STUDIES ON HOUSING PRICE DYNAMICS

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CONTENTS

INTRODUCTION TO STUDIES ON HOUSING PRICE DYNAMICS

1 MOTIVATION AND PURPOSE OF THE STUDY

Housing prices are not only affected by the general economic conditions but are also likely to have substantial effects on the macroeconomy. There are a number of reasons why housing markets are of great importance to the overall economy and why policy makers should be concerned about housing prices. Housing composes the majority of many households' wealth, and the "wealth effect" of housing on consumption is significant, apparently even larger than the wealth effect of financial assets (see e.g. Case et al. 2001, Benjamin et al. 2004, Campbell and Cocco 2004). Hence, a decline in the housing price level leads to less consumption. A drop in housing prices is likely to have a negative effect also on housing construction. Furthermore, a notable fall in housing prices would affect the banking sector by inducing unanticipated losses for mortgage lenders, which could strain the financial system. Moreover, lending is likely to decrease as housing prices drop because of the significant role of housing as collateral. Finally, institutional investors such as pension funds usually have a notable part of their funds invested in housing and housing related securities.

Through the effect of housing wealth on household consumption, on construction activity and on the financial sector, housing price movements may strengthen and on some occasions even create macroeconomic cycles. The volatility induced by housing markets on the broad economy is likely to be the larger the stronger co-movement is between regional housing markets. That is, for the macroeconomy it is more harmful if booms and busts occur simultaneously in distinct regional markets. Notable differences between price cycles in regional housing markets, in turn, could create diversification benefits not only for a housing investor but for the whole nation as well.

Also the links between housing markets and the other asset markets are of importance to the economy. Obviously, co-movement between different asset prices lessens the diversification gains obtainable to a portfolio investor. Perhaps even more importantly, positive linkages between financial asset markets and housing markets toughen economic cycles. This is reinforced by the fact that simultaneous crash in the stock and housing markets or crash in one market followed by a bust in the other market in a relatively close future may put into trouble even large banks that hold widely diversified portfolios. It is probable, for example, that housing and equity price movements notably contributed to the deep recession in Finland in the early 1990s. Weakening in the economic fundamentals evidently influenced housing and stock prices negatively during the early 1990s. At the same time, however, decreasing asset prices further exacerbated the depression by affecting consumption and construction activity negatively and by putting the bank sector into trouble.

Finnish housing markets have gone through major institutional changes during the past two decades. Firstly, in the late 1980s the Finnish financial market was deregulated. Secondly, in 1993 there was a reform in the tax codes concerning the deductibility of mortgage interest payments in taxation. Thirdly, rent regulation was released in several stages during 1992-95. These institutional changes may have had major impacts on the housing price dynamics. Furthermore, mainly due to increased migration from peripheral areas to the Helsinki Metropolitan Area (HMA) and to a couple of other centres in Finland, regional housing price development has diverged to a much greater extent since the early 1990s than earlier.

Divergence of the housing price development between distinct regions may have improved the geographical diversification opportunities of a housing portfolio. On the other hand, sharp rise in real housing price level in some areas and at the same time housing price stagnation in some other regions have put households into unequal positions. The increasing difference in the housing prices between a few growing centres and the rest of the country is also likely to hinder the movement of labour force thereby disturbing the operation of the labour market.

Globalization of capital markets, in turn, may have altered the interdependences between different asset categories. In particular, since housing market is always unavoidably local to a great extent and the stock market is mostly driven by global forces today, co-movement between housing and stock prices may have weakened to some extent.

Despite the significance of housing wealth to the economy, empirical evidence of housing price dynamics in Finland and also in the other countries is still relatively limited. Moreover, housing prices have often been analyzed as if one country formed one coherent housing market. In reality, however, there are many distinct housing markets within Finland for example. Housing in one area cannot be considered a substitute for housing in another region geographically far away. In other words, housing price dynamics are a local phenomenon, and national level data may obscure important economic differences between different cities or regions.[1]

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[1] Note, however, that in some cases the use of national level housing price data is sensible. For example, in the fourth essay of this research national housing price index is employed. This is because in that particular study it is useful that housing price data represent the whole Finnish housing portfolio. When evaluating, for instance, the effects of housing prices on national consumption instead of analyzing e.g. the over- or undervaluation of housing, national housing price index is a reasonable variable to be used.

The attention towards the interdependences between housing and financial assets has been even scarcer. Previous empirical literature has typically ignored linkages between different asset categories. If interdependence between asset markets and the differences between regional housing markets are ignored, important information relevant to portfolio allocation and to predictability of asset price movements as well as to policy decisions is left aside. This may lead to defective conclusions and actions. For instance, 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). This is important to long-horizon investors, in particular, such as pension funds and real estate investors in general.

Also the possibility and effects of structural breaks, typically caused by institutional changes, on price dynamics and linkages between different markets have often been neglected in the empirical literature. If structural breaks have actually occurred but are not catered for, misleading conclusions may be made regarding both diversification opportunities and price dynamics in general.

The purpose of this study is to bring new empirical evidence on housing price dynamics as well as on linkages between regional housing markets and between housing and financial assets. The empirical analyses are based on Finnish data, and structural changes are tried to take account of in each of the empirical studies. The firsts essay studies housing price formation within a single metropolitan area, i.e. the HMA. The purpose of the second article, in turn, is to study co-movement between housing prices in different areas within the HMA and in various cities in Finland, and to evaluate the implications of the co-movement between different areas for housing portfolio diversification. The third empirical study examines the diffusion of housing price movements from central areas to surrounding regions. Finally, linkages between stock, bond and housing prices are analyzed in the fourth essay.

The second and fourth essays concentrate on diversification potentials of a portfolio. In those two studies a large investor's viewpoint is taken. This is because, in general, only a large investor, such as a pension fund or some other institutional investor, can hold large enough housing portfolio to be able to exploit the diversification potentials properly. Hence, when the text refers to an "investor", the "investor" stands for institutional investor that holds large housing portfolio, not for an owner-occupant of housing. Furthermore, "investment" housing refers to dwellings that are rented out, i.e. whose purpose is to bring wealth to the owner in the form of rental cash flows and appreciation, not to satisfy the owner's demand for housing consumption.

A major reason for previous empirical research to concentrate on the financial markets has been the substantially better quality of the data from the financial markets compared with the available data from the housing market. Data concerning housing prices is relatively infrequent and short and has got also other problems such as the heterogeneity of housing. As explained in section 7 of this introductory part of the research, there are also a number of problems with the data employed in this thesis. Furthermore, the empirical methods used in the four essays are not without complications. Nevertheless, it is reasonable to assume that the data and methods employed in this research are reliable enough to be able to draw a number of conclusions concerning housing price dynamics and linkages between regional housing markets and between housing and financial assets.

This introductory chapter discusses issues related to the four empirical studies included in the thesis. This section gives an overview of the topic of the thesis, after which the theoretical aspects of housing price dynamics are discussed. Then, existing literature on housing price dynamics and linkages between housing markets and financial assets' markets is reviewed. In the fourth section, some features of the Finnish housing markets and of the HMA housing market are presented and the development of the Finnish housing markets during the last three decades is delineated. In the same context, the influences of institutional changes on the housing price development are discussed. Next, cointegration, the central methodological concept of this research, is presented and its implications are considered. Complications with the data utilized in the empirical studies are pondered in section seven. Finally, the four studies the research consists of are briefly summarized.

2 THEORETICAL ASPECTS OF HOUSING PRICE FORMATION

Housing price level is dependent on a large number of factors. Some of these factors are macroeconomic, i.e. they influence housing prices in all regions within a country in a similar way. There are, however, also a number of regional, or local, variables that drive housing prices. Because of the importance of the regional factors, a country such as Finland contains numerous distinct regional housing markets.

Housing price level, growth and dynamics may differ significantly between different regional markets. Hence, it is sensible to analyze the operation of a housing market not at the national level but at the regional level. A metropolitan area is a reasonable basis for analyzing housing price dynamics since, in general, dwellings within a metropolitan area can be regarded as relatively close substitutes for one another. The aim of this section is to give a brief theoretical overview of the price formation and dynamics in a metropolitan housing market. Interdependence between different regional housing markets is discussed as well.

Price of a dwelling consists of the physical structure together with the value of land upon which the house is built. Similarly, the growth rate of the price of a house is the weighted average of increase in the value of the structure and appreciation of land the house stands upon. The price of the structure is typically measured as the replacement cost of the physical building, after accounting for depreciation. Land, in turn, is the factor that makes a house worth more than the cost of putting up a new structure of similar size and quality on a vacant lot. In other words, land is the market value associated with the location, size and attractiveness of the site. In this study, “housing” always refers to the entity consisting of both the structure and the site.

2.1 Static models

In the short run, housing supply is typically extremely inelastic. Housing supply responds slowly to positive demand shocks because construction of new dwellings is time consuming and also zoning decisions take time. Downwards adjustment of housing supply, in turn, is slow because of the slow depreciation of the structures. In the long horizon the supply curve of housing is much gentler. Nevertheless, the supply curve is likely to be upward-sloping even in the long-run.[2] This is because the value of land increases as the metropolitan area occupies more area (see e.g. DiPasquale and Wheaton 1996, Chapter 3). With geographical constraints (water, mountains etc.), building restrictions and other impediments to construction, housing supply schedule can be quite vertical even in the long horizon. It should be noted that the growth of a metropolitan area might take place through higher density as well. The implications are similar to the case where the growth occurs by larger occupied area, however: also greater density leads to higher housing prices (see DiPasquale and Wheaton, 1996, Chapter 4).

The four-quadrant model introduced by DiPasquale and Wheaton (1992) can be used to examine housing price formation in the long run.[3] In the model, graphed in Figure 1, the two right-hand quadrants represent the market for the use of space, while the two left-hand quadrants deal with the asset market for the ownership of housing.

Rental price level is set in the upright quadrant. The vertical axis represents rental level per square meter (R), whereas the horizontal axis shows the housing stock. In equilibrium, rental level is such that demand for housing (D) equals the stock. Together with the capitalization rate (i), the net (of maintenance costs) rental level determines housing price level in the upleft quadrant. The higher the capitalization rate is the lower is the price level (P). Generally, four factors make up i: the interest rate level, the expected growth in rents, the risk associated with rental income stream, and the tax treatment of housing and of mortgage interest payments. Note that i is assumed to be exogenous in the model. In reality, housing cycles may influence the capitalization rate.

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[2] Empirical estimates of the long-run price elasticity of housing supply and of new housing construction presented in the literature vary typically around 1-3 at the national level (see e.g. Poterba 1984, Tobel and Rosen 1988, DiPasquale and Wheaton 1994, Blackley 1999, Malpezzi 2001, Meen 2002, Harter-Dreiman 2004). The results by Malpezzi and Mayo (1997) and Malpezzi (2001), however, suggest that the elasticity of supply deviates notably between different countries. Expectedly, countries with more stringent regulatory environments seem to have a less elastic supply of housing. Similarly, Harter-Dreiman (2004) shows that supply is more inelastic in cities with tighter building regulations.

[3] The model, just as any theoretical model describing the operation of housing market, includes some simplifying assumptions. Nevertheless, the model is a reasonable tool to analyze the operation of the housing market in the long horizon.

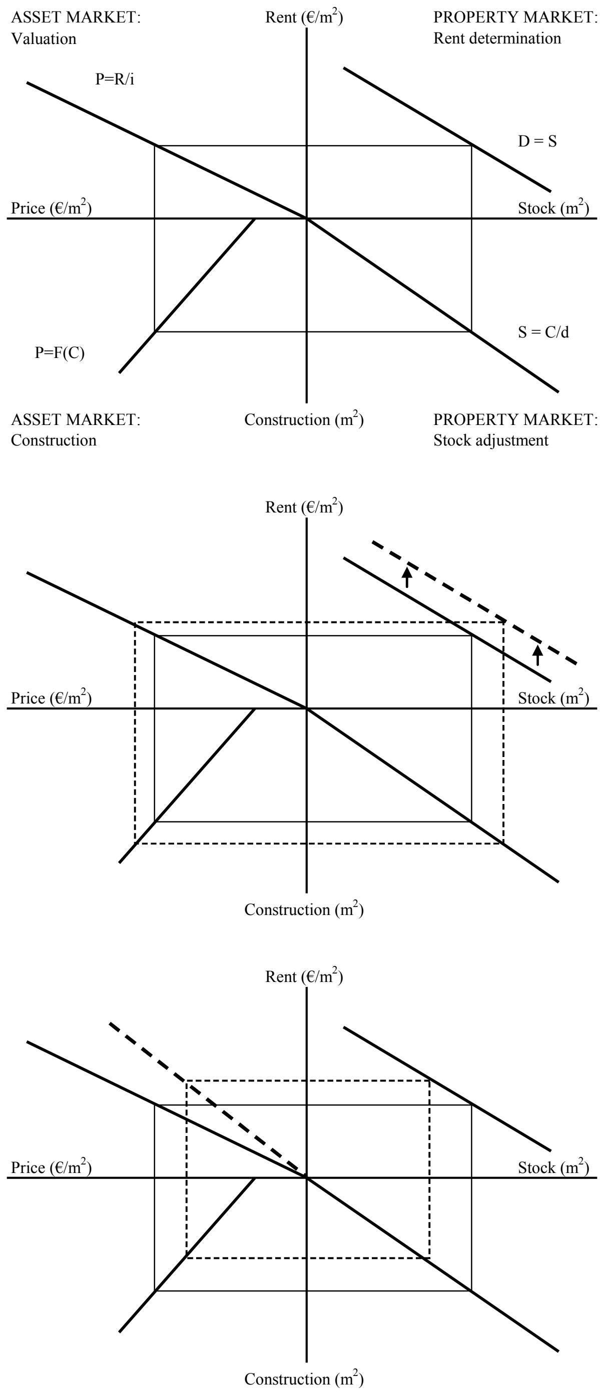

Figure 1 Four-quadrant model

The southwest corner describes the construction of new housing. Here, f(C) represents the replacement cost of housing. The cost of replacement is assumed to increase with greater building activity (C). In the long-run equilibrium price level equals the replacement cost. If the input supply for the construction sector is inelastic, the f(C) curve is more horizontal. Consequently, the more inelastic supply of for example skilled construction workers is, the greater is the housing price response to a shock. Finally, the southeast quadrant shows the long-run stock of housing. Stock is in the long-term equilibrium when the level of construction equals housing depreciation (d).

It is evident that all of the four corners of the model affect each other. Rent level is a crucial part in the asset price determination, price level influences construction activity, the level of construction affects the housing supply and rental price level is dependent on the stock. The housing market equilibrium necessitates that equilibrium condition is fulfilled in each of the four quadrants. In the highest part of Figure 1 the black box shows the equilibrium level in each of the markets.

Change in the long-run equilibrium can originate from any of the quadrants. Increases in variables such as household income or the number of households in the area can move D upwards. Changes in i due to, for example, shifts in interest rates, growth expectations or risk characteristics of housing, in turn, lead to price adjustment. Construction costs may increase, for instance, because of decrease in the supply of skilled employees. Furthermore, the slope of the curve in the southeast part alters if the depreciation rate of housing changes for some reason.

Second part of Figure 1 demonstrates what happens if demand curve for space moves upwards due to an increase in household income or in the number of households. The black box shows the initial equilibrium. After the demand shift, all the corners of the "equilibrium-box" lay outside of the box that connected the four curves in the original equilibrium. The new long-run equilibrium is illustrated by the dashed box. The magnitudes of the changes in rents, prices, construction and stock depend on the slopes of the curves in all the quadrants. Note that in the short run, as housing stock is unable to adjust to the new situation, the prices and rents grow more than in the long term.

In the lowest part of Figure 1, a shock hits the capitalization ratio. Because of, for instance, rise in the interest rates, the slope of the curve in the valuation part of the model becomes steeper. As a consequence, price level declines, construction activity diminishes, housing supply decreases and rental level rises so that the new equilibrium is reached.

The four-quadrant model applies also to a housing market dominated by owner-occupants (DiPasquale and Wheaton 1996, pp. 10-11), such as Finnish housing markets in general. In the owner-occupant case rental level (net of maintenance costs) shows the benefit that an owner-occupant gets by owning a dwelling. In equilibrium, this benefit must equal the cost of owning the dwelling, which is determined by the price of the dwelling and the capitalization ratio.[4] Hence, owner-occupants have the same investments motives as the owners of rental property, and the decisions of owner-occupants are influenced by the same fundamentals that influence rental housing.

Some economists have claimed that real housing price level should be constant, i.e. housing appreciation should equal inflation, in the long term. This assumption, however, is unrealistic concerning a growing metropolitan area. As a metropolitan area grows, the value of land in it rises even in real terms, *ceteris paribus* (for the detailed underlying theory, see e.g. DiPasquale and Wheaton 1996, chapters 3 and 4). A number of other economists, in turn, have used (housing) price-to-income ratios (P/Y) to assess if housing is overvalued or not. They have typically assumed that the ratio should stay constant in the long run. Also this assumption is problematic.

The relationship between income growth and housing appreciation can be analyzed by a simple three-sector model of metropolitan economic growth (see DisPasquale and Wheaton 1996, pp. 155-165). The model simplifies the reality, of course, but it can still be utilized to consider the evolution of P/Y. The model suggests that, depending on the elasticities of supply of labor and of supply of housing and on the driving forces behind metropolitan growth, P/Y can be decreasing, constant or growing in time. The more inelastic housing supply is the greater is housing price increase compared to income growth in an expanding metropolitan area. However, if regional growth is purely demand-induced, housing prices must rise less than wages. On the other hand, (labor) supply-induced growth of a metropolitan area may lead to a larger increase in real estate prices than in wages.

Because the value of land increases as a city occupies more area, the housing supply curve is expected to be upward-sloping even in the long-run. With geographical constraints (water, mountains etc.), building restrictions and other impediments to construction, housing supply schedule can be quite inelastic. In the HMA, there are evidently factors that increase the inflexibility of housing supply: the area is bounded by sea and building restrictions are relatively tight.

All in all, although the growth of the HMA has been mainly demand-driven, the theory cannot say straightforwardly whether the equilibrium P/Y

[4] The relationship between the user cost of an owner-occupant and the rental price level is discussed in more detail in section 2.3.

should have declined or grown in the area. This is due to the upward-sloping housing supply curve together with the fact that there has probably been also some supply-induced growth in the HMA. For example, increases in the number of student places and other amenities in the HMA as well as the high level of unemployment in many Finnish regions may have caused movements in the labor supply schedule.

2.2 Adjustment process

The models presented in the previous section are static. With a static model, it is possible to describe the new equilibrium solution. The actual time path of adjustment to the new equilibrium cannot be derived from the static model, however. Hence, a dynamic model must be analyzed in order to understand the adjustment dynamics in more depth. A simple but realistic and commonly used dynamic model to study the operation of the housing market is the housing market stock-flow model. The derivation of the model below follows DiPasquale and Wheaton (1996, pp. 243-246) with some additions and modifications.

