housing prices do not follow random walk. Instead, momentum effect in housing price growth is long-lasting and considerable in size. The variance ratios peak at the horizon of 4-5 years after which mean reversion starts. Since the eventual reversion is substantially weaker than the shorter-term mean aversion, housing is notably riskier asset in the long term than suggested by the typically reported quarterly or annual variances figures. The findings also indicate that there can be substantial differences between distinct regional housing markets as well as between flats and single-family housing. There seem to be notable regional variation in the duration of momentum and, in particular, in the magnitude of momentum. Moreover, the long-term mean reversion appears to greatly vary between the distinct Finnish cities. While the variance ratios generally imply that in more liquid markets the momentum effect is somewhat weaker and shorter than in more illiquid markets, the estimated correlation of momentum is, somewhat surprisingly, positive with market size and with the population density.

The findings have a number of implications. Since the stock and bond returns do not appear to exhibit similar strong momentum as housing prices, the relative attractiveness of housing investments is weaker for a long-horizon investor than suggested by the unconditional portfolio analyses that employ short-term variances and assume i.i.d. returns. This justifies, at least partly, the relatively small share of direct real estate investments in institutional portfolios. Nevertheless, in the Finnish market the volatility of housing price movements does not appear to reach the volatility of stock returns even in the long horizon. In addition, the differences between regional housing markets influence the optimal housing portfolio allocation and highlight one more reason why it is complicated to use country level housing price data when analyzing the optimal portfolio allocation or housing price dynamics. Moreover, the high variance ratios for housing price movements indicate significant predictability in housing returns. The predictability makes the traditional unconditional mean-variance analysis inefficient both for short- and long-horizon investors.

In the future, it would be useful to analyze the reasons behind the regional variation in the momentum and reversion patterns using larger dataset than the one in this study. Furthermore, it would be interesting to investigate whether similar regional variation exists in other countries as well.

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Figure 1 Indices used in the empirical analysis