The stock-flow model assumes that housing price level in any period is determined only by current values of the model's other variables, while, because housing capital is highly durable, the housing stock depends on the historic values of these variables. To keep the model simple, let's assume that the demand for owner-occupied housing in period t (D_t) is influenced only by the number of households in the area (H_t) and the cost of owning a dwelling (U_t). In (1), the parameter α_0 can be thought of as the fraction of households that would own dwellings if the user cost of housing was zero. The parameter α_1, in turn, shows the responsiveness of demand for owner-occupied housing to changes in the user costs.

$$D_t = H_t\,(\alpha_0 - \alpha_1 U_t) \tag{1}$$

U_t depends on the prevailing price level (P_t), the current after-tax mortgage rate (R_t), maintenance costs of housing (M_t), and on the current expectations regarding the nominal rate of future housing appreciation (I_t):

$$U_t = P_t\,(R_t + M_t - I_t). \tag{2}$$

The after-tax mortgage rate is assumed to equal the opportunity cost of capital. R is derived as $(1\text{-}T)^*r^m$, where r^m is the before-tax mortgage rate and T is the deductibility of mortgage interest payments in taxation. M_t, in turn, includes property taxes and depreciation as shares of the value of housing.

Here, depreciation refers to the maintenance and repair costs that are necessary to maintain constant quality of the structure.

Housing prices today adjust so that demand for owner-occupied housing equals the existing stock of housing (S_t):

$$D_t = S_t \tag{3}$$

Employing equations (1) through (3) yields the following measure for housing price level:

$$P_t = (\alpha_0 - S_t/H_t) \,/\, [\alpha_1(R_t + M_t - I_t)]. \tag{4}$$

The model assumes that (4) holds during every period. Thus, today's housing price will be higher when housing stock compared to the number of households is smaller, mortgage rates are lower, depreciation speed is slower or the expected housing appreciation is greater.

The change in housing supply is expressed by (5). The equation states that housing stock growth equals new construction (C_t) minus a small fraction (δ) of the previous period's stock that is lost due to demolition and other causes. When $C_t = \delta S_{t-1}$, the stock is said to be in a stable steady state equilibrium (SSE).

$$S_t - S_{t-1} = C_t - \delta S_{t-1} \tag{5}$$

Supply involves also other equations. The amount of new construction clearly depends on the housing price level but it is dependent on the current stock as well. Increase in housing prices brings forth new construction only until the value of developed land[5] (= housing price – structure value) is equal to the price of vacant land in a similar site.[6] Let ES_t denote the long-run equilibrium stock of housing. If S_t equals ES_t, no construction occurs, since in this part of the model it is assumed that no dwellings are lost due to demolition. If housing demand increases, the value of developed land rises and housing prices go up. This leads to a temporary flow of new construction, since ES_t increases. The need for new construction augments demand for vacant land. Hence, also the price of undeveloped land increases. The stock grows until the values for developed and undeveloped land converge again. In the words of DiPasquale and Wheaton (1994, p. 7), "*The rise in prices initially generates excess returns …As the stock of units grows,* (undeveloped) *land prices rise and eventually absorb the excess returns*". This relationship can be captured by equations (6) and (7).

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[5] For simplicity, it is assumed that the only kind of development is for residential use.

[6] For detailed discussion concerning the value of developed land and its impacts on the housing supply, see e.g. DiPasquale and Wheaton (1996, chapters 3 and 4).

$$ES_t = -\beta_0 + \beta_1 P_t \qquad (6)$$
$$C_t = \tau(ES_{t-1} - S_{t-1}) \qquad (7)$$

The parameter β_1 determines how rapidly higher prices bring about vacant land for development. The more constrained land supply is, for example due to geographical boundaries to the area, the smaller is β_1. In other words, the more inelastic supply of vacant land (smaller β_1), the greater is the rise in the value of land after a positive shock in housing prices. Hence, due to smaller β_1 housing prices have to be higher to induce a certain amount of stock, and the response of housing prices to a demand shock is greater. Therefore, in a growing metro area it is expected that housing price level increases more slowly in the suburbs than in the tightly built centre, where there may be no vacant land for new housing construction at all.

The basic model assumes that the height of the structures is constant. In reality, the stock can often increase through taller buildings. Nevertheless, the costs of construction per housing unit typically rise as more floors are added to a building. Therefore, profit maximization limits housing supply because it is not profitable to increase the height of a building above a certain limit. In any case, the option of increasing density can be incorporated into (6): If there are tight regulations on the height of the structures that are allowed to be built (and the restrictions are binding) or if the per unit construction costs increase with the height of a building, β_1 is smaller.

β_0 takes into account the fact that land has got value also in agricultural use and it is costly to put up dwellings. Any housing supply to exist, housing price level has to be at least equal to the agricultural value of land added by the cost of putting up the structure. Hence, construction costs affect β_0 as well – higher construction costs lead to bigger β_0. τ, in turn, represents the speed at which construction takes place in response to deviation between current stock and the long-run equilibrium stock level. Notice that the lag from construction decision to completion of new dwellings is assumed to be one period.

In a dynamic model, where part of housing stock is lost every period, the stock must decrease if construction is zero. Therefore, ES_{t-1} must exceed S_{t-1} to generate construction that exactly equals the attrition of the stock, to keep the stock stable. Utilizing equations (5) through (7), relationship between price level and stock growth can be derived:

$$S_t - S_{t-1} = \tau(-\beta_0 + \beta_1 P_{t-1} - S_{t-1}) - \delta S_{t-1}, \qquad \text{if } ES_{t-1} > S_{t-1} \qquad (8)$$
$$S_t - S_{t-1} = -\delta S_{t-1}, \qquad \text{if } ES_{t-1} \leq S_{t-1} \qquad (9)$$

As the stock grows, the absolute amount of demolitions increases as well. Eventually, in the steady-state level the stock does not increase any longer. The SSE of housing stock, S^*, is the stock that would eventually occur if the price level stayed at P_{t-1} forever. S^* can be solved by setting $S_t = S_{t-1}$ in equation (8):

$$S^* = \tau(-\beta_0 + \beta_1 P_{t-1}) / (\delta + \tau) \qquad (10)$$

For any price level, (10) defines the level of stock that will eventually prevail if the price level held forever. The model's full steady-state equilibrium involves also an equation for the SSE of housing prices (P^*). P^* can be solved utilizing (4):

$$P^* = (\alpha_0 - S^*/H_t) / [\alpha_1(R_t + M_t - I_t)]. \qquad (11)$$

Solving the system of the two equations, (10) and (11), yields the following solution for P^*:

$$P^* = [\alpha_0 H_t(\delta + \tau) + \tau\beta_0] / [H_t(\delta + \tau)\alpha_1(R_t + M_t - I_t) + \tau\beta_1]. \qquad (12)$$

In the SSE both housing prices and stock are expected to stay constant. Hence, I_t equals zero in the SSE. By setting I_t=0, equation (12) gives the equilibrium price that will obtain in the market if today's households, mortgage rates, maintenance costs and the model parameters held forever.[7] Obviously, P^* is the higher the more households there are, the lower the mortgage rates are, and the more inelastic the housing supply is.

The equation for P^* presented above does not include household income (Y). Nevertheless, as illustrated in section 2.1, growth in the level of income should increase the equilibrium housing price level. Income growth moves the demand curve for housing upwards. For example, according to the q-theory of housing investment (see Sörensen and Whitta-Jacobsen 2005, pp. 450-456), demand for housing can be expressed as in (13) and the equilibrium price level as in (14). Consequently, income growth can be assumed to increase α_0 and decrease α_1. In the literature it is often assumed that permanent income should be the income variable affecting housing demand. Nevertheless, because of financial constraints faced by households, also current income is likely to have an impact on D_t.[8] It is essentially an empirical question, which income variable has been a better explanatory factor for housing price level. In any case, the q-theory implies that the elasticity of housing prices with respect to income should be less than one in the long run.[9]

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[7] Notice that the housing stock is included neither in (12) nor in (14). The models assume that the variables in (12) and (14) determine the SSE housing supply imlicitly.

[8] Permanent income takes implicitly into account also the effect of household wealth on housing demand.

[9] In reality, however, the income elasticity of housing demand can, at least occasionally, exceed one due to factors such as liquidity constraints.

$$D_t = (\eta Y_t) / [(R_t + M_t - I_t)P_t], \qquad 0<\eta<1 \qquad (13)$$

$$P_t = (\eta Y_t) / [(R_t + M_t - I_t)S_t] \qquad (14)$$

In practice, the steady-state equilibrium prevails rarely, if ever. This is because the variables of the model are generally not constant for a period that is long enough for the full stabilization to occur. Moreover, the expectations of future values of the fundamentals equal current values rarely. This complicates the model somewhat. Therefore, a concept that I call the "fundamental level" or the "long-run equilibrium level" of housing prices is introduced. I define the fundamental housing price level as the price level that is accordant to current fundamentals including future expectations. The expectations are taken account of by I_t. That is, when I_t=0, P^* refers to SSE, whereas P^* denotes for the fundamental price level if $I_t \neq 0$. The fundamental price level then gives the equilibrium price for the current period given today's households, mortgage rates, maintenance costs, model parameters and price expectations (derived from the expectations concerning the fundamental variables and model parameters). The fundamental price level, therefore, is the level towards which the housing prices should adjust.

Consider, for example, the HMA. Population and income in the area have been growing relatively steadily and are expected to keep rising in the future. Hence, the SSE price level of housing that is in line with future values of H and Y is expected to be different from the SSE that is accordant with today's H and Y. Consequently, it would be unrealistic to assume that housing prices should currently adjust towards the SSE implied only by today's values of the variables. Expectations have to be taken account of to really know if present price level is higher or lower than the fundamental price level.

After a shock, i.e. unexpected change, to the fundamental variables prices and supply start to adjust to the shock by moving towards the new long-run solution given in (10) and (12).[10] The four-quadrant model can be used to analyze the new long-run solution, but not the dynamics of the adjustment process. According to the stock-flow model, along the way towards the new long-run equilibrium current price level comes from equation (4) and the stock evolves according to (8) or (9). The greater τ is, i.e. the faster the stock adjusts, the faster is the adjustment of P towards the long-run fundamental price level.

The dynamics of housing prices after a shock to one of the fundamental variables are also dependent on the formation of expectations. As DiPasquale and Wheaton (1996, pp. 251-256) demonstrate, the response of housing price

[10] Similar process starts also if a shift in expectations about the future takes place.

level to a shock differs substantially if the housing market participants' expectations are backward-looking instead of being rational.

In the extreme case of purely backward-looking expectations future price growth expectations are formed based on only the previous period's appreciation. In reality, price growth over several recent periods may affect expectations concerning future housing price growth. Because of backward-looking expectations, current and past price movements are positively related. Hence, backward-looking expectations lead to a cyclical behavior of the housing market. The longer the construction lag of housing is, the more cyclical the housing price response to a shock is likely to be. If the lag is very long, price level keeps growing for a long time after a positive shock in the market. As the new construction, due to higher housing prices, finally starts to enter the market, housing price drop is deep and lasts for long. Because of the price drop construction activity halts, and after a while prices start to rise again. This cycle then goes on indefinitely if expectations are purely backward-looking.

In contrast, if expectations are rational, a shock induces only a single price overshot, after which prices gradually move towards the long-run equilibrium without any cyclicality. This is because rational expectations theory assumes that agents operating in the housing market are perfectly informed about the operation of the market. Therefore, the agents are able to predict correctly how the market will respond to a shock.

It seems reasonable to assume that housing markets involve features of both backward-looking expectations and rational expectations. While the endless oscillating cycle of purely backward-looking expectations is not plausible in practice, housing markets still seem to respond somewhat cyclically to shocks in the fundamental variables. Furthermore, the positive feedback effect (see e.g. Shleifer 2000, chapter 6), highlighted by the behavioral finance theory, suggests that expectations are backward-looking to some extent.

Positive autocorrelation in housing appreciation can be strengthened by informational inefficiencies. It seems probable that housing markets are, in general, informationally inefficient in the sense that it takes several quarters for housing prices to fully reflect the new information set. In other words, demand may adjust slowly to shocks. For example Case and Shiller (1988, 1989 and 2003), Mankiw and Weil (1989) and Poterba (1991) present empirical evidence for sluggishly adjusting demand in the housing market. As Riddel (2004) states, "*it is not surprising that a market subject to frequent disruptions and fraught with informational asymmetries, high transaction costs, and long investment horizons fails to instantly adjust to new information*". In fact, slow adjustment of demand may be due to rational behavior. The anticipated sales time for a dwelling can be long and exhibit significant variance (see e.g. Chinloy 1980, Wheaton 1990). Individual sellers are not able to determine easily whether an overly long sales time indicates an anticipated downturn in the markets or whether it is only due to random misfortune. Rapid price adjustment may not be rational within this environment (DiPasquale and Wheaton 1994, p. 6).

Hence, it is likely that after a shock housing prices underreact at first, failing to fully incorporate the new information. Price level keeps rising, however, and at some point overshoots. Eventually, housing prices start to gradually adjust towards the fundamental price level. The eventual adjustment process towards the long-run equilibrium may be cyclical, and housing may be occasionally notably over- or undervalued with respect to the prevailing fundamentals also after the initial overshooting.

The discussion above suggests that housing price movements are likely to be predictable to a large extent at least in the relatively short run. Giving the sluggish adjustment of housing stock and the backward-looking features in the expectation's formation, it is expected that it takes several years for housing prices to fully adjust to a shock. Consequently, housing appreciation may be predictable to some extent even in a few years horizon.

Evidently, for P^* to qualify as a long-run fundamental equilibrium, the expectations in (12) have to be forward-looking. Backward-looking expectations would add a speculative, i.e. non-fundamental, factor in the equation. Then, the equation would no longer show the fundamental price level. A major problem is that in an empirical application it is extremely hard to measure the fundamental price level towards which housing prices should adjust. This problem is further discussed in section 4.1.

Although P^* should not be affected by backward-looking expectations, a number of authors have included a backward-looking component in their estimations of the long-run equilibrium housing price level. This is problematic, at least if the aim is to evaluate the over- or undervaluation of housing with respect to the fundamental price level. It is apparent that the possibility of backward-looking features in expectation formation has to be catered for in an empirical application. The backward-looking element, however, should be included in the short-run model, not in the estimation concerning the dynamics of the long-run equilibrium. A reasonable method is to estimate a vector error-correction model that takes into account both the short-run dynamics, including the linkages between housing prices and the fundamental variables, and the adjustment towards the fundamental price level. Vector error-correction models are discussed in more detail in section 6.1 of this chapter.

It should be noted that the stock-flow model presented above, like any economic model, is naturally a simplification of the reality. For example, in practice changes in demographical factors and financial constraints are likely to have an effect on housing demand, i.e. on coefficients α_0 and α_1. Note also that the stock-flow approach assumes that H_t takes implicitly into account the shifts in rental demand[11] that occur due to growth of the area. Furthermore, growth in rental demand induced by income growth moves up the demand curve for owner-occupied housing thereby affecting α_0 and α_1. The effect of income is already presented in (13). In addition, the model does not tell anything about the evolution of the expected appreciation. Finally, in (2) the mortgage rate is assumed to equal the opportunity cost of capital. In reality, the opportunity cost is affected also by the risk premium associated with housing and by the risk-free interest rate. Consequently, an increase in the risk premium for housing or in the risk-free interest rate has got a negative impact on housing prices. At least in the Finnish case the risk-free interest rate and the mortgage rate are typically tightly linked, though.

The stock-flow model is based on the demand for owner-occupied housing. Nevertheless, just like the four-quadrant model applies to housing market dominated by owner-occupants, the dynamics indicated by the stock-flow model basically apply to markets that include substantial amount of rental housing. This is because, in the end, the same factors influence the demand for investment housing and owner-occupied housing.[12]

2.3 No-arbitrage condition between user costs and rental prices

The no-arbitrage condition between the user cost of housing and rental prices is one option to evaluate if housing is over- or undervalued with respect to fundamentals. The theoretical basis of the no-arbitrage condition lies on the asset market approach of housing markets introduced by Poterba (1984).[13] The no-arbitrage condition states that the user cost of housing should equal rent of similar housing. More specifically:

$$U_t = P_t\,(R_t + M_t - I_t) = P^R{}_t, \tag{15}$$

where $P^R{}_t$ denotes for the rental price level. As mentioned above, R may include also other components than the after-tax mortgage rate. For example, in Himmelberg et al. (2005) the specification is as follows: $R_t = P_t\,(-T{*}r^m{}_t + r^f{}_t$

[11] As the four-quadrant model showed, rental price level should have a direct impact on housing prices.

[12] Actually, it can be thought that an owner-occupant has bought an “investment” dwelling and rents it out to himself (without having to pay taxes for the rental income).

[13] Poterba (1984) focuses on the price of housing structures only. Nevertheless, the same basic idea should apply (and has often been applied) to housing prices consisting of both the structure and the site.

+ λ), where the first term in the parenthesis is the tax benefit of mortgage payments, r^f_t is the risk-free interest rate and λ is an additional risk premium to compensate homeowners for the higher risk of owning vs. renting. Himmelberg et al. also add $P_t(-T^*\omega_t + \omega_t)$, where ω_t is the property tax rate, to the formula. In Finland, however, property tax payments are not deductible in the taxation of the owner-occupiers, and in (16) it is assumed that M_t includes also the property tax on housing.

In general, only a fraction σ of the value of a dwelling is financed by mortgage. Then, because usually $r^m_t \neq r^f_t$, U_t can be presented as in (16).[14]

$$U_t = P_t\,[\sigma_t\,(1 - T_t)\,r^m_t + (1 - \sigma_t)r^f_t + \lambda_t + M_t - I_t] = P^R_t \qquad (16)$$

If the user cost of owner-occupancy is lower than rental cost, it is attractive to move from rental housing to an owner-occupied dwelling. Therefore, households are eager to buy housing, which raises housing prices until the no-arbitrage condition is fulfilled. The same logic, but with the opposite signs, applies naturally if user cost exceeds rental cost. Due to the high transaction costs and low liquidity of housing as well as households' liquidity constraints, in reality, there can be slight divergence from the no-arbitrage relation in the short run even if the market participants are rational. The relation should hold in the long run, nevertheless.

There are several complications in the measurement of the user cost. Because of these complications the use of the no-arbitrage condition is problematic in empirical applications. The two major questions concern the measurement of the risk premium and of the expected appreciation. Specifically, how should one estimate these two variables and are these variables constant through time? Note also that renting and buying a house are not, in general, perfect substitutes since households might derive extra utility from owning a house (e.g. pride of ownership or ability to customize the interior). However, this can be taken account of by setting a lower risk premium. In addition, also the measurement of the other variables may include some difficulties, and is likely that borrowing constraints have been binding at least occasionally. Naturally, incorrect measurement of the variables can give rise to misleading conclusions.

The basis in the no-arbitrage condition lies in the same underlying factors as in the stock-flow model. Thus the no-arbitrage condition, basically, leads to

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[14] Englund et al. (1995) incorporate also a term catering for the effect of housing ownership on the wealth tax. In Finland, owner-occupied housing is not taxed in the wealth taxation. Hence, assuming that the capital, instead of being invested in housing, would be invested in an investment form that is taxed in the wealth taxation, there is an extra tax benefit for owner-occupied housing. However, the rules regarding the wealth tax are complicated in Finland and it would be highly complicated to try to include a wealth tax benefit term in an empirical application.

the same conclusion as the stock-flow model – it just considers the formation of housing prices from a slightly different viewpoint. Poterba (1984) utilizes the asset market approach to emphasize the role of the inflation rate and tax benefits on housing prices. Higher inflation rate reduces the user cost, since, while nominal mortgage interest payments are tax deductible, the capital gains from appreciation of owner-occupied housing are essentially untaxed. Consequently, it is expected that higher inflation rate induces greater housing appreciation also in the real terms. According to Poterba, the effective cost of owner-occupation was actually negative during the 1970s for some high tax bracket individuals.

On the other hand, higher inflation rate causes tighter liquidity constraints for households. That is, in highly inflationary times the financial burden of a loan is "front-loaded", i.e. the real payment profile is tilted towards the earlier periods. More binding liquidity constraints in the first period of the mortgages, in turn, depresses housing demand. Thus, liquidity constraints act as a counterforce for the tax distortions during fast inflation, and high inflation and credit market frictions may together cause notable deviations from (16). In the literature this is called the "tilt effect". Furthermore, the results by Brunnermeier and Julliard (2006) suggest that households suffer from money illusion, which may lead to negative relationship between inflation and real housing prices and to temporary mispricing of housing.[15]

Note that from (16) we get $P_t = P^R{}_t \,/\, (R_t + M_t - I_t)$, which is equivalent to the price formation of owner-occupied housing in the north-west corner of the four-quadrant model. In addition, the no-arbitrage condition is closely related to the present value condition, i.e. to the fact that in an efficient market the price of a house must equal the present discounted value of its future net service (cash) flows. The basic asset pricing formula for owner-occupied housing can be presented as in (17).

$$P_t = E_t \sum_{\tau=1}^{h} [P^R{}_\tau - M_\tau + (T * \sigma_\tau * r^m{}_\tau)]/(1+\theta_{t,t+\tau})^\tau + E_t\,[P_h/(1+\theta)^h] \quad (17)$$

In (17), P_t is the price of a dwelling at time t, E_t is the expectations operator, $\theta_{t,t+\tau}$ denotes for the required rate of return for the dwelling from t to τ and h is the length of the planned investment horizon. θ takes into account the risk premium and the risk-free opportunity cost of capital. Notice also that in

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[15] Actually, it seems that even a housing researcher can suffer from money illusion. For instance, Smith and Smith (2006) have calculated the effect of changes in mortgage rates or in required returns on the "fundamental" value of housing. They state (p. 34) that one potential cause of the changes is movements in the inflation rate. However, they have not taken into account the fact that at the same time changes in the inflation rate are also likely to influence the expected growth of housing and rental prices.

contrast to (16), in (17) M and σ refer to absolute values of maintenance costs and of the mortgage rate. The formula is basically equivalent to the no-arbitrage condition. The two relations just present the same idea somewhat differently. Naturally, the use of (17) to assess housing prices is problematic due to similar reasons as the use of the no-arbitrage condition – it is complicated to measure the expected cash flows and required rates of return accurately.

Notice that because of the tax benefits of owner-occupants, housing is worth less for investors than for owner-occupiers if all the variables in (17) are the same in both groups. Hence, in general, the required return of investors has to be lower or the future expectations more positive than those of the owner-occupants, in order for investments on dwellings to be worthwhile. The returns required by portfolio investors may be relatively small due to the greater diversification benefits gained by having multiple dwellings (and possibly also other assets) in a portfolio. In addition, investors may also be less risk-averse than households and may have lower interest costs on debt. Furthermore, professional skills and scale economies of a large investor may lower the maintenance costs. On the other hand, turnover of tenants induces costs and vacancy of the rental dwellings. In any case, many investors must see housing as an attractive investment because there are so many free-market rental dwellings in Finland (the composition of Finnish housing stock is discussed in part 7 of this introductory chapter).

2.4 Co-movement between regional housing markets

As mentioned above, both macroeconomic and local factors affect housing prices. Because of the importance of the local variables, there are several distinct regional housing markets within a country. This is why the theoretical models above describe the formation and dynamics of housing prices in a regional housing market.

There are, typically, distinct geographical submarkets also within a single regional housing market, such as a metropolitan area. Furthermore, regional housing market may be divided to several segments based on the type (flat / row house / detached house), on possessory relation and on financing of housing. Price level may differ substantially between different submarkets and segments. However, housing price development between different regional submarkets within a metro area is generally substantially more uniform than between distant regional markets. This is because dwellings in different submarkets located in the same regional market can be typically regarded as relatively close substitutes for one another (this is exactly why they form one relatively coherent regional market). That is, the possibility of households to move to another submarket within a metropolitan area without great costs is expected to link housing price movements in different submarkets tightly together.

On the contrary, dwellings in distinct regional markets far away from each other cannot be considered to be close substitutes. Major reason for this is that it is time and money consuming to commute long distances. Hence, growing demand for housing in one region cannot be satisfied by housing supply in another regional housing market, in general. Therefore, contrary to the case of a coherent metropolitan area, migration does not work as a factor forcing housing prices to move tightly together between far away regions. Consequently, housing prices may rise notably in one region and at the same time decrease in some other region so that housing appreciation may be far from uniform within a country. Due to the lack of the substitution effect between distant regions, it is possible that housing is simultaneously overvalued with respect to market fundamentals in one area and undervalued in some other region. During the last ten years differences in the success of distinct local economies, especially in the employment development, have caused significant divergences in housing appreciation in different parts of Finland. National housing price level and growth are weighted averages of all the distinct regional markets, and neglect any regional differences within the country.

Nevertheless, there are reasons to believe that housing prices co-move to some extent also between regional markets. Changes in macro level variables, such as interest rates and taxation rules, have got a similar impact on housing prices in all the regional markets. Furthermore, especially within a comparatively small and coherent country, such as Finland, changes in business cycles typically hit different areas relatively simultaneously even if there are structural differences between the regions. This is to a large extent due to the substantial trade flows between various cities and regions. Also informational reasons can lead to strong housing appreciation correlations between regional markets, at least in the relatively short run.[16]

Together with the elasticity of regional housing supply, an area's industrial structure, competitiveness of local firms and industries, and the attractiveness of the area from the households' viewpoint determine how much local housing appreciates compared to the other regions. As higher housing prices typically lead to claims for higher wages (i.e. move the labor supply curve left) and make the area less attractive also for the households that are not in the labor market, in the long run there may be some substitution effect between remote

[16] This phenomenon is discussed in more detail in the third essay.

regions as well. That is, higher housing prices in one area relative to the other regions may induce, to some degree, a flow of jobs and households from the high-price area to the lower-price regions. In any case, despite the links between the regional markets, it is likely that both short- and long-run housing price co-movement is stronger between submarkets within a metropolitan area than between remote regional housing markets.

3 DIFFERENCES BETWEEN HOUSING AND FINANCIAL ASSETS

Like other asset prices, housing prices should equal the discounted stream of future cash flows, i.e. net rents, in the long run. Rents and discount factors of housing are affected, to a large extent, by the same macroeconomic factors as are the discount factors and expected future cash flows of financial assets. Nevertheless, housing differs substantially from the financial assets, such as equity, in many ways. The differences between the housing markets and the financial asset markets are of importance, since they have significant implications for portfolio analysis, for the efficiency of the housing market, for the predictability of housing returns and for macroeconomic cycles. In this section, the differences between housing and financial assets are discussed. Furthermore, the consequences of the special features of housing are evaluated.[17]

3.1 Special features of housing investments

Housing has got several characteristics that make housing investments different from financial assets. Heterogeneity, large unit size and indivisibility are often regarded as crucial special features of housing (and of real estate in general). In the case of financial assets, there are usually a great number of homogenous assets traded in the market. In the case on housing, however, no two dwellings are exactly alike, i.e. dwellings are heterogeneous. For instance, each dwelling occupies a location that is unique. Dwellings differ from each other by a number of other factors, such as size and age, too. Hence, there is no direct information regarding the market value of a particular dwelling, and sometimes housing market participants may have to use sales distant in time and location in evaluating the market values of different dwellings. Furthermore, because dwellings are usually large in size and value, and single dwellings cannot, in general, be divided into multiple assets, direct investment in housing demands a large amount of capital.

[17] Note that the discussion concerns direct housing investments. Obviously, securitized housing lacks a number of the special features introduced here.

Partly because of the lack of homogenous dwellings, there is no public market place for housing. The absence of a public market place makes the deficiency of housing price information even more pronounced. Due to the heterogeneity of housing and the lack of a public market place, market participants often have to put substantial effort to collect relevant information on a particular neighborhood and dwelling. Moreover, even if time and money is put on information gathering, it is typical that there is significant informational asymmetry between a buyer and a seller of a dwelling. On the contrary, in stock and bond markets there are public market places, and availability and quality of the price and return information is typically notably better than in the housing market.

Due to the significant information costs, the lack of public market place and the relatively high stamp duties, transaction costs are usually higher in the housing market than in the (publicly traded) financial assets' markets. For owner-occupants the transaction costs associated with housing transactions are particularly high, since they include also moving costs.[18]

Housing also poses notable maintenance costs including real estate taxes. The maintenance costs are mainly due to the physical nature of housing – if dwellings are not maintained properly, they are prone to substantial physical depreciation. Moreover, effort must be put in to get tenants and to thereby receive rental cash flows. Usually the maintenance costs of financial assets are notably smaller than those of housing. The fact that housing is real capital has also got benefits, though. Specifically, housing investments incorporate a real option, i.e. an option to alter the physical structure in the future.

Being a durable good, housing has got another special feature. As depreciation of housing is slow and it takes time to construct new dwellings, housing stock adjusts slowly to changes in the fundamentals. Because of the slow adjustment of supply, housing price movements may exhibit significant autocorrelations even if the market participants are rational.

Even though the large portfolio investors' viewpoint is taken when diversification and portfolio allocation is discussed in this thesis, it is worthwhile to mention the special attribute of housing as both investment and consumption good. As Flavin and Yamashita (2002) point out, the household's demand for real estate (housing) is "overdetermined". The level of housing ownership which is optimal from the viewpoint of household consumption for housing services may exceed substantially the level of housing assets that is optimal from a portfolio allocation point of view. This is because rental

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[18] Including psychological costs caused by factors such as having to leave from a familiar neighborhood.

housing is not a perfect substitute for owner-occupied housing[19] and because dwellings are indivisible units, i.e. one cannot, in general, own part of a dwelling and be a tenant in the rest of the dwelling.

Note also that in a number of countries the tax code favors owner-occupancy of housing. In Finland, for example, the implicit rent earned by owner-occupants is untaxed as are the capital gains on owner-occupied housing if the owner has lived in the dwelling for at least two years. The public sector influences housing price movements also by other means, such as zoning, subsidized housing production and rental controls. Hence, for example DiPasquale (1999) states that "*government policy can have a profound impact on the operation of the housing market*".

Finally, the significant role of the housing market with respect to the overall economy is worth mentioning. According to several studies, the wealth effect of housing on consumption is greater than that of the financial assets (see e.g. Case et al. 2001, Benjamin et al. 2004, Campbell and Cocco 2004). This is not surprising, since housing forms majority of many households' assets. Furthermore, a drop in housing prices is also likely to have a negative effect on housing construction. Moreover, a notable fall in housing prices would affect the banking sector by inducing unanticipated losses for mortgage lenders, which would strain the financial system. In addition, lending is likely to decrease as housing prices drop because of the significant role of housing as collateral.

3.2 Major implications of the special features

The special characteristics of housing have got significant implications for housing market efficiency and predictability as well as for portfolio analysis and allocation. Housing investments involve risks that are similar to the risks of financial assets. In particular, housing returns are expected to react negatively to interest rate increase and are also dependent on other macro level fundamentals just like stock returns. However, due to its special features, housing involves risks, such as the risks regarding maintenance costs and depreciation of the physical structure, that are not incorporated in the financial assets.[20] Furthermore, because the importance of housing prices and rents to the welfare of households, governments are often keen to intervene in the housing market, which may affect housing returns significantly.

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[19] In fact, owning a home may be a good hedge against the risk of unanticipated future rental price movements (see Sinai and Souleles 2005).

[20] Not directly at least – naturally many of the companies whose stocks are traded in the markets own real estate and thereby possess risks involved in real estate investment.

Other than the macro level risks can be diversified to a large extent. Nevertheless, large unit size and indivisibility of housing impedes housing portfolio diversification. An investor has to possess a large amount of capital if he aims to diversify his housing portfolio. Because of the large unit price of housing, households typically own one or two dwellings at most, and well diversified housing portfolios are owned mainly by institutional investors. Diversification of financial asset portfolio, instead, usually calls for only a relatively small amount of money.

Large unit size of housing also induces another drawback. Mainly due to large unit size and high transaction costs, housing markets are thin compared to publicly traded financial assets' markets. As a consequence, the liquidity of housing is, in general, worse than the liquidity of financial assets. Because of the relatively low liquidity and the high transactions costs, housing is typically a long-horizon investment. In case of owner-occupants, the holding period is also lengthened by the costs of moving between dwellings. The long holding period has got important implications for portfolio analysis. In particular, relatively long-term correlations and volatilities should be employed when examining the influence of housing in a portfolio containing multiple assets or when evaluating the diversification potentials of a housing portfolio. The use of only short-run correlations and volatilities may lead to misleading conclusions regarding the diversification possibilities and to misallocation of a portfolio.

Partly due to long holding periods of housing, the role of dividends, i.e. rental return (rental cash flows deducted by the maintenance costs), is usually important for housing investors.[21] Similarly, the implicit rent yield is of great importance to owner-occupants. As the rental return is, in general, steady compared to housing price movements, the rental return component is not likely to affect correlations between different assets notably, however. For instance, the annual total return correlations between ten major Finnish cities have practically been the same since 1987 as the capital return correlations.

Together with the heterogeneity of housing the thinness of the housing markets causes informational problems. For example, due to a lack of sufficient number of transactions of particular type of dwellings in a given area, price movements of housing cannot usually be measured as frequently as price movements of the financial asset. Typically, quarterly data are the most frequent data available concerning housing appreciation, and the price series are usually published with a lack of several months. Furthermore, the heterogeneity problem weakens the reliability of housing price and return data.

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[21] Other factors emphasizing the role of rental returns are the facts that housing generally offers relatively steady cash streams to its owner, and that the rental return often forms a major part of the total return of housing.

Even quality adjusted quarterly or annual price indices are not able to take into account all the variability in the quality of dwellings transacted during different periods. All in all, the problems with housing data undermine to some extent the comparability of housing returns with financial asset returns.

Also the high transaction costs of housing may have additional significant consequences. If the transaction costs are substantial, owner-occupants do not necessarily adjust quickly their housing consumption to changes in the fundamentals, even if they foresee future price changes correctly (see e.g. Edin and Englund 1991). Similarly, due to high transaction costs, portfolio investors' reallocate their housing portfolios relatively infrequently. Therefore, transaction costs are likely to slower the adjustment of housing prices to shocks in the fundamentals.

In addition, housing markets are likely to be relatively inefficient due to the informational problems concerning housing returns. Here, efficiency refers to informational efficiency. In an informationally efficient asset market, asset returns cannot be predicted in such a way that above average returns can be gained constantly. Even if housing markets were informationally efficient, it seems evident that housing price movements are predictable to some extent. This is due to the sluggish adjustment of housing supply and because of the reductive effect of transaction costs on housing sales. In other words, it seems clear that it takes a relatively long time for the housing markets to fully adjust to new information. According to Dolde and Tirtiroglu (1997) "*in real estate markets, substantial transaction costs, lack of centralized information gathering and lengthy delays in information availability may account for lagged effects on returns even in the absence of irrationality*".

Generally, given that housing market is not as efficient as stock and bond markets, and that the price adjustment is likely to be more sluggish in the housing market, it is expected that causality, at least in the Granger sense, runs from the financial assets to the housing market. That is, stock and bond price movements may well lead housing appreciation. Nevertheless, it is also possible that, through its influences on the overall economy, housing appreciation affects stock and bond prices.

The consumption good nature of housing may slightly undermine co-movement between housing prices and financial asset prices. As housing is a durable good producing utility to owner-occupiers, its pricing may differ somewhat from the assets that do not possess such consumption nature.[22] Due to housing consumption of households, housing markets are typically dominated by households, whereas the share of professional investors is

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[22] See e.g. Henderson and Ioannides (1983) for a model of housing choice taking account of both consumption demand and investment demand.

usually substantially larger in the financial asset markets. The different structure of agents operating in housing markets compared to financial asset markets may to some extent weaken the linkages between financial assets and housing.

4 PREVIOUS LITERATURE ON HOUSING PRICE DYNAMICS

Although empirical research on housing markets is substantially scarcer than on financial asset markets, there are a large number of articles examining housing price dynamics in various countries and regions. There is a great variability in the literature regarding empirical results reported. The theoretical grounds and methods employed vary somewhat as well. This section presents previous empirical literature on the dynamics of housing prices and ponders the reported results and problems with the empirical analyses in the context with the theoretical discussion above. Furthermore, empirical evidence on co-movements between regional housing markets and between different asset markets is reviewed briefly at the end of this section. Due to the aim and theme of this thesis, the emphasis is set on the literature employing time series data.

4.1 Data

Typically, empirical research on housing price dynamics incorporates notable complications with the data. Firstly, the heterogeneous nature of housing complicates the measurement of housing price movements. Ideally, because of the heterogeneity of housing, housing price series should be quality adjusted. The time series derived straightforwardly from average sales prices may be biased, since the average quality (including location) of dwellings transacted may differ substantially over time. Hence, many studies apply some kind of quality adjusted data, either repeated sales data (e.g. Abraham and Hendershott 1997, Lamont and Stein 1999, Harter-Dreiman 2004, Himmelberg et al. 2005) or hedonic index (e.g. Hort 1998, Meese and Wallace 2003). Unfortunately, quality adjusted series are in general scarce and relatively short. Therefore, e.g. DiPasquale and Wheaton (1994) and Riddel (2004) combine quality adjusted index with an average sales price index to get longer time series. Furthermore, a number studies, e.g. Takala and Pere (1991), Englund and Ioannides (1997), Holly and Jones (1997), Laakso (2000) and Capozza et al. (2002), employ data that are not quality adjusted. The papers are, with a few exceptions, similar in that housing price series are based on transactions in the secondary market, i.e. sales of “old” dwellings.