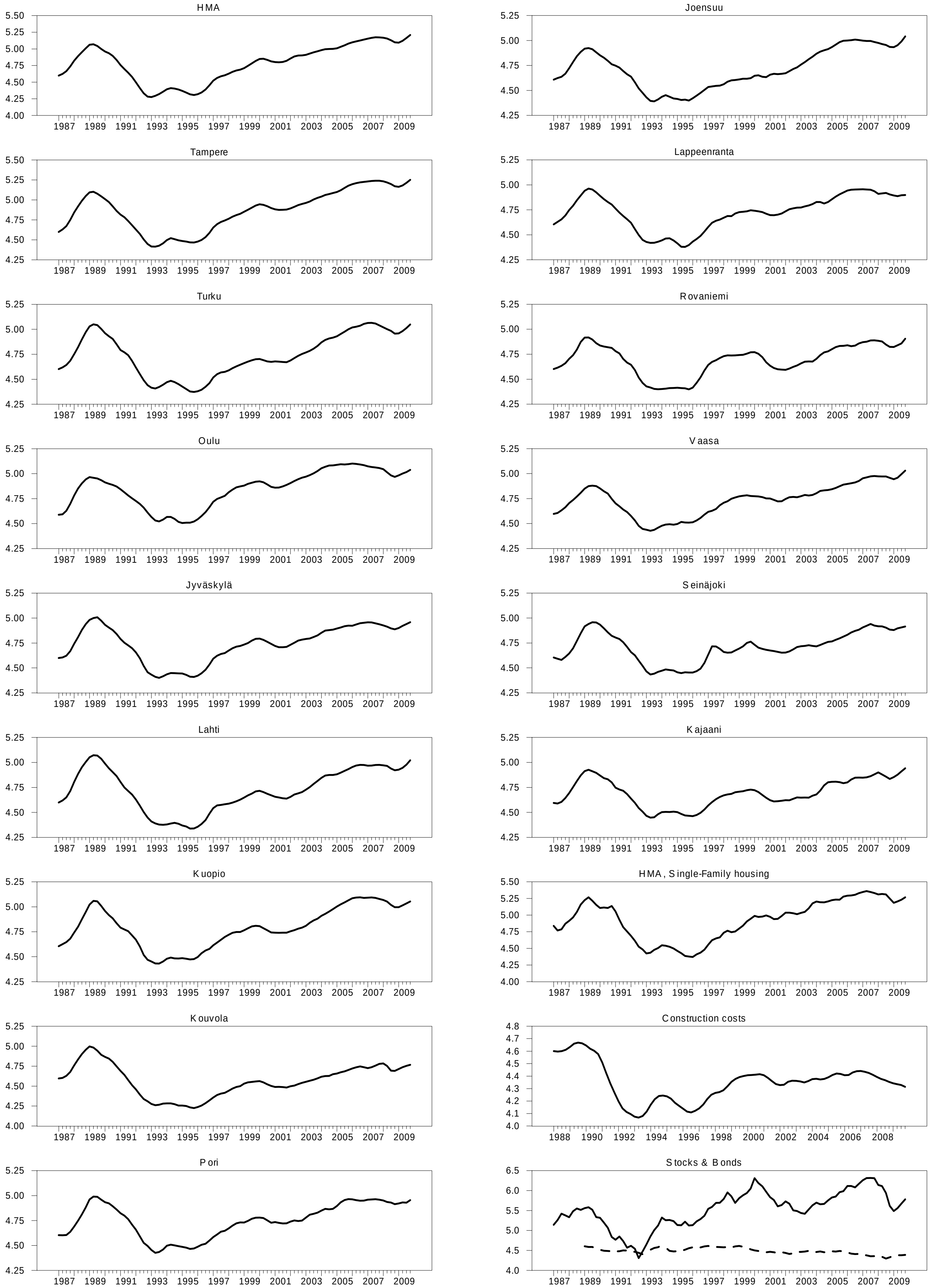
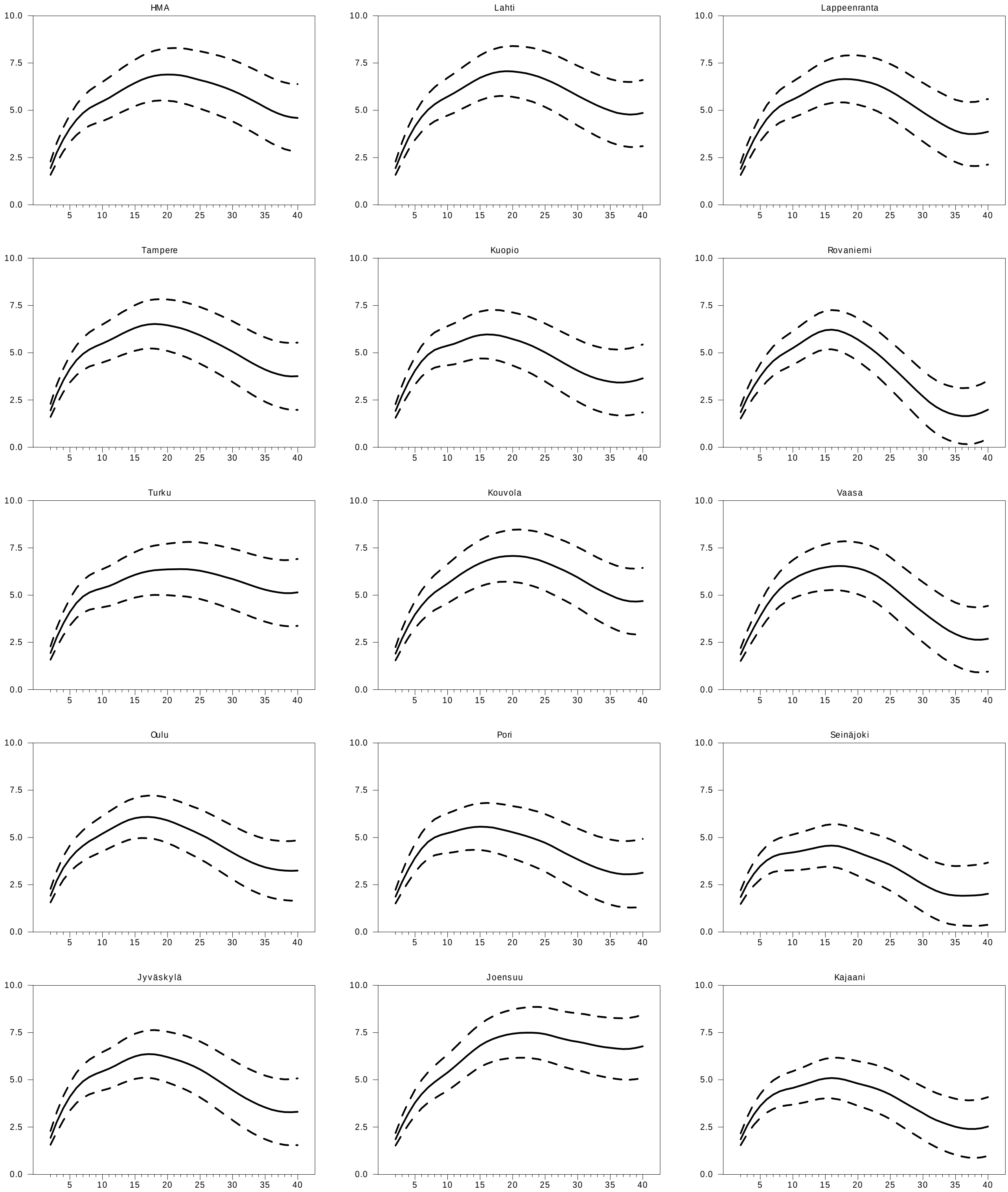
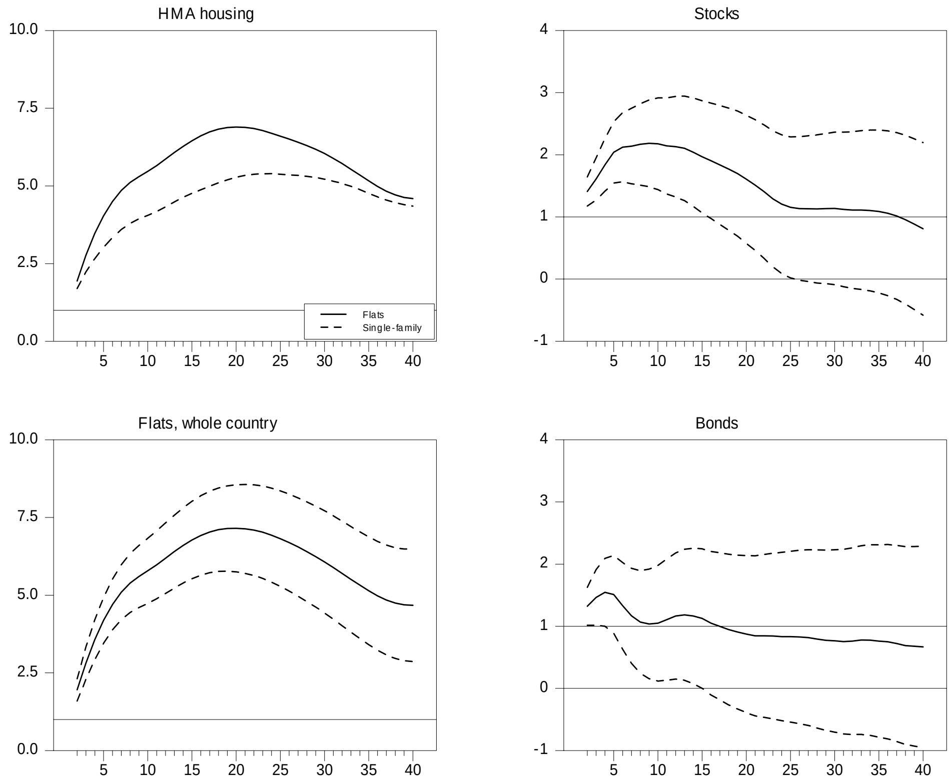


Figure 2 VR curves for flats



The figure shows the VRs at each horizon until 40 quarters with ±2 standard error bands. The horizontal axis shows the investment horizon.

Figure 3 VR curves for flats, single-family housing, stocks and bonds



The figure shows the VRs at each horizon until 40 quaters with ±2 standard error bands. A vertical grid line crosses at value 1 in each of the graphs

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