Secondly, the data measuring the fundamental variables affecting housing prices are never perfect. As Harter-Dreiman (2004) states: "*no one study seems to be strikingly superior to any of the others. The problem seems to be that the data are sparse and wrought with measurement error*". Many of the fundamental variables are hard to measure, and there is simply no data concerning some of the factors that, according to the theory, affect housing prices. Moreover, non-linearity, multicollinearity and other problems with the data often cause implausible signs and sizes of some estimated parameters.

A major problem in an empirical application, at least if the fairness of price level is being evaluated, is the measurement of the fundamental price level towards which housing prices should adjust. Some authors, for instance Riddel (2004), have assumed that expectations are purely backward-looking. The problem with this assumption is that it adds a speculative component, i.e. component that should not be part of the fundamental price level, into the long-run model. Some other papers have related the expected next period appreciation to current and in some cases also previous changes in the fundamental variables. For instance, DiPasquale and Wheaton (1994) estimate two long-run models, one with backward-looking expectations and one using, what they call, rational expectations. The former is just a three-year moving average of past appreciation. The latter is a forecast based on the historic values of the fundamental variables. Poterba (1991), Capozza et al. (2002) and Girouard et al. (2006), in turn, derive the expected appreciation based on inflation rates during the previous year or years, and Himmelberg at al. (2005) measure the expected appreciation using the average housing price growth from 1940 to 2000. Also all of these methods may include a backward-looking component that should not affect the long-run equilibrium price level. Furthermore, the method of Himmelberg et al. assumes that expected appreciation is constant, while in reality expectations vary over time. Many authors, e.g. Hort (1998) and Meese and Wallace (2003), totally exclude the appreciation component from the long-run equation. An approach to cater for the impact of the income growth expectations on the expected housing appreciation is to include permanent income, instead of current income, in the estimation for the fundamental price level. The permanent income is typically proxied by household consumption (see e.g. McCarthy and Peach 2004).

Because of the data problems, the long-run relations reported in the empirical literature are typically simple, excluding a number of variables that should enter the equation according to the theory. In a number of studies for example construction costs, user costs or even interest rate separately, are not significant in the estimated long-run relations or are not at all included in the analysis. Furthermore, it is constantly assumed in the literature that the maintenance costs and risk premium of housing are constant over time.

Moreover, due to the lack of proper data regarding some of the supply side variables, it has been often supposed that the supply variables in (12), other than construction costs, have been constant over time. Construction costs have regularly been added to empirical analyses to take account of the supply side. In some cases also housing stock or housing starts have been included in the time series analysis to accommodate the supply factors (see e.g. DiPasquale and Wheaton 1994, Holly and Jones 1997, Riddel, 2004), even though (12) does not directly include housing stock or starts. Capozza et al. (2002), instead, use a measure of the land around the city available for development as a proxy for supply constraints.

Thirdly, there are substantial differences in the length of the time series utilized. In general, it is easier to get long time series by using annual data. The problem with more infrequent data, such as annual time series, is that information concerning short-run dynamics may be lost and the number of data points is typically relatively small. Holly and Jones (1997) apply annual data that cover a period as long as 56 years, whereas the annual dataset of Jud and Winkler (2002) covers only 15 years. The quarterly time series in the literature are usually around 15-20 years in length. Meese and Wallace (2003) are able to employ monthly data, but the series cover only seven years. Such a short period may be problematic, since it does not possibly cover a whole price cycle, and consequently may result in misleading results. Long time series, in turn, may be tricky, because there may be one or more structural changes during the sample period.[23]

In a number of articles, e.g in Poterba (1991), Abraham and Hendershott (1996), Englund and Ioannides (1997), Hort (1998), Lamont and Stein (1999), Laakso (2000), Jud and Winkler (2002), Capozza et al. (2002) and Harter-Dreiman (2004), panel data are applied. A main reason to use panel data has been to get more observations – annual observations are used in all the studies that are reviewed here and employ panel data. Potential problem with panel data is that there may be substantial differences, especially in the elasticity of housing supply, between different areas. The regional differences cannot often be taken into account properly in a panel regression.

Housing price dynamics have been studied applying data at the metropolitan or other urban area level (e.g. Abraham and Hendershott 1996, Hort 1998, Lamont and Stein 1999, Laakso 2000, Jud and Winkler 2002, Capozza et al. 2002, Meese and Wallace 2003, Harter-Dreiman, 2004) as well as at the national level (e.g. DiPasquale and Wheaton 1994, Englund and Ionnides 1997, Holly and Jones 1997, Kosonen 1997, Riddel, 2004). The use of national level data neglects the regional differences, but may still be

[23] Structural breaks are further discussed in section 6.4.

sensible on some occasions, for instance when comparing housing price dynamics between different countries as in Englund and Ioannides (1997). The papers utilizing regional data have typically been based on panel datasets. This illustrates the point that data, especially more frequent than annual data, covering a long period of time concerning regional markets is exiguous. Although most studies use US data, there are several papers analyzing housing price dynamics in the other countries as well.[24]

Note that almost without exception real variables, instead of nominal values, are used in the econometric analyses. In addition, the studies have usually been based on price data that include both the value of the structure and the value of land. An exception to this is Poterba (1984), who studies the dynamics of the structure only.

4.2 Theoretical framework and empirical methods

In most cases, the theoretical approaches to study housing price dynamics have been based on some modification of the stock-flow model. In several papers, however, the theoretical basis lies on the asset market approach of housing (see Poterba, 1984) and the no-arbitrage condition presented in section 2.3 (see e.g. Englund and Ioannides 1997, Hort 1998, Meen 2002). This approach, in any case, leads to similar conclusions and predictions regarding housing market adjustment as the stock-flow model. The different theories just approach housing market dynamics from a bit different viewpoints.

In general, the empirical results are in line with the predictions of the theoretical models. The problems with the data are probably a partial explanation for the fact that the estimated adjustment speeds of housing after a shock to fundamentals as well as the other parameters and variables in the estimated models vary substantially. Another explanation for the differences in the empirical results is that there are likely to be significant differences across various markets, and the dynamics may vary in time. Because of the problems with the data, several estimations concerning both long- and short-run housing price dynamics are reported in many of the papers.

Not all of the studies that examine housing price dynamics have linked housing appreciation to any long-run equilibrium price level. The theory, however, suggests that these studies neglect important information concerning the factors that drive housing prices. Therefore, in a number of papers a model

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[24] For example, Kosonen (1997, Finnish data), Holly and Jones (1997, UK data), Muellbauer and Murphy (1997, UK data), Hort (1998, Swedish data), Englund and Ioannides (1997, data from 15 OECD countries) and Meese and Wallace (2003, data from Paris).

or models describing the long-run dynamics of price level are estimated, and a gradual adjustment towards the long-run equilibrium level is assumed. Recently, many of the papers have utilized cointegration analysis to test for the existence of a stationary long-run relation between housing prices and their fundamental determinants. In the cointegration analyses both the Engle-Granger method (e.g. Hort 1998, Harter-Dreiman 2004), and the Johansen method (e.g. Holly and Jones 1997, Meese and Wallace 2003) have been employed.

In several papers a long-run relation is estimated, but the stationarity of the relation is not tested. Non-stationarity of the estimated relation may be problematic, since it might imply that the model is misspecified.

DiPasquale and Wheaton (1994) and Riddel (2004) estimate long-run equations by two-stage least squares, because of the likelihood of endogeneity of some explanatory variables. Riddel makes also corrections for non-stationarity by the Phillips and Loretan approach, sometimes also called the augmented least squares. In addition, Riddel contributes to the literature by constructing a multiple error-correction model. This approach makes it possible to decompose deviation from the fundamental price level into that generated by supply-side disturbances and that arising from changes in demand conditions. Finally, in the papers employing panel data, panel data estimator that controls for both year and area fixed effects is used, as e.g. in Capozza et al. (2002) and Lamont and Stein (1999).

4.3 Empirical results

4.3.1 Long-run income elasticity

In general, the empirical literature indicates that income is a variable that should not be left out of the long-run regression models. According to Case and Shiller (2003) income alone almost completely explains home price increases in the vast majority of states in the US. Also Holly and Jones (1997), using UK data, suggest that the single most important determinant of real house prices is the real income. Furthermore, the results of Girouard et al. (2006) imply that the housing price-to-income ratio in Finland has been stationary over 1970Q1-2004Q4. However, there is a substantial amount of variation with respect to the income elaticities of housing prices in the estimated long-run equations, and Tsatsaronis and Zhu (2004) even claim that household income has got only a small explanatory power over national housing price movements in a set of 17 industrialized economies. Tsatsaronis and Zhu, though, employed only differenced variables, i.e. did not estimate a long-run fundamental level towards which prices should converge.

Empirical evidence reported by Harter-Dreiman (2004) gives support to the hypothesis that the long-run income elasticity is greater in more supply restricted areas. Employing US data Harter-Dreiman estimates the long-run income elasticity to be .38 in the more constrained metro areas compared with .21 in the less supply restricted metro areas. The results by Capozza et al. (2002) are relatively well in line with Harter-Dreiman, suggesting that the long-run elasticity in the US metro areas is .43. In a highly constrained area – Paris – the corresponding figure is .65 according to Meese and Wallace (2003). In the HMA the long-term income elasticity of housing price level is as high as .8 based on the Feasible Generalized Least Squares estimation by Kuismanen et al. (1999). The estimations of Laakso (2000), in turn, imply that in the short run the price elasticity is close to one in Finland.

Even though the underlying theory expects the long-run income elasticity of housing prices to be less than one, Muellbauer and Murphy (1997) and Kosonen (1997) get long-run coefficients of 1.3 and 1.4 using national level UK data and Finnish data, respectively. The estimations of Riddel (2004), in turn, suggest that the income elasticity of housing demand is as large as three in the US. Furthermore, in their empirical analysis, Lamont and Stein (1999) apply an assumption, which they base on the findings of Poterba (1991), that the long-run elasticity of metropolitan housing price level with respect to income equals one. Long-run income elasticities that exceed one only slightly may be explained by factors such as liquidity constraints faced by households. Elasticity in the magnitude of three, however, seems implausible in reality. Hence, it is probable that data problems or model misspecification have got to do with some of the reported large coefficients.

The above mentioned income elasticities are estimated using income per capita or household. In some papers also aggregate income data, i.e. income per capita multiplied by the population of the area, are employed. This may often be reasonable, since multicollinearity problems may lead to insensible results if population and income per capita are added to the empirical model separately. Actually, multicollinearity may well be a major reason for the fact that in a number of papers population is excluded from the reported models.

In any case, the prior expectations regarding the size of the elasticity of housing prices with respect to the aggregate income are similar to those concerning the "pure" income elasticity. Nevertheless, Meen (2002) and McCarthy and Peach (2004) report long-run coefficients as large as three in the US. Similarly, Meen (2002) estimates coefficient in magnitude of two and a half in the UK. Such large coefficients may well be due to misspecification of the model.

Further issue is the selection between permanent income and current income as the income variable added to the empirical analysis. In most of the papers reviewed here, current income is included in the estimations. If permanent income is employed, it is typically approximated by current consumption. According to the empirical literature, the coefficients do not seem to differ whether current or permanent income is used. This is not surprising, since expectations regarding future income are likely to depend strongly on the development of current income.

4.3.2 Other long-run elasticities

In addition to income, an interest rate variable is usually added in the long-run model and found to be both statistically and economically significant. Typically, the interest rate variable tracks the movements in the mortgage rate over time. As Himmelberg et al. (2005) emphasize, house prices should be more sensitive to interest rate movements when the user cost of housing is low – when the mortgage rate (i.e. opportunity cost of housing capital) is low or when the expected housing appreciation is high. In empirical analysis, the differences in the sensitivity of housing prices with respect to interest rate movements in different states are hard to take account of. Actually, at least in all of the studies mentioned here, only the "average" sensitivity is estimated and reported.

The long-run effect of a one %-point increase in the real after-tax interest rate on real housing price level varies substantially between different studies. DiPasquale and Wheaton (1994) suggest that the negative impact is slightly over 10% in the US, whereas in Capozza et al. (2002) the figure varies between 4% and 9% depending on the model specification, and Meen (2002) suggests that the effect is as small as 1.3%. According to Hort (1998), in turn, the negative influence of a %-point rise in the real after-tax interest rate on urban housing prices is only 2%-3% in Sweden, and Meen (2002) reports a sensitivity of 3.5% in the UK. Finally, Meese and Wallace (2003) estimate the coefficient to be 7% in Paris. The relatively large value in Paris appears to be reasonable, since housing price sensitivity to demand shocks is expected to be greater in more supply restricted regions. In Finland the long-run coefficient of the real after-tax rate is estimated to be 9% by Kosonen (1997). The value of less than 1% in the HMA reported in Kuismanen et al. (1999) seems surprisingly small.

Other variables rarely appear in the empirical models compared to the interest rate and income variables. A major reason for this is the data problems explained above. Moreover, it seems, based on the empirical literature, that income and interest rate are the two most important variables driving housing prices in the long run.

Theoretically, one would expect that an increase in the construction costs leads to a smaller relative increase in housing prices, because the structure accounts only for part of the price of a dwelling. Nevertheless, Capozza et al. (2002) get a long-run construction cost elasticity of 1.2. Meese and Wallace, in turn, report a figure as high as 6.5. These values seem improbable in practice, and it is likely that data problems (and possibly also model misspecification) have biased the estimated coefficients. On the contrary, Hort (1998) reports coefficients of around .5 for construction costs.

Capozza et al. also included population as a variable explaining housing price level across US metro areas. The results imply that one percent growth in population leads to a .15% increase in housing prices in the long-term. Following the results of Mankiw and Weil (1989), which emphasized the role of age distribution of population in housing demand, in some studies a specific demographic demand variable that also takes into account the age distribution of the population has been added as an explanatory variable. According to Kuismanen et al. (1999) demographic demand is an important variable driving housing prices in the HMA. Furthermore, Kosonen (1997) tried to fit unemployment rate to the long-run model to take account of income uncertainty, but found the rate to be insignificant.

Note that the exclusion of a variable that takes into account population growth in the area may lead to peculiar long-run equations. For instance, Holly and Jones (1997) include housing stock in their long-run model, but add the share of 20-29 aged as the only demographic variable. Hence, the model is clearly misspecified and it is not surprising that housing stock has got the wrong, i.e. positive, sign in the cointegrating relation. Housing stock takes the population growth implicitly into account – it is obvious that, as the number of households in a given area grows, both housing stock and housing prices are expected to increase, in general. It is, however, usually problematic to add both stock and population into a model because of the extremely high correlation between the two variables.

Finally, studies by e.g. Poterba (1984 and 1991), Koskela et al. (1992), Muellbauer and Murphy (1997) and Kosonen (1997) highlight the notable influences of the tax code and of financial constraints on the fundamental level of housing prices. Interestingly, Kosonen shows evidence that in Finland house prices have become responsive to real after-tax interest rates only after the financial deregulation. This result is in accordance with the findings of Muellbauer and Murphy (1997), whose analysis implies that income growth expectations and real interest rates became significantly more important with respect to the housing price formation in the UK after the financial liberalization in the early 1980s.

There are also a great number of studies examining the formation of housing demand that employ micro level cross-section data. An example is the study by Laakso and Loikkanen (1995), according to which housing demand in the HMA is significantly affected by the age of the household head. Laakso and Loikkanen also estimate that the elasticity of housing demand with respect to permanent income was .2-.4 in 1988. Because the theme in this thesis is related to housing price dynamics over time, the articles that do not exhibit time series analysis are not reported here any further.

4.3.3 Adjustment towards the fundamental level

Error-correction models are estimated in several papers to study also the short-run dynamics. In most of the other papers, the error-correction term is regarded as the factor forcing housing prices eventually towards their fundamental level after the price level has overshot following a shock (just as proposed in the theoretical section). Typically, of particular interest is the adjustment speed towards the fundamental level.

Employing national level US data DiPasquale and Wheaton (1994) found an adjustment speed of 29% per annum using myopic expectations in the long-run model and 16% a year utilizing rational expectations estimation in the long-term equilibrium. Riddel (2004) estimates considerably greater speed of adjustment coefficients and suggests that in the US price adjustment is faster after demand generated disequilibrium (63% a year) than after a supply side shock (34%). The results of Holly and Jones (1997), in turn, propose that adjustment is faster when housing prices are above (17% annually) than below (2%) the long-run relation. This finding might be explained by that fact that the adjustment of supply is even more sticky downwards than upwards. In Finland, the speed of convergence is estimated to be about 7% per quarter by Takala and Pere (1991) and 15% per quarter by Kosonen (1997).

The variability between the reported adjustment speeds is great also in the papers utilizing metropolitan level data. The fastest convergence speed is estimated by Hort (1998). Hort’s results imply that housing prices adjust as much as 84% per annum towards the fundamental level. Also Meese and Wallace (2003) estimated a large adjustment coefficient, 30% per month (76% a year) in Paris. Capozza et al. (2002), instead, report a substantially slower adjustment speed of 25% in the US. In line with Capozza et al., Lamont and Stein (1999) report a 20% and Harter-Dreiman (2004) a 22% annual adjustment speed in the US metro areas. In the two latter mentioned studies, the long-run level includes only the income level in addition to housing prices. This is problematic, and may indicate model misspecification. Note also that, with the exception of Meese and Wallace (2003), the reported results are based on panel data, neglecting any differences in adjustment speeds between different areas.

Giving support to the backward-looking element in expectations, in all of the error-correction models reviewed here the coefficient for at least the one period lagged price change is significant and large. The reported coefficients for the previous year's appreciation is approximately .8 in DiPasquale and Wheaton (1994), .6 in Hort (1998), .2 in Lamont and Stein (1999) and .3 in Harter-Dreiman (2004). Moreover, Meen (2002) suggests that the figure is .3 in the US and half of that in the UK. Using quarterly Finnish data, Takala and Pere (1991) and Kosonen (1997) get .25 and .5, respectively, as the coefficient for lagged price increase.

Abraham and Hendershott (1996) and Harter-Dreiman (2004) also exhibit evidence suggesting that the coefficient for lagged price change is substantially greater in cities with more constrained housing supply. According to Abraham and Hendershott the value of the coefficient for the previous year's price growth is .19 in the less constrained US cities, whereas it is .52 in the more supply restricted metro areas. The corresponding figures reported by Harter-Dreiman are .12 and .34. Malpezzi (1999), in turn, presents result supporting faster adjustment in less stringently regulated environments. In addition, Capozza et al. (2002) suggest that autocorrelation is larger in metropolitan areas in the midst of strong economic expansion.

The large coefficients on lagged appreciation suggest that after a shock the adjustment towards the fundamental housing price level may be cyclical. First, after a shock, the backward-looking element pushes housing prices further away from the long-run equilibrium level. Then, during the eventual adjustment process towards the fundamental level, housing prices are likely to behave somewhat cyclically.[25] Note, that despite the backward-looking feature discussed above, there seem to be also some forward-looking elements in expectations formation (see e.g. Poterba 1991).

The assumptions of an initial overshooting that takes for several periods and the eventual gradual adjustment towards the new long-run fundamental level are supported by the impulse response curve that Harter-Dreiman (2004) derives based on a vector error-correction model. This kind of adjustment pattern is accordant to the discussion in the theoretical section. The impulse response curve derived by Lamont and Stein (1999), in turn, implies that it

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[25] Abraham and Hendershott (1996) specify the lagged appreciation term as a "bubble-builder" and the error-correction term as a "bubble-burster".

takes a long time before new information is fully reflected in housing prices, i.e. it takes a long time before price level reaches and overshoots the new long-run level. The analysis of Lamont and Stein further suggests that in cities with high household loan-to-value ratios prices respond more quickly to a shock and overshoot more than in cities with lower loan-to-value ratios. Some important fundamental determinants are missing from both of the models from which the impulse responses are derived. It is, however, unlikely that the inclusion of further variables would change the shape of the impulse curves. This is supported by the estimated models in the other papers, even though impulse response analysis is not conducted in the other reviewed studies.

It is important to understand that taking account of all the short-run dynamics, including the backward-looking features, the actual adjustment speed towards the fundamental level may differ notably from the one implied by the speed of adjustment parameters only. As shown by Harter-Dreiman (2004), due to the existence of the lagged appreciation term and the interaction between housing prices and the fundamental variables in a vector error-correction framework, in reality the adjustment is likely to be slower than the speed of adjustment coefficient indicates.

Similarly, if the income elasticity of housing prices is, say .5, a two percent shock in income level does not, in general, predict that the fundamental level of housing prices towards which housing prices will adjust increases by one percent. This is because it is likely that (at least) some of the fundamental determinants of housing prices, including income, are endogenous in the model explaining housing prices.

As a final issue concerning the short-run adjustment, let us consider the predictive power of the various error-correction models presented in the literature. The adjusted coefficient of determination (aR^2) typically varies approximately between 40% and 70% (see e.g. Abraham and Hendershott 1996, Lamont and Stein 1999, Capozza et al. 2002, Riddel 2004, Harter-Dreiman 2004).[26] However, according to Holly and Jones (1997) as much as 97% of the annual housing appreciation in the UK during 1941-94 can be explained by their model. On the other extreme is the model presented by Meese and Wallace (2003). The fit of their model is relatively poor, the aR^2 is only 35%. Employing Finnish data Takala and Pere (1991), Kosonen (1997) and Laakso (2000) get relatively nice fits, around 65%. The difference between the two former studies and the last paper is that the former two use quarterly national level data from 1970 to 1990 and from 1979 to 1995, respectively, whereas the latter is based on annual panel data from Finnish regions covering 1983-1997.

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[26] The adjusted R^2 usually exceeds 90% in the long-run fundamental level estimations.

4.4 Linkages between regional housing markets

Research on housing price co-movement between different regions is relatively limited. Data problems are also present in the studies examining regional linkages. Differing from the studies reported above, most of the studies on interdependence between regions employ quarterly data. As in the articles examining housing price formation over time, also in the papers investigating regional price linkages both hedonic (e.g. Clapp and Tirtiroglu 1994, Clapp et al. 1995) and repeat sales (e.g. Pollakowski and Ray 1997, Jones et al. 2003) indices are employed as well as indices that are not quality adjusted (e.g. Dolde and Tirtiroglu 1997, Kuosmanen, 2002). Typical length of the time series utilized in the analyses is ten to twenty years.

In general, the empirical results are in line with the logical assumption that co-movement between housing prices in closeby areas is stronger than between distant regions. Strong interrelations are found also between distant housing markets, though. Within a single metropolitan area the substitutability of dwellings is likely to augment co-movement between different submarkets. A number of authors relate regional linkages to informational factors.

Clapp and Tirtiroglu (1994), Clapp et al. (1995), Dolde and Tirtiroglu (1997) and Pollakowski and Ray (1997) emphasize the role of information in the diffusion process of housing price movements between nearby areas in the US. The first two apply regressions in which appreciation in a given town is explained by lagged appreciation in either neighboring or non-neighboring towns. Dolde and Tirtiroglu employ GARCH-M methodology to examine the diffusion of housing price shocks through contiguous regions. Pollakowski and Ray, in turn, use vector autoregressive (VAR) models to test for Granger causality between regional housing markets. Expectedly, all of the four papers conclude that the price linkages between nearby areas are significantly stronger than the interdependence between areas further away from each other. This result applies even within a single metropolitan area.

Dynamic linkages have been found also between relatively distant areas. Using Finnish data Kuosmanen (2002) reports dynamic interdependence between cities that lie relatively far away from each other, i.e. between cities whose dwellings cannot be regarded as close substitutes for each other. In particular, Kuosmanen finds evidence in support of the leading role of Helsinki. According to Berg (2002), in turn, housing price changes in Stockholm lead house price movements in the other parts of Sweden. Similarly, the analysis of Meen (1996) indicates that there is a uni-directional spatial dependence from the South-East UK (including London) to the other UK regions. All of these results suggest that housing price changes in the main economic centre of a country lead housing price movements in other parts of the country. Both Kuosmanen and Berg apply VAR framework to study Granger causalities between regions. Meen does not test causalities formally, but uses single ordinary least squares and seemingly unrelated regressions to derive the conclusions.

In addition to short-run co-movements, empirical literature reports strong long-run linkages between regional housing prices. The research on long-run interrelations between distant housing markets is still scarce, however. In the existing literature, cointegration analysis is utilized to study the existence of long-run interdependences. MacDonald and Taylor (1993) found cointegrating relationships between old housing prices in different areas in the UK using both the Engle-Granger method and the Johansen[27] method. The results of Meen (1996), based on prices of newly built dwellings and Engle-Granger methodology, and of Worthington and Higgs (2003), utilising the Johansen technique, are congruent with MacDonald and Taylor. Smyth and Nandha (2003), in turn, reported causalities and some long-term equilibrium relationships between Australian capital cities. Worthington and Higgs conduct also Granger causality tests and a variance decomposition analysis based on the estimated cointegrated VAR model. The results suggest that actually it is not housing prices in the London area but prices in the Outer South East UK that lead the rest of the country. The variance decomposition further implies that housing price movements in the Outer South East account on average for as much as 60% of the forecast error variance of housing appreciation in the other regional markets.

The evidence on cointegrating relationships between distant areas reported in the four papers mentioned above is somewhat surprising, since one could expect that the regional factors affecting housing prices would significantly "disturb" such long-term links. Within a metropolitan area, on the contrary, it would not be unexpected to find cointegrating relations between different areas. This is because it is likely that within a metro area there are several areas whose dwellings are close substitutes for one another. Jones et al. (2003) is among the very few papers studying dynamics between intra metropolitan submarkets. Jones et al. divide Glasgow into six distinct submarkets and provide evidence for the existence of cointegration between some of the areas. Jones et al. state that due to the cointegration between a couple of the defined submarkets, it actually seems that there are only four distinct housing submarkets in Glasgow – the areas that are cointegrated are likely to form one larger submarket. The analysis, just like none of the studies utilizing cointegration analysis that are mentioned in this section, does not consider the

[27] The Johansen test results, however, probably suffer from small sample bias, since altogether ten different regions are added to the test simultaneously and the sample consists of 76 observations only.

possibility that structural break(s) may have resulted in the acceptance of the hypothesis of no cointegration between some areas.

In the literature, the importance of lead-lag relations between housing markets is typically related to the predictability implications. That is, for those planning to buy, sell or build residential property, identification of price behavior can create optimal timing policies. The studies, however, have usually not considered the effect of lead-lag relations on housing portfolio allocation and diversification potentials. Because of positive lead-lag relations and long-run interdependences housing portfolio diversification potentials are likely to be substantially weaker than implied by quarterly or even annual correlations.

There are, of course, data problems, especially the fact that total returns on housing are only rarely available on a regional basis, which hinder the examination of housing portfolio diversification potentials. Nevertheless, it is reasonable to assume that correlations between housing returns in different regions can be approximated well using only price data. For example, Dolde and Tirtiroglu (1997) employ only capital return data to estimate the volatility of housing returns. They justify the use of solely price data by the non-existent rental return data and by the argument that it is likely that the volatility of total housing returns is dominated by the price change component in quarterly data. In fact, Capozza and Seguin (1994) indicate that housing price change volatility dominates total return volatility even in decennial data. Brown et al. (2000), in turn, use average transaction price time series to study housing portfolio diversification in Hong Kong. The evidence on diversification gains is only mildly encouraging. On the other hand, because of the lack of sufficient price data, Wolverton et al. (1998) base their analysis regarding intracity housing portfolio diversification on vacancy and rental data. Their results implied significant risk reduction opportunities from investing in apartments located in different parts of Seattle.

4.5 Linkages between housing markets and financial asset markets

Most of the studies examining dynamic linkages between real estate and other asset categories have used securitized property, typically real estate investment trusts (REIT), as the real estate variable (see e.g. Okunev and Wilson 1997, Chaudhry et al. 1999, Glascock et al. 2000, Okunev et al. 2000 and 2002). Research analyzing the existence of dynamic interrelations, especially long-horizon interdependence, between housing and financial asset prices is still scarce. The measurement problem regarding total returns on housing are naturally present also when examining co-movement between housing returns and financial asset returns. Moreover, housing price series are usually based on all the transactions during a particular period, whereas financial market return series typically use the values at the end (or beginning) of each period. This may distort the reported correlation coefficients and Granger causality test results slightly.

To estimate capital returns on housing in Geneva, Hoesli and Hamelink (1996) employ a hedonic price index that covers 1978-1992 and is constructed on the basis of a sample containing 295 transactions only. The small number of observations is partly explained by the fact that the unit of analysis is the apartment block, not the apartment. Income returns, in turn, are counted by assuming that operating expenses equal 1.5% of the value of the apartment block. The real (nominal) return correlations are .23 (.20) and .06 (-.07) with stocks and bonds, respectively. To investigate co-movement between returns on different assets in 1981-92, Hoesli and Hamelink (1997) use the same annual housing data as Hoesli and Hamelink (1996) for Geneva and similar data for Zurich. Geneva data is utilized as a proxy for income returns in Zurich, however, because of the unavailability of income data from Zurich. The reported nominal correlations between housing and bond returns are approximately -.3. There is a substantial difference between the correlations with stocks, however: the figure for Geneva is -.11, while it is .18 for Zurich. The negative figure between Geneva housing and stocks is an exception – in general, the correlation between housing returns and stock returns has been systematically found to be positive in the literature. Note, that according to both of the articles by Hoesli and Hamelink, income returns on housing are extremely stable compared to the capital returns, and the influence of income returns on annual correlation between housing and the financial assets is negligible. Hence, it seems that even if the housing return data consists of the capital returns only, one can get a good picture about the diversification potentials between housing and financial assets.

Gyourko and Kleim (1992), in turn, report a quarterly correlation of .26 between housing appreciation in the US and the changes in the S&P 500 stock index during 1966-1990. The housing index that Gyourko and Kleim use is transaction based but not quality adjusted. A relatively large quarterly correlation, .44, between excess returns, i.e. returns over risk-free interest rate, on stocks and housing in Hong Kong is showed by Fu and Ng (2001). Fu and Ng utilize quality adjusted time series of housing prices and rents, and housing maintenance costs are assumed to equal 30% of the rental yield. In the Finnish market, Kuosmanen (2002) found the correlation to be .37 based on quarterly transaction data. According to Hutchinson (1994) and Flamin and Yamashita (2002), instead, housing returns are practically uncorrelated with returns on stocks. Hutchinson employs a short sample of appraisal based UK housing price data and assumes that the income return is a constant percentage of the capital value. Given the problems with appraisal based data, it is not surprising that the correlation between housing and stock returns reported in the paper is as small as .08. In the analysis of Flamin and Yamashita concerning the US markets, housing appreciation is based on households' own views about the values of their dwellings. Furthermore, because no direct observation of rental values is available, Flamin and Yamashita estimate rental value by a simple model.[28] The data problems may distort the perceived correlations somewhat.

Contrary to the findings between housing and stock returns, correlation between housing and bond returns seems to be negative in general. Gyourko and Kleim (1992) present monthly correlation of -.01 whereas Hoesli and Hamelink (1997), and Hutchinson (1994) report substantially larger negative correlations, from -.26 to -.33 based on annual observations.

Regardless of the measurement of housing returns, the reported correlations of housing returns with returns on stocks and bonds are sufficiently low to imply significant diversification opportunities. However, if there are lead-lag relations between the asset returns, the contemporaneous correlations are likely give a misleading idea of the strength of the co-movement between housing market and the financial asset markets. Fu and Ng (2001), for example, showed that real estate market inefficiency depresses the relatively short-term correlation between real estate and financial markets. This, in turn, has got implications for policy and investment decisions. Therefore, it is important to study dynamic linkages between the assets. Nevertheless, research on the longer-term linkages between real estate prices and financial asset prices is still scarce.

Englund et al. (2002) point out that the relationship between investment horizon and correlations between asset returns is particularly relevant when housing is included in the analysis. This is because housing series, typically, exhibit positive autocorrelation and because of the measurement bias in the short-term housing returns due to the heterogeneity of housing. Englund et al. consider the effect of the investment horizon on correlations between different assets' returns based on a VAR model employing quarterly data from 1981 to 1993. The estimates suggest that while quarterly correlation between stock and housing returns in Stockholm is .16, the figure is .22 using ten quarter investment horizon and practically zero when an investment horizon of ten years is assumed. The corresponding figures between housing and bonds are -.13, -.62 and -.47.[29] Englund et al. use a total return estimate of owner-

[28] Flamin and Yamashita (2002) report the correlations between after-tax returns. The housing return component represents the after-tax return on owner-occupied housing.

[29] The findings by Englund et al. (2002) further imply, that all the asset returns exhibit mean-aversion in the relatively short term and mean-reversion in the long horizon.

occupied housing returns. The capital return component is based on a quality-adjusted price index that utilizes a dataset consisting of all the sales of one-family houses during the sample. The income return component, in turn, is based on the index of rents for residential apartments, assuming that in 1981Q1 the rent level was 1 percent of the value of the house.

Especially research analyzing the existence of long-horizon interdependence between housing and financial assets is still extremely limited. In the Finnish market the existence of a long-term relationship between housing and stock prices in 1970-90 is studied by Takala and Pere (1991). Using quarterly data, Takala and Pere found evidence of cointegration between the two asset prices. According to Barot and Takala (1998), in turn, stock prices could be most properly used as a weakly exogenous variable in a trivariate cointegrated system including also housing prices and private consumption deflator using both Finnish and Swedish data. Both of the papers employed the Johansen test for cointegration and non-quality adjusted average housing sales price data.

The empirical results imply that stock price growth leads housing appreciation. Granger causality from the stock market to the housing market, but not the other way round, is reported by Chen (2001) using data from Taiwan (Taipei) and by Takala and Pere (1991) and Kuosmanen (2002) regarding the Finnish asset markets. Moreover, Englund at al. (2002) show evidence of stock returns Granger causing housing returns, but not *vice versa*, in Stockholm.[30] Note, that Chen (2001) employs quarterly housing data that does not represent the actual market prices. Instead, the housing data represents "to-be-constructed housing prices" and is not quality adjusted.

Leading role of the stock market with respect to the housing market is implied also by Borio and McGuire (2004). They show that there is a tendency for peaks in the equity prices to precede peaks in the housing prices. Furthermore, employing annual panel data including 130 metropolitan areas across the US, Jud and Winkler (2002) found that real stock market appreciation has got a strong current and lagged effect on the growth of quality adjusted real housing prices. In contrast with the other results are the findings of Fu and Ng (2001), which indicate that in the Hong Kong market excess returns in the housing market have got predictive power for stock market excess returns but not the other way round.

[30] Surprisingly, the estimated VAR model suggests that higher stock returns anticipate lower housing returns.

5 FEATURES AND DEVELOPMENT OF THE FINNISH HOUSING MARKETS

Because of the importance of housing on the welfare of households and on the overall economy, the public sector intervenes in the housing markets all over the world. Governments have placed tight financial regulations, regulated rental prices, and subsidized housing demand and supply in various ways. These actions are likely to have impacts on the composition of the housing stock as well as on the housing and rental price level and dynamics. Also in Finland public policies have had a major role in the housing market and have evidently affected the operation of the markets.

This section delineates some special features of the Finnish housing markets that are in many occasions caused by the public policies. First, the structure of the housing markets is discussed. Then, the major institutional changes affecting the housing markets in Finland are presented together with the development of the Finnish housing markets during the last three decades.

5.1 Structure and features of the Finnish and HMA housing markets

In Finland, the housing market is divided into two main sectors. Privately financed housing can be bought and sold at market prices without any restrictions. In the publicly regulated (i.e. subsidized) sector, instead, selling prices and rental prices are controlled. The focus of this thesis is on the privately financed market. Nevertheless, it is worthwhile to discuss the role of the subsidized housing production, since it is likely to influence the volume, prices and rents of the privately financed housing stock.

At the beginning of 2005 the total housing stock in Finland covered approximately 2.6 million dwellings, of which owner-occupied housing formed almost 60%. About one percent of the dwellings are placed in between the owner-occupied and rental housing.[31] The rest are rental dwellings. Institutional investors (including the public sector) own approximately half of the rental homes. Little less than 40% of the rental dwellings are privately financed. It is evident that a great majority of the owner-occupied housing is privately financed. There is no precise information on the share, though. Of

[31] The so-called "right of occupancy" (*asumisoikeus*) dwellings.

the owner-occupied dwellings, multi-storey condominiums cover some 30%. The share of dwellings in multi-storey buildings is about 70% in the free rental market. Hence, privately financed flats form little less than 30% of the total housing stock.

Starting from the 1950s until the early 1990s the share of rental dwellings decreased. The substantial decline probably was significantly influenced by the rent regulation that was finally abolished in several stages during 1992-1995 concerning the privately financed sector. The share of rental housing increased temporarily during the 1990s, but since the late 1990s the portion of owner-occupied housing has grown again. (Laakso and Loikkanen 2004, p. 248.) The loosening in credit constraint is likely to have a role in the recent development.

Composition of the HMA housing stock differs somewhat from the national stock. Of the about half a million dwellings in the HMA, only 46% were owner-occupied in 2005.[32] Free market sector covers around 80% of the owner-occupied stock (Laakso and Loikkanen 1995, p. 477).[33] As much as three fourths of the stock is located in multi-storey buildings. Owner-occupied housing in multi-storey condominiums forms 28% of the total stock. Corresponding figure for free market rental dwellings is 19%. Hence, the total share of privately financed flats of the HMA housing stock is approximately 40% of which little less than 60% is owner-occupied.

The different segments of housing markets are not perfect substitutes for each other. Nevertheless, it is likely that changes in the housing stock subsidized by the public sector, i.e. in the regulated sector, have got impacts also on the privately financed market. In particular, construction of subsidized housing generally decreases demand for privately owned rental units (DiPasquale and Wheaton 1996, pp. 18-19). The decline in demand for private units results in an inward shift in the demand curve in the upright quadrant of the four-quadrant model exhibited in Figure 1. This reduces rental prices and the value of housing in the free market sector, leading to reduction in the private construction and stock. Furthermore, land occupied by subsidized housing makes the lots available for free market housing a scarcer resource. This moves the free market construction curve to the left in the southwest quadrant of the four-quadrant model leading to an even greater reduction in the construction of privately financed housing, thereby restraining the decrease in the free market housing prices and rents. That is, construction of subsidized

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[32] The HMA consists of three cities – Helsinki, Espoo (including Kauniainen) and Vantaa – located next to each other.

[33] The figure reported by Laakso and Loikkanen (1995) is rather old. Nevertheless, it is likely that the share has not changed significantly.

housing crowds out private construction through two channels.[34] It is likely, however, that subsidized construction leads to somewhat greater overall stock and to a slightly lower price level of privately financed dwellings. This is supported e.g. by the findings of Nordvik (2007). The greater the supply elasticity of privately financed housing is, the smaller the impact of subsidized construction on the overall stock and on the free market prices is expected to be.

Demand side subsidies to households buying housing services, instead, are expected to augment demand for the privately financed housing. The demand increase should raise prices and rents, stimulating also construction and thereby leading to a greater housing stock. The more inelastic supply is, the smaller is the increase in the stock and the larger is the impact on prices and rents.

All in all, both supply and demand subsidies have probably affected the housing price development in Finland to some extent. The exact influence of the subsidies aimed at housing market on the price level and on the dynamics of the free market housing is still unclear to a great extent, and the purpose of this thesis is not to study that subject.

5.2 Institutional changes and the development of Finnish housing markets since the 1970s

Finnish housing markets, and capital markets in general, have gone through major institutional changes since the 1970s. These institutional transformations have evidently affected the path of housing prices as well as interrelations between regional housing prices and co-movement between housing prices and financial asset prices. Hence, from the point of view of this study it is of great importance to understand the possible consequences of the modifications in the institutional environment. Below, price development in the Finnish housing markets during the last couple of decades is delineated.[35] Emphasis is put on the development at the national level and within the HMA. Also the effects of the institutional changes on the linkages between regional housing markets and between housing prices and financial asset prices are discussed briefly.

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[34] Murray (1999) and Lee (2007) present evidence of subsidized housing crowding out private housing stock in the US and in Korea, respectively.

[35] Housing price indices provided by Statistics Finland are employed in the analysis. The indices are based on arithmetic averages of transaction prices in the secondary market until 1986 and on hedonic price indices since 1987. The indices describe housing price (per m^2) development of privately financed flats. More detailed exposition of the developments in the Finnish housing markets is documented by Bengs and Loikkanen (1991) concerning the pre 1990s period and by Laakso (2000).

Housing prices have been extremely volatile since the beginning of the 1970s as can be seen in Figure 1. The first price peak occurred in 1973-74, after which real prices decreased notably until the end of the 1970s. The long-lasting drop in real housing prices was mostly due to a recession that followed the oil crises. It must be noted that nominal housing prices constantly increased also during 1974-1980. The downwards adjustment of real housing prices was based on rapid inflation.

After 1979 the prices grew relatively strongly until the beginning of 1984. After a two-year period of stable real prices, an immense rise in the housing prices started in 1987. The extensive increase in housing prices from the early 1987 to the early 1989 was to a great extent a consequence of the financial deregulation that took place in the 1980s.[36] Up to the mid-eighties the banking system was highly regulated with tightly controlled and rigid lending rates. Low, administratively controlled lending rates together with foreign capital controls caused credit rationing. This system was fairly stable until the early 1980s. In 1986 the Bank of Finland gradually deregulated the banking system and the ceilings on average lending rates were abolished. Availability of housing loans for households became significantly easier than earlier. Accessibility of mortgages was further enhanced by lower down payment ratios. As a result the financial deregulation induced a huge growth of credit and led to a housing market boom.

Eventually the bubble burst and housing prices continuously declined until 1992Q4. At the national level, the real housing price index rose by 58% during 1986Q4-1989Q1 and declined by 50% from 1989Q1 to 1992Q4. Prices were even more volatile in the HMA, where the corresponding figures were 66% and 57%. The HMA centre exhibited the most dramatic movements. In the centre, prices topped a quarter later than in the rest of the country being almost 80% higher than in 1986Q4, and the subsequent decrease was 60%. In 1993 real housing prices were lower than in 1986 all over the country. The drastic drop in housing prices was mainly due to two factors – housing prices climbed far beyond their long-run fundamental level during the boom[37] and the market fundamentals substantially deteriorated due to an abnormally deep recession that took place in Finland in the first part of the 1990s and because of a climb in the mortgage rates. On the other hand, decreasing housing prices probably exacerbated the depression (see e.g. Honkapohja and Koskela 1999). Note that there was a boom-bust cycle also in the stock market during the second half of

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[36] Papers by Takala and Pere (1991) and Koskela et al. (1992) indicate that the changes in the Finnish financial system during the 1980s affected housing prices significantly.

[37] Empirical analysis in the first essay of this study implies that housing prices in the HMA were substantially over the long-run fundamental level during 1989.

the 1980s and at the beginning of the 1990s. Rise and drop were even greater in the stock market than in the housing market.

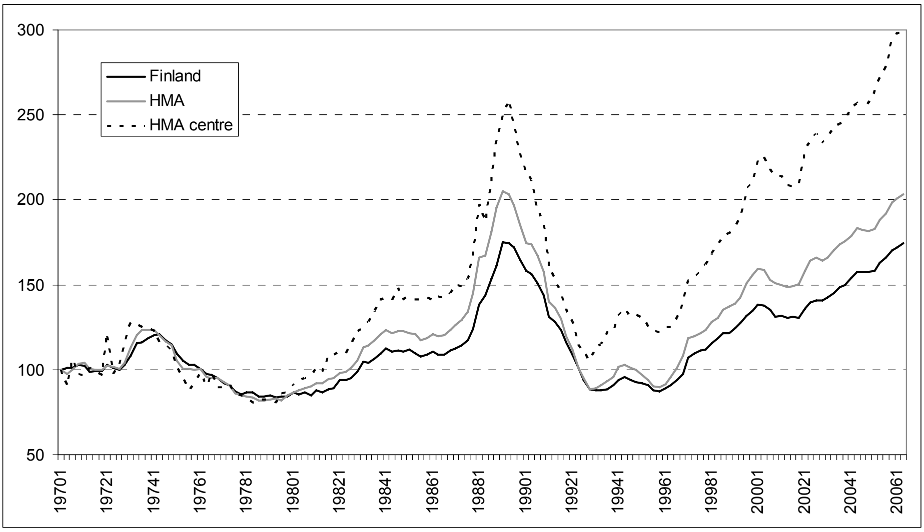

Figure 2 Real housing price indices in the HMA and in Finland 1970Q1-2006Q2

The fact that housing prices have been more volatile in the HMA than in the other Finnish regions and that volatility has been greater in the centre of the HMA than in the suburbs is not surprising. Volatility is expected to be the greatest in the areas with the most inelastic housing supply. Empirical evidence from the US market accordant with the theory is reported by e.g. Abraham and Hendershott (1996) and McCarthy and Peach (2004). Housing supply is obviously more constrained in the HMA, especially in the centre, than in the other parts of Finland because of the scarcity of available land at favourable sites.

Financial market liberalization may have also had permanent effects on housing price dynamics. The results of Kosonen (1997) and Muellbauer and Murphy (1997) concerning the Finnish market and the UK market, respectively, suggest that the abolishment of credit controls strengthened the impact of real lending rate and undermined the influence of nominal rate on housing prices. Furthermore, Muellbauer and Murphy suggest that slacker financial restrictions diminish the role of current income and fortify the significance of income expectations in housing price determination. Empirical analysis in the first essay of this thesis, however, suggests that there has not been notable structural change in the long-run relation between real housing prices and fundamentals.

Housing prices grew faster in the HMA than in the rest of the country from 1970 to the late 1980s. After the burst of the bubble the price indices of the whole country and of the HMA converged, however. After the recession, housing prices started to increase again. Since 1996 the price growth has been steep. In 2006Q2 the value of the national real housing price index was approximately twice that of 1995Q4. Similarly to the pre 1989 period, price rise has been even sharper in the HMA than in the rest of the country – the real price level has risen by about 125%. In the HMA centre real housing prices were higher in 2006Q2 than during the peak of the bubble in 1989. The faster price growth in the HMA both before the burst of the bubble and after the recession is mainly attributable to the rapid population and income growth in the HMA together with the relatively inelastic supply. Note that the price climb in the rest of Finland outside the HMA has, naturally, been slower than in the whole country – a little less than 80%.[38] In 2006Q2 the average selling prices of privately financed flats in the HMA and the rest of Finland were 2750€/m^2 and 1370€/m^2, respectively.

The rapid rise in the real housing prices during the last ten years has raised questions concerning the sustainability of the current price level especially in the HMA. It is not always understood that a long-lasting growth in real housing prices does not necessarily imply that housing prices have exceeded their fundamental level. Price level was at the bottom in the mid 1990s and since then fundamentals have developed favorably. Even the fact that real housing prices are in 2006Q2 at the level of 1989 (actually substantially over that in the centre of the HMA) cannot alone be used as an evidence of overvalued housing. It should also be understood that national housing price index should not be used to assess housing prices in different regions. Because of the existence of distinct regional housing markets, which are not substitutes for one another, housing may be undervalued with respect to fundamentals in some parts of the country while there may be overvaluation in some other regions. Moreover, one cannot, in general, draw conclusions about housing prices by comparing cities. For instance, price-to-income and price-to-rent ratios that would be considered high for one city might be typical for another as Himmelberg et al. (2005) show using US data.

The empirical analysis conducted in the first essay does not show evidence for alarming overpricing in the HMA housing market. In particular, it seems obvious that the price level in 2006Q2 is not based on high expected appreciation. This does not, however, mean that a notable drop in real housing prices is not possible in the future. The fundamentals may deteriorate leading to a decrease in housing prices. Actually, since 2005 the real mortgage rates

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[38] Unfortunately, price statistics for Finland outside the HMA exist only starting from 1987.

have already risen notably. The Finnish housing markets are expected to be especially vulnerable to the interest rate movements since most of the mortgages are tied to relatively frequently changing interest rates. With raising interest rates many households might not be able to meet their mortgage payments, which would cause selling pressure in the market. At the same time, increase in the lending rate would impair demand for housing. If the interest rate increase is not accompanied with strong macroeconomic conditions, influences on the Finnish economy might be severe.

In addition to housing subsidies and financial market controls, the public sector has affected housing price determination also through rental controls and through deductibility of interest payments on housing loans in taxation. Even the privately financed rental market was regulated in Finland for long periods. Due to the rent control, real rents continuously declined in Finland from the early 1970s to the late 1980s. Lifting in rent ceilings started in the late 1980s and the rent regulation was finally released in several stages during 1992-95. Consequently, real rents in the free market have increased substantially since the late 1980s. The rental level of the subsidized stock is still controlled, though.

The abolishment of the rent control may have had a twofold influence on the relationship between housing prices and rents. The possibility and expectations of loosening in the rent control may have led to high expected growth in the rental level during the late 1980s and early 1990s. This, in turn, may have capitalized as higher price-to-rent ratios – when there are expectations of future dismantlement of rental control (and the rental ceiling is binding), it is expected that the equilibrium price-to-rent ratio is larger than when the rental prices are determined freely by supply and demand. On the other hand, households may view the risks involved in tenancy higher when the market is not controlled. This could increase demand for owner-occupied housing and raise the price-to-rent ratio compared with the regulated situation.

The tax deductibility of mortgage payments, naturally, leads to lower real after-tax mortgage rate and to higher demand for housing. At the same time deductibility undermines the impact of before-tax interest rate movements on housing prices. Furthermore, tax rules may strengthen the link between current income and housing demand. This is the case if the deductibility of mortgage payments is based on marginal income tax rate. Interest payments on mortgages were fully tax-deductible in Finland up to 1974, after which the rules of tax deductions have been changed several times by setting an upper limit or excess limit to the sum of annual deduction. Until 1992 the interest payments were deductible in income taxation. Hence, the after-tax interest rate was determined by marginal income tax rate. Since the tax reform in 1993, instead, a taxpayer can in practice deduct the interest expenditure multiplied by the capital income tax rate from her taxes. The capital income tax rate, which has varied between 25% and 29%[39], has been substantially lower than the average marginal income tax rate, increasing the real after-tax interest rates on housing loans.[40] Results by Koskela et al. (1992) are consistent with the view that rising marginal tax rate increased housing prices by increasing the rate of return on housing in the 1970s and 80s. In the first article of this thesis the changes in the deductibility are taken account of by employing after-tax lending rates in the econometric analysis.

Note also that the decrease in the inflation rate during the last ten years may have influenced real housing prices. Higher inflation rate reduces the user cost, since, while nominal mortgage interest payments are tax deductible, the capital gains from housing appreciation are essentially untaxed. Actually, due to the financial market regulation and high inflation rates, the real after-tax interest rate was negative for many Finnish households in the 1970s. On the other hand, higher inflation rate caused tighter liquidity constraints for households. Thus, liquidity constraints acted as a counterforce for the tax distortions during fast inflation. Now, during low inflation rate, the tax distortions are smaller and the liquidity constraints looser.

There have been major institutional changes that may also have changed the interdependence between housing prices and financial asset prices. The financial liberalization in the late 1980s may have transformed the determination of both housing and financial asset prices somewhat. Nevertheless, the fourth essay suggests that a major structural break in the linkages between housing and stock prices was caused by the abolition of foreign ownership restrictions concerning financial securities in 1992. The change in the tax deductibility rules probably had an effect on the perceived structural break in the long-run relationship between stock and housing as well. Also earlier literature has noted the extensive impact of the abolishment of foreign ownership restrictions on stock prices (see e.g. Booth et al. 1997, Kallunki and Martikainen 1997, Antell 2004).

[39] For the first-time dwelling-buyers the deduction rate has been 30%.
[40] During 1972-1992 the average marginal income tax rate varied between 41.4% and 52.8%.

6 COINTEGRATION AND ITS IMPLICATIONS

In all the four essays of this thesis empirical analysis employing econometrics is in a central role. In particular, cointegration analysis plays a major part in the empirical work conducted in all the empirical articles. Cointegration is of importance in this research, since it has important implications for predictability of asset prices as well as for optimal portfolio allocation and for policy decisions. Cointegration analysis allows for testing the existence of one or more long-run relationships between regional housing prices, between different asset prices and between housing prices and economic factors driving housing prices. If the possibility of cointegration is ignored in the econometric modeling, important information regarding the behavior of different variables may be left aside. Below the concept of cointegration is described and its implications are discussed.

6.1 Concept of and tests for cointegration

Today, cointegration analysis is a popular method when analyzing economic time series. The popularity of cointegration analysis mostly stems from its applicability to modeling a great number of distinct economic phenomena and from its appealing intuition. For example, in the words of Granger (1986): "*At the least sophisticated level of the economic theory lies the belief that certain pairs of economic variables should not diverge from each other by too great an extent, at least in the long run. Thus, such variables may drift apart in the short run or according to seasonal factors, but if they continue to be too far apart in the long run, then economic forces, such as the market mechanism or government intervention, will begin to bring them together again*."

Cointegration can be thought of as a long-run relation between variables imposed by an economic system. Two cointegrated variables tend to co-move strongly in the long run. If there is only one long-run relation between a set of variables, then the relationship is often called a "long-run equilibrium". However, as Campbell and Shiller (1988) note, this "equilibrium" has no clear relation to other concepts of equilibrium in economics.

The adjustment back to the long-run relation may not be instantaneous for many reasons. Campbell and Shiller suggest such factors as sticky prices, long-term contracts and costs of adjustment as possible causes for the sluggish adjustment. The adjustment of economic variables towards their long-run relationship brings forth "error-correction", a concept central to cointegration.

As defined by Engle and Granger (1987), two variables are cointegrated [of order (1, 1)] if each variable is individually non-stationary in levels and stationary in first differences, i.e. integrated of order one [I(1)], but some linear combination of the variables is stationary in levels. More generally, a set of variables is cointegrated of order (*d, b*), if at least two of the variables are integrated of order *d* but there exists at least one linear combination of the variables which is of order (*d* – *b*) and in which the coefficients of the I(*d*) variables are different from zero. As in most of the empirical applications, in this study the focus is in the case *d* = 1, *b* = 1. This is reasonable, since, as Roll (2002) shows, housing prices as well as equity prices are likely to be non-stationary, but housing and stock appreciation should be stationary. Indeed, there is a great deal of empirical evidence supporting these assumptions. Hence, in what follows cointegration refers to the (1, 1) case.

Cointegration may or may not exist between variables that do or do not "look cointegrated", and the only way to find out if data is actually cointegrated is through a careful statistical analysis, rather than rely on visual inspection (see Hendry and Juselius 2000 and 2001). It should be kept in mind, however, that even a careful statistical analysis cannot give *absolute certainty* on the existence of cointegration between a set of variables. There is always some, often very small, probability that a faulty conclusion is made based on the statistical analysis. Furthermore, cointegration tests typically involve both size distortions and power problems (see e.g. Maddala and Kim 1998).

Engle and Granger (1987) proposed a straightforward method to test whether two I(1) variables are cointegrated. First, the variables are pretested for their order of integration. If the variables seem to be I(1), the next step is to estimate long-run relationship between the variables of the form:

$$y_t = \beta_0 + \beta_1 z_t + e_t, \qquad (18)$$

where y and z are the two I(1) variables and e is the series of the estimated residual of the long-run relationship. Finally, the stationarity of e is tested by employing the Dickey-Fuller (1979, 1981) or the augmented Dickey-Fuller (ADF) unit root test. Finding that e is stationary indicates that y and z are cointegrated. Because the residual sequence is generated from a regression equation, i.e. only the estimate of the residual is known, the Dickey-Fuller tables themselves do not give the right critical values in the unit root test for e.

The equation of the long-run relationship can be modified if necessary. More than just one variable can be included on the right hand side of (18). In addition, the drift term (β_0) can be excluded or a deterministic trend term and even a quadratic trend term may be included in the equation. MacKinnon (1996) reports response surface coefficients, based on which one can estimate the relevant critical values depending on the number of I(1) variables in the model, on the deterministic variables included in the regression and on the number of observations in the sample.

A more sophisticated and today more commonly used method to test for cointegration between different economic variables is the Johansen (1996) test. Basis for the Johansen is a cointegrated vector autoregressive model (CVAR)[41]:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \mu + \Psi D_t + \varepsilon_t, \qquad (19)$$

where X_t is a p-dimensional vector of the stochastic variables, ΔX_t is X_t - X_{t-1}, t = 1,…,T, Γ_i is p x p matrix of coefficients for the lagged differences of the stochastic variables at lag i, k is the maximum lag, i.e. the number of lags included in the corresponding vector autoregressive model (VAR) in levels, μ is a p-dimensional vector of intercepts, D_t is a (s-1)-dimensional vector of centered seasonal dummies (in this study s = 4, since quarterly data is used), Ψ is a p x (s-1) coefficient matrix and ε_t is a p-dimensional vector of independently and identically distributed errors. Also a trend term can be included in the short-run dynamics of (19), though it is necessary only rarely. Because in this study the inclusion of the trend term in the short-run model does not seem to be sensible, the possibility of the trend term is elided herein. Finally, matrix $\Pi = \alpha\beta'$. Π defines the cointegrating vector(s) β, i.e. the coefficients for the stochastic variables and possible deterministic variables (these will be discussed later) in the stationary long-run relation(s), and the speed of adjustment coefficients to the long-run relation(s), α. Both α and β are p x r (full rank) matrices.

The part ΠX_{t-1} in the CVAR can be regarded as the long-run model or as the error-correction term, whereas the rest of the equation forms the short-run part of the model. The error-correction term is the difference between regular VAR in differences and CVAR. If cointegration is present, i.e. long-run interdependence between the variables exists, an error-correction term should be included in the model, since it incorporates significant information concerning the dynamics of the variables. If, however, variables are not cointegrated, then the dynamics are only short-run in nature.

The rank r, r = 0, …, p, of the matrix Π determines the number of cointegrating vectors. If Π is of full rank (r = p), the variables in X are stationary, and if r = 0, the variables are not cointegrated. Instead, if $0<r<p$, the

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41 CVAR is also often called vector error-correction model (VECM). In this thesis both expressions (CVAR and VECM) are used.

variables exhibit cointegration. The rank can be tested by the two following test statistics:

$$\lambda_{trace}\,(r) = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i) \tag{20}$$

$$\lambda_{max}\,(r, r+1) = -T\ \ln(1-\lambda_{r+1}), \tag{21}$$

where T is the number of usable observations and λ:s are the estimated eigenvalues obtained from the Π matrix. The Trace statistics test the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against the alternative of more than r cointegrating vectors. The Max statistics, in turn, test the null that the number of cointegrating vectors is r against the alternative of r+1 cointegrating vectors.

Both test statistics have non-standard asymptotic distributions, which depend on the deterministic terms (other than centered seasonal dummies) in the data generating process and in the estimated model. Osterwald-Lenum (1992) and Doornik (1998) have tabulated the asymptotic critical values depending on the included deterministic components. Four different cases concerning the deterministic variables are considered in this study. Equation (19) exhibits the most typical model used in the literature. In (19) there is a drift term in the short-run model. Drift in the short-run model is needed if at least one of the series has got linear trend in the levels. In the most restrictive model $\mu = 0$ so that there are no deterministic terms in (19). This can be the case if there are no linear trends in the levels of the data, i.e. the differenced series have a zero mean, and if the series have got equal means in the levels. The second most restrictive model includes a constant term in the long-run relationship as in (22), where β_0 is the value of the constant term in the long-run model. In this model the series exhibit no linear trend in levels but the means of the series are not equal. Note that in (19), the drift term takes account of both the drift in the short-run model and the constant in the long-run relation. Therefore, μ is called an unrestricted drift.

$$\Delta X_t = \alpha(\beta', \beta_0)(X'_{t-1}, 1) + \Gamma_1\Delta X_{t-1} + \ldots + \Gamma_{k-1}\Delta X_{t-k+1} + \Psi D_t + \varepsilon_t \tag{22}$$

The least restrictive model contains a drift in the short-run model and a trend term in the long-run relationship:

$$\Delta X_t = \alpha(\beta', \beta_1)(X'_{t-1}, t) + \Gamma_1\Delta X_{t-1} + \ldots + \Gamma_{k-1}\Delta X_{t-k+1} + \mu + \Psi D_t + \varepsilon_t, \tag{23}$$

where t is the time trend and β_1 its coefficient. The trend variable may be needed in the long-run relation if the growth rates of the distinct series are not equal. For example, in a pairwise Johansen test between housing prices and stock prices a trend term might be needed in the long-run model if stock prices grow faster than housing prices (or the other way round). Nevertheless, in previous literature the possibility of a need for a trend in the long-run relation has usually been neglected when studying cointegration between different asset prices.

In reality, it is hard to know which deterministic variables are actually present in the data generating process. The series in this study are typically growing in time. Hence, usually at least an unrestricted drift term should be included in the CVAR. Often it is also worthwhile to set a trend in the long-run relation. If one is not certain, whether (19) or (23) should be used in the Johansen test, the use of (23) is suggested by Doornik et al. (1998).[42]

If cointegration is present, the stationary equilibrium-error, i.e. the deviation from the long-run relation, has to Granger cause at least one of the cointegrated variables (see Engle and Granger 1987, Campbell and Shiller 1988). In other words, at least one variable should adjust towards the long-run relation. This is the concept of error-correction – if the variables deviate from their long-run relation, at least one of the variables has to move towards the relationship, otherwise the relationship cannot hold in the long run. There can be variables that affect the long-run relation but do not react to deviations from it. These variables are called weakly exogenous, i.e. variables that are exogenous to the long-run relation. In the case where one or more variables in CVAR are weakly exogenous, the methodology and asymptotic tables presented in Harbo et al. (1998) should be applied to increase the power of the Trace test. The number of cointegrating relationships in the partial model, i.e. in a model including weakly exogenous variables, is tested based on the following CVAR model:

$$\Delta X_t = \alpha(\beta_X', \beta_1)(X'_{t-1}, t)' + \alpha\beta_Z' Z_{t-1} + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1}\Delta X_{t-k+1} + \gamma_1 \Delta Z_{t-1} + + \gamma_{k-1}\Delta Z_{t-k+1} + \mu + \Psi D_t + \varepsilon_t, \quad (24)$$

where Z_t is a vector of the weakly exogenous stochastic variables in period t and $\alpha(\beta_X', \beta_1)(X'_{t-1}, t)' + \alpha\beta_Z' Z_{t-1}$ forms the long-run relationships.

In this thesis, only the Johansen method is utilized, because it has got many advantages over EG. Firstly, the Johansen technique allows to test if there are multiple cointegrating vectors between the variables. Secondly, the Johansen method enables to test restrictions on the cointegrating vectors to identify the long-run relations in detail. In addition to testing restrictions on the long-run relation(s) the Likelihood Ratio (LR) test described in Johansen (1996) can be

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[42] According to the Monte Carlo analysis conducted by Doornik et al. (1998), adopting a model with a trend in the cointegration space has low cost even when the data generating process does not actually have one, and the cost of excluding the trend term when there should be one is markedly larger.

employed to test weak exogeneity of the variables. Furthermore, the Johansen test is, in general, more powerful than EG (see e.g. Maddala and Kim, 1998).

It the cointegration analyses, the econometric software package CATS, which works together with RATS, has been employed.[43]

6.2 Various potential reasons for cointegration

Cointegration between two or more variables may arise for a number of reasons. In this study, four types of long-term interdependences are of interest: long-term co-movement 1. between housing prices in different subareas within a single metropolitan area, 2. between housing prices in different regions within a country, 3. between prices of different broad asset categories and 4. between housing prices and fundamental variables driving housing prices.

It is expected that housing prices between different neighborhoods inside a common metropolitan area are closely related to each other both in the short run and in the long run. In fact, it is reasonable to believe that dwellings within a metropolitan area can be considered relatively close substitutes for one another. If housing in one suburb is a close substitute for housing in another suburb, then prices of privately financed housing in these two suburbs are likely to be cointegrated. This is because the same driving factors are behind housing prices in both of the neighborhoods, and migration within a metropolitan area is expected to link housing price movements in different submarkets tightly together. The expected cointegrating relation may, however, be disturbed due to changes in peoples' tastes or in submarket factors such as reputation, services, employment and studying possibilities, traffic connections and crime level of the sub area. In other words, there may be multiple structural changes in the expected cointegrating relations.

In the literature the co-variation of housing prices within a metropolitan area is typically studied based on contemporaneous correlations neglecting the probable longer-term interrelation between different submarkets. One of the very few studies, where cointegration between different submarkets has been examined, is conducted by Jones et al. (2003). According to Jones et al., notably less than half of the defined submarket pairs in Glasgow exhibit cointegration. The second study of this thesis brings further evidence on this area by studying cointegration between housing submarkets inside the HMA. The results imply that housing prices in different HMA subareas are tightly linked in the long horizon.

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[43] Regression Analysis of Time Series (RATS, version 6.2), Cointegration Analysis of Time Series, version 2 (CATS 2).

Although dwellings in regions far away from each other cannot be regarded as substitutes for one another, there are common driving factors also behind regional housing prices. These macroeconomic and institutional factors affecting housing prices all over the country include variables such as the inflation and interest rates as well as taxation.[44] It is possible that these common driving factors create a cointegrating relationship between housing prices in distant regions by affecting discount factors of housing and cash flows created by housing in a similar manner. On the other hand, if there are notable differences in the performance of regional economies, the relation between regional housing prices is likely to be less tight. Because of the importance of regional factors driving housing prices and due to the fact that dwellings far away from each other are not close substitutes, it is much more unlikely to find cointegrating relations between distant housing markets than between submarkets within a metro area.

Empirical evidence of long-run interdependence between regional housing prices is scarce. Previous literature examining cointegration between Finnish regions does not exist. However, as reported in section 4.4, there are some studies using overseas data where cointegration between regional real estate prices has been tested and found. This study adds to the literature on long-term regional housing price interdependence by studying the existence of cointegration between housing prices in Finnish cities and regions in the second and third articles of the study. The results support the existence of cointegration between some distant areas, while long-run linkages between most of the distant areas seem to be only short-run in nature.

There are common macroeconomic driving forces also behind the price formation of different asset categories. The existence of factors common to price formation of different asset forms can generate tight linkages between different asset prices even in the long horizon. Moreover, Bossaerts (1988) presents theoretical reasons for cointegration between asset prices. Bossaerts shows that asset prices should be cointegrated if the economy moves close to, but does not attain, the separating equilibrium of the Capital Asset Pricing Model. Cointegration does not have to hold, for example, between two single stock price series, but it should hold between broad asset categories. Many factors can disturb the expected cointegration between different asset forms, however. Changing risk premiums and subjective time preferences, changes in tax rules, market interventions of the public sector as well as long-lasting irrational expectations about future returns all may change the long-run relations between the asset prices. Moreover, innovations that increase

[44] It should be noted that within a much larger country than Finland, such as the US, there are likely to be regions whose housing prices share common driving factors to a substantially smaller extent than housing prices in even the farthermost areas in Finland.

productivity in some firms or industries but not in the others may induce structural breaks in the long-run relations between different asset prices. For example, an innovation that reduces the construction costs of housing significantly is likely to have a permanent negative effect on housing prices relative to stock prices.

Most of the studies examining long-run interdependences between real estate and other asset categories have used securitized property, typically real estate investment trusts (REIT), as the real estate variable (see e.g. Chaudhry et al. 1999, Glascock et al. 2000, Okunev and Wilson 1997, Okunev et al. 2000 and 2002). Research analyzing the existence of long-horizon interdependence between housing and financial asset prices is still extremely scarce. In the Finnish market the existence of a long-term relationship between housing and stock prices has been studied by Takala and Pere (1991). Using quarterly data over 1970-1990 Takala and Pere found evidence of cointegration between the two asset prices. According to Barot and Takala (1998), in turn, stock prices could be most properly used as a weakly exogenous variable in a trivariate cointegrated system including also housing prices and private consumption deflator using both Finnish and Swedish data. Furthermore, Barot and Takala note that stock prices seem to have a rather minimal effect on the long-run equilibrium relation. In the fourth essay of this research, cointegration analysis including price indices of Helsinki Stock Exchange, of Finnish government bonds and of housing in Finland is performed. The results imply that tight long-term linkage between stock and housing prices does exist. The evidence is not comprehensive, however.

Cointegrating relation between an asset price and fundamental variables affecting the asset price can be useful when investigating if the asset is fairly priced or possibly over- or undervalued. In the short run, asset prices can deviate from their so-called fundamental price level[45] for several reasons, but in the long run asset prices should correspond to the fundamentals. Therefore, cointegrating relationship is expected to exist between an asset price and factors crucial to the asset price formation. Fundamental variables that may form such a tight long-run relation with housing prices are likely to include e.g. disposable income, income expectations, after-tax lending rate and some demographic factors such as the number of households. Note also, that there should be a cointegrating relationship between the cost of owner-occupancy and the rental price level, as explained in section 2.3. Also these kinds of cointegrating relations may exhibit structural breaks for a number of reasons. Especially institutional changes that affect taxation, global capital movements

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[45] Fundamental price level refers to a price level that is in line with the vital (fundamental) variables that drive the price of an asset in the long run.

and financial constraints faced by households and by firms may induce changes in the long-run relation. Shifts in tastes and risk premiums can disturb the expected cointegration as well.

Cointegrating relation between metropolitan housing prices and fundamental variables has been found e.g. by Hin and Cuervo (1999) in Singapore, and Meese and Wallace (2003) in Paris. Kosonen (1997) and Riddel (2004), in turn, report long-run relationships between national housing prices and fundamentals in Finland and in the US, respectively. Cointegration between metropolitan housing prices and fundamentals has not been studied in Finland previously. Some filling to this gap is implemented in the first essay. The results imply that there are cointegrating relations between HMA housing prices and a couple of fundamental variables.

6.3 Implications of cointegration

Cointegration between a set of variables basically implies that there is a long-run relationship between the variables towards which at least one of the variables adjusts. In the literature, the stationary long-run relationship is often called long-run equilibrium. However, as already mentioned, the notion of "long-run equilibrium" is specific to the defined error-correction model, and has no clear relation to other concepts of equilibrium economics. It is probable that most of the time there is slight deviation from the long-run "equilibrium" relation between cointegrated economic fundamentals or asset prices. This is because the adjustment of fundamentals and asset prices is not instantaneous in general. The sluggish adjustment of asset prices can be contributed to factors such as transaction costs, imperfect information and also irrational behavior of the investors.

It is often claimed that cointegration among asset prices necessarily implies informational inefficiency. Granger (1986) first proposed that the prices of assets determined in efficient markets cannot be cointegrated. Corresponding comments were made by e.g. Baillie and Bollerslev (1989), Hakkio and Rush (1989), and MacDonald and Taylor (1989). More recently, in a vast number of papers cointegration tests have been applied to test the efficiency of different asset markets. The conventional definition of "efficient markets" states that asset price movements cannot be predicted in efficient markets. Deviation of asset prices from a cointegrating relationship, in turn, implies predictable future changes. The claims that cointegration cannot exist in efficient asset markets are due to this contradiction.

Nevertheless, some papers have challenged the conclusion that market efficiency and cointegration are incompatible. Dwyer and Wallace (1992) suggested that a more useful definition of an efficient market is a market with no arbitrage opportunities. They showed that with this definition there is no general equivalence between market inefficiency and cointegration. This point was later reinforced by Engel (1996). Also Ferre and Hall (2002) reported similar conclusions. Ferre and Hall state that "*the simple fact that an error-correction model exists will not tell us anything about efficiency. However, the precise form of the error-correction model will tell us something about efficiency*".

While Dwyer and Wallace (1992), and Ferre and Hall (2002) study the relationship between efficiency and cointegration from a time series point of view, Lence and Falk (2005) examine the issue from a point of view of general asset pricing model. According to Lence and Falk, in the absence of sufficiently well-specified model, cointegration tests are not informative with respect to market efficiency. Specifically, asset prices are cointegrated if their underlying "endowment processes"[46] are cointegrated and preferences satisfy certain conditions. It seems reasonable to assume that cointegration for example between housing prices in different subareas within the HMA is due to common endowment process.

It should be noted that all the reported arguments against contradiction between cointegration and market efficiency are basically based on models with no lead-lag relations. Nevertheless, at least in theory the role of cointegrated endowment process may also explain lead-lag relations in some cases. In particular, if shocks in the endowment process of one asset lead shocks in the endowment process of another asset, lead-lag relation between the asset prices may not be in contradiction with informational efficiency. Consider a simple example. There are two stocks, x and y. At t=0 it is expected that the dividend streams of x and y are equal and stay constant for ever. If the required rate of return for x and y is the same, the prices (P) of the assets are given by:

$$P_x(0) = P_y(0) = d/r, \tag{25}$$

where d is the dividend and r is the required rate of return for the assets. At t=1 there is a shock that affects the profitability of firm x instantaneously but is known to influence the profitability of firm y one period later (e.g. because the firms are located in distinct geographical areas which do not face the economic cycles simultaneously). At t=1, the prices of the asset are:

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[46] Endowment process refers to driving factors behind asset price formation. If prices of two assets are affected similarly by fundamentals, then their endowment processes are cointegrated. Lence and Falk (2005) give an example concerning wheat prices in two countries: If wheat endowments in the countries are cointegrated (e.g. because wheat supply in both countries experience the same process of technological progress), wheat prices in the two countries are cointegrated.

$$P_x(1) = (d+s)/r = (d+s)/(1+r) + 1/(1+r) * (d+s)/r \quad (26)$$

$$P_y(1) = d/(1+r) + 1/(1+r) * (d+s)/r, \quad (27)$$

where s is the increase in the dividends due to the shock. The price of x has grown by s/r, whereas the price of y has increased by s/r – s/(1+r). During the following period the price of asset y further increases by s/(1+r). Assuming that shocks to the endowment process of x, in general, lead shocks to the endowment process of y, changes in P_x Granger cause movements in P_y. This does not, however, automatically indicate market inefficiency. If the endowment shock in y is lagged by more than one period, the econometric model describing dynamics between P_x and P_y naturally exhibits more lags. Therefore, cointegration even in the presence of clear lead-lag relations does not necessarily imply market inefficiency. However, with plausible r, s/(1+r) is small relative to s/r. Hence, the coefficient of Δy for the lagged values of Δx is expected to be small if markets are efficient. The same logic can be applied to regional housing markets. Economic cycles that affect rental demand and thereby rental prices (dividends) may, in general, take place first in some regions and later in some other areas.

Note that in real life there are probably many cases where the above reasoning cannot be used to claim that cointegration and lead-lag relations do not imply inefficiency. Unfortunately, it is hard to distinguish the cases where the dynamic relations indicate inefficiency and where they do not. The problem is that in CVAR and VAR models coefficients in the short-run model cannot often be estimated with accuracy, i.e. the standard deviations of the estimated short-run coefficients are often large. It is also hard to say whether the sluggish adjustment of housing prices towards a cointegrating relation with fundamental variables (found in the first essay) implies that above normal returns can be constantly gained. Transaction costs and illiquidity of housing should be incorporated in the analysis when doing conclusions about the informational efficiency of housing markets.

In the empirical literature, cointegration has been seen as a necessary condition for market integration (Lence and Falk 2005, p.874). Hence, if cointegration indicates inefficiency, integrated markets cannot be efficient. In general this cannot hold, of course. Above it is already noted that cointegration does not necessarily imply market inefficiency. Lence and Falk (2005), in turn, show that cointegration is not necessarily informative with respect to market integration either.

For instance, the finding in the third essay, according to which the HMA housing price level is cointegrated with the housing price level in the towns surrounding the HMA, does not necessarily imply that many households consider housing in the neighboring towns as substitute for housing in the HMA. Nevertheless, knowing that commuting from the surrounding towns to the HMA is extremely common, it is *likely* that housing in the HMA works as a relatively close substitute for housing in the surrounding towns. The adjustment of the HMA housing prices towards the long-run relation also suggests that housing appreciation in the HMA can be restrained by increasing supply in the surrounding towns.

On the other hand, the inability to detect cointegration between two nearby HMA submarkets would not necessarily mean that dwellings in the subareas are not close substitutes for each other. This is because changes in submarket level factors, such as reputation, services, employment and studying possibilities, traffic connections and crime level, that affect the relative housing prices between two submarkets, may lead to the acceptance of the hypothesis of no cointegration.[47] Note also that cointegration between housing prices in two cities far away from each other is not likely to be due to substitution effect. Rather, it is likely to be due to the same driving macroeconomic fundamentals behind housing prices in the distant regions together with similarities in the economic bases of the regions.

In any case, it is evident that cointegration implies predictability of at least one of the cointegrated variables. As mentioned above, if cointegration is present, the equilibrium-error has to Granger cause at least one of the cointegrated variables. Hence, better forecasts can be made, in general, if existing long-term relationships are taken account of. Furthermore, predictability of 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 the presence of predictability in asset returns, myopic expectations are likely to lead to suboptimal portfolio allocation.

Asset returns can naturally be predictable even in the absence of cointegration. The implications of cointegration for portfolio allocation, however, are stronger than if only short-run dynamics exist between prices for different assets. The existence of cointegration between two I(1) series means that the long-run correlation between their differences must approach one, even though the series may diverge in the short run (see e.g. Cochrane 2001, p. 423).[48] 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

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[47] Of course, in some cases also the power problems of the cointegration tests may lead to the acceptance of the null hypothesis of no cointegration.

[48] Cointegration of the form of (23) does not necessarily lead to long-run correlations that are close to one, however.

equilibrium. 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 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 diversification benefits.

If two return indices are not cointegrated, the diversification potentials are, in general, better considering long-term investments. It should be noted, nevertheless, that also short-term dynamics between asset prices are of significance to portfolio allocation. If a short-term lead-lag relation exists between two asset prices, correlations that are based on short observation windows are likely to give a wrong picture concerning the co-variation of the asset returns in the longer horizon.

It is obvious, therefore, that long-horizon buy-and-hold investors should not look at short-term correlations when there are dynamics between asset prices and especially if the asset prices exhibit cointegration. The articles in this research show that housing prices are clearly predictable and that there are strong dynamic interrelations between different regional housing markets. Furthermore, the results imply that there are both short- and long-term linkages between housing prices and financial asset prices. Nevertheless, both short- and long-term interrelations between different assets have often been neglected in the financial literature and in real life portfolio allocation. Since the holding period for direct real estate investments is typically long, often several decades, dynamics between asset returns should be considered particularly rigorously by an investor holding direct real estate in his portfolio.

Finally, long-run relationships between regional housing prices and between prices of different asset categories have got implications for the broad economy. It is likely that busts and booms occur more synchronously in two asset markets if the markets are cointegrated. Because of the wealth effect of asset prices, it is more harmful for the macroeconomy if booms and busts take place simultaneously in different markets. Notable differences between price cycles in regional housing markets, in turn, could create diversification benefits not only for a housing investor but also for the whole nation.

6.4 Structural breaks

As mentioned above, an expected cointegrating relation may be disturbed due to a number of factors. In particular, in the long horizon structural breaks (or changes) may take place in the cointegrating relationships due to several reasons. In other words, the coefficients in a cointegrated long-run relation may change occasionally. If these kinds of structural changes take place relatively frequently, it may not be sensible to talk about cointegration at all – after all, it then seems that there is no *stable long-run* relation between the variables. Instead, if there are breaks that alter the long-run relation once in every twenty years due to, for instance, some unique events, it is reasonable to state that the variables are cointegrated. Nevertheless, these kinds of structural changes may enhance the diversification benefits between regional housing markets, whose price levels are cointegrated (allowing for a unique structural break).

Structural changes cause problems in the testing of cointegration. Due to a structural break, the conventional cointegration tests that ignore the possibility of changes in the long-run relation may lead to rejection of cointegration even if the variables actually are cointegrated. In addition, the estimated long-run coefficients are likely to be flawed if structural breaks that have happened in reality are not taken into account. Therefore, it is important to consider the possibility of structural breaks especially if there are notable institutional changes, such as the liberalization of the financial markets or the abolishment of international capital movements, during the sample period.

In this thesis, several different approaches have been utilized in order to try to cater for the possibility of structural breaks in the long-run parameters. In many cases, both recursive and backward recursive estimations are employed to investigate the stability of the estimated long-run relation.[49] Moreover, in the second and third essays the methodology proposed by Johansen et al. (2000) for cointegration analysis in the presence of a break at known point of time is used. Finally, in the last article the sample is divided into two separate sub-samples and the existence of a structural change is illustrated graphically.[50] At least to my knowledge, the three approaches have not been employed to housing data earlier. Due to the relatively small numbers of observations and the features of the methodological approaches in the empirical analyses of this thesis, it is reasonable to consider the possible existence of only one or at maximum two structural changes. In the last three studies, evidence for structural change is found in the data.

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[49] The recursive estimations are conducted with the program CATS2 (see Dennis 2006, pp. 93-112).
[50] Similar approach has been used by Juselius (2001).

Because of the relatively long sample periods and several institutional changes during the sample periods, it is possible that there have been more than one or two structural breaks in the long-run relations reported in the empirical studies. Nevertheless, according to the recursive analysis suggested by Hansen and Johansen (1992) utilized in the first, third and fourth essays, the estimated long-run relations are relatively stable over the sample periods. One would expect that the recursive tests would reject the stability of the cointegration space if there were notable structural changes in the long-run relations. Furthermore, it is expected that the cointegration test accepts the hypothesis of no cointegration if there were to be significant breaks in the relation that are not catered for. Anyhow, it is possible that some actual structural breaks have not been detected in the cointegration analyses and, therefore, some cointegrating relations have not been found. In addition, it cannot be excluded with *absolute certainty* that some estimated long-run relationships are actually unstable.

Note, however, that even though the existence of structural changes makes cointegration analyses complicated in this thesis, it is still worthwhile to test for cointegration and estimate CVAR models in case cointegration is found. This is because, as explained above, cointegration has got important implications and because the error-correction term gives significant information concerning the dynamics of a variable that has got a long-run relation with some other stochastic variable(s). On the other hand, if cointegration is not found, the outcome of the econometric analysis (i.e. the estimated VAR model) is not any worse than if the possibility of cointegration is neglected in the first place (and, therefore, a VAR model is estimated).

7 DATA AND ITS PROBLEMS

As emphasized in section 4, the data are typically far from perfect in the empirical analyses studying housing price dynamics. This study is not an exception. The complications with the data make empirical research on housing price dynamics extremely challenging, and there does not seem to be one “correct” answer to how one should perform the analysis. Below, problems with the data employed in this thesis and their potential consequences are discussed.

7.1 Housing indices

Even the construction of housing price indices and the measurement of housing price movements are themselves problematic. Because of the heterogeneity of housing, the use of quality adjusted indices is desirable. In this thesis, quality adjusted indices, i.e. the hedonic price indices published by Statistics Finland, are utilized in all of the four empirical studies. In the first and fourth essays, however, also non-quality adjusted series over the early sample period are used to get longer sample periods.

The datasets used in the empirical analyses should be accounted for when evaluating the reported results. Firstly, the use of non-quality adjusted series may exaggerate at least the relatively short-horizon volatility of housing appreciation. Secondly, short-term correlations between price movements that are derived from non-quality adjusted data are probably somewhat smaller than the actual correlations. The shorter the observation window the more pronounced this phenomenon is likely to be. Thirdly, the average appreciation figures obtained from quality unadjusted data may differ slightly from the true ones. Furthermore, inaccurate indices may distort the estimated coefficients in econometric models to some extent. In general, the smaller the housing market, i.e. the smaller number of housing sales there are in the market, the greater the problems are.

Note also that even the hedonic indices cannot track all the variability in the quality of dwellings transacted in different periods. Hence, the hedonic indices may exhibit similar problems to those of non-quality adjusted indices, but the problems are less significant. Actually, the average price series, in general, co-vary extremely strongly with the hedonic series. For example, in the case of the HMA the correlation between quality adjusted and unadjusted series is about one, and even between the differenced series the correlation is .90.

To overcome part of the heterogeneity problem, the housing price series used in this thesis are based on privately financed flats (in multi-storey buildings) sold in the secondary market. Hence, in this research only the dynamics of "old" privately financed flats are considered empirically. The price dynamics in the other housing market sectors may differ somewhat from the price dynamics reported in this study. The data used is more representative of the price development in urban areas than in rural areas, since flats in multi-storey buildings account for greater part in the housing stock in cities than in the countryside. Note also that owner-occupied and rental housing is not separated in the data. Instead, they form together the total stock based on which the price series are constructed.

In the last study of the thesis, housing price index regarding the whole of Finland is employed. The national index ignores the heterogeneity between distinct regional housing markets within the country. This is not a major problem in the analysis though, since the aim is to measure the performance of housing portfolio consisting of housing in all the regions in Finland.

One deficiency in the second essay is that mainly capital return, i.e. housing appreciation, is used to examine the diversification potentials between different housing markets. Of course, it would be optimal to employ total returns. Unfortunately, there is no decent estimate of rental return in many of the areas considered in the study. Nonetheless, it is reasonable to believe that the effect of rental returns on the geographical diversification gains, i.e. on return correlations between different areas, are negligible. This is because rental return is typically extremely steady compared to housing appreciation. The influence of the rental gains on optimal portfolio allocation may be more important, though, since the level of rental yield is likely to vary between different regions.

The sample periods in this thesis are relatively long, from 20 to 36 years. However, because the most frequent housing price data available from the markets considered in this study are at quarterly level, there are a relatively small number of observations in the empirical analyses. The comparatively small number of observations may result in size distortions and power problems in the econometric tests employed in the essays. In some cases, small sample corrected test values have been used in order to account for the limited sample sizes.

The two other asset price series utilized in the thesis (in the fourth study, to be precise) do not exhibit problems similar to housing data. Reasons for this are discussed in section 3. In any case, quarterly data have to be used also regarding stock and bond prices, of course.

In the first essay, there is also the question of how well the privately owned rental flats correspond to the whole privately financed stock of flats. The correspondence is likely to be less than perfect. It is commonly assumed that rental dwellings are on average of lower quality than owner-occupied dwellings. If this is true and is not taken account of, then the use of the no-arbitrage condition presented in section 2.3 might imply that housing is overvalued even if it is actually not.

The rental price data also exhibit other complications. Firstly, the data are non-quality adjusted. This is problematic, since the average quality of the dwellings based on which the average rental prices are counted may have changed in the course of time. Secondly, there are no rental data concerning the whole HMA prior to 1990. Hence, rental price changes in Helsinki are used to estimate rental prices in the HMA before the 1990s. Thirdly, the rental price series represents the whole privately financed stock of rental dwellings, not only flats. This should not matter significantly, however, since some 90% of the privately financed rental dwellings in the HMA are flats. Finally, the rental data are on an annual basis until 2002. Thus, the quarterly changes are approximated according to the "living, heating and light" part (1975-1999) and the "rental cost" part (2000-2002) of the nationwide cost of living index.

7.2 Fundamental variables

According to the theory, proper analysis of the short- and long-run housing price dynamics calls for a number of demand and supply side variables. There are reasonable data available on many of the fundamental determinants of housing prices, but data on some – especially supply side – variables are inadequate. In this thesis, data concerning fundamental variables is in important role in the fourth study and especially in the first essay. In the former, national level data is employed, whereas data on the HMA is used in the latter if available.[51]

One problem is that, just like regarding the rental data, there are only annual data available on some variables. In these cases, the quarterly values have to be estimated by some reasonable method, because the use of annual data could cause significant small-sample problems. Naturally, the estimated quarterly values may differ somewhat from the actual figures, thereby affecting the estimated model coefficients and test values slightly.

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[51] More detailed delineations of the employed data and its sources are presented in connection with the empirical studies themselves.

Concerning some variables the time series is shorter than desired. Thus, some time series have been lengthened by using different methods to add more observation points. This may have similar consequences to those of estimating the quarterly values.

In some cases, in turn, there is simply no data available. There is no time series on the expectations regarding housing appreciation. These expectations could be proxied to some extent by adding data on expectations concerning a number of fundamental variables, such as income and interest rates, to the analysis. Such time series data are not available, however. Hence, other variables that reflect changes in the expectations, at least to some extent, have to be used. In the first essay it is assumed that data on households' loan stock caters for alterations in the income and interest rate expectations. Loan data may take account of the effect of household wealth on housing demand as well: according to the permanent income hypothesis, increase in household wealth should increase current consumption thereby increasing current borrowing. Anyhow, it is evident that household borrowing can work only as an approximation of the true household wealth and expectations.

Furthermore, there is no long enough data on mortgage rates. Therefore, the average lending interest rate concerning the whole outstanding loan stock is employed in the thesis. This, however, is not likely to affect the results notably, since the average mortgage rate seems to co-move extremely strongly with the lending rate concerning the whole loan stock. Both the average rate of the whole stock and the rate on the new mortgages probably affect housing demand.[52] The average rates on the whole stock and on the new loans naturally correlate strongly. However, average rate on new loan stock is much more volatile and responds more rapidly to shocks. Unfortunately, there are not so long time series regarding interest rate on new loans as would be desired.[53] Note also that there is no direct data on the share of the mortgage capital of the value of the dwelling, which would be desirable according to the parity expressed in (16).

In the literature, the measurement of the supply side fundamentals is, generally, particularly complicated (as discussed in section 4.1). The elasticity of housing supply may change substantially in the course of time e.g. due to shifts in the zoning policies or growth of the area. Hence, the parameters β_0, β_1 and τ in equation (12) can vary with time. For instance, in a growing metro area, land is likely to become a more scarce resource leading to more inelastic supply of land and housing (smaller β_1). In general, the variables, such as

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[52] This is likely to hold at least in Finland, where it is, in general, costly for the debtor to re-negotiate the terms of a loan.

[53] The data on the average rates on the whole mortgage stock and on the new housing loans is available since 1989.

zoning policies, altering the elasticity of housing supply are hard to measure. However, the effect of the growth of the area can, at least to some extent, be taken account of in an empirical model by the number of households living in the region (or by population of the region) or by the total housing stock in the area. Because the two variables correlate extremely strongly, the inclusion of both of them in an econometric model would be problematic. Instead, some kind of vacancy rate measure could be utilized to take account of the changes in the abundance of the housing supply relative to the demand. Unfortunately, such long vacancy time series is not available concerning the markets studied in this thesis. Furthermore, there is no sufficient data on the stock of subsidized housing that could take account of the impact of subsidized production on privately financed housing prices.

Variation in β_0 can be proxied by the construction cost index. There are problems with the construction cost index too, however. There is no construction cost index separately for flats prior to 1990. Therefore, the index employed in the thesis depicts the development of construction costs concerning all housing types. Anyhow, after 1990 the co-movement between the changes in the overall index and in the flat index is strong. This indicates that the overall index approximates well the development of the construction costs of flats. A more significant problem probably is that the construction cost index does not take account of the profit margins of the construction companies. Hence, the actual replacement costs are likely to be more volatile than suggested by the construction cost index. Furthermore, the index comprises the whole country. There may be regional differences in the development of construction cost. Nevertheless, in a relatively small and coherent country such as Finland, it seems probable that differences between changes in the construction costs in different regions are small.

In any case, it is improbable that the variables included in the empirical analyses are able to take completely into account the possible changes in the supply elasticity. Hence, assuming that supply has become more inelastic, at present housing prices may react more strongly to shocks in the demand side variables than implied by the coefficients of an econometric model utilizing time series over several decades.

Finally, there are two more complications with the data. One is the existence of seasonal variation in some of the time series. Luckily, the potential problems caused by seasonal variation can be eliminated by either conducting seasonal smoothing to the series or by adding seasonal dummy variables in the econometric analyses. The other problem – the possible existence of structural changes in the data – is unfortunately harder to cater for. For instance, it is hard to accurately measure the impact of credit rationing on housing prices in the 1970s and 1980s. The problem of structural breaks is discussed in more detail in section 6.4 above.

7.3 Do the data problems make the analyses defective?

As explained, there are clearly a number of complications with the data employed in the empirical analyses of this thesis, and the data problems may distort the results somewhat. In any case, in this study substantial effort has been put to gather as reliable and as extensive dataset as possible. In many aspects, the dataset is more comprehensive and more reliable than the datasets often used in the previous literature. Hence, despite its deficiencies, it seems reasonable to believe that the data employed in this thesis is sufficient enough for one to make relatively reliable conclusions.

Furthermore, it would not be sensible to neglect empirical research on housing price dynamics only because the data is imperfect. This fact is illustrated by the great number of empirical studies on housing price dynamics, all of which have got their own complications with the data, usually similar to those in this thesis.

Anyhow, the complications with the data and their potential consequences should be kept in mind when evaluating the empirical results and drawing conclusions. In particular, it should be understood that the reported results are necessarily not exactly accurate.

8 EMPIRICAL STUDIES OF THE THESIS

This thesis includes four separate empirical studies, each of which examines housing price dynamics. The overall purpose of the essays is to bring light to dynamic interrelations between regional housing markets, between housing prices and financial asset prices and between metropolitan housing prices and economic fundamentals, and to evaluate the implications of these interdependences. The aim is also to assess the HMA housing price level. The essays show that there are tight interrelations between regional housing markets. There are clearly dynamic linkages between different asset categories as well. Furthermore, housing prices seem to be predictable to a large extent.

The first of the empirical articles investigates housing price determination within a single metropolitan area, i.e. the HMA. A long-run relation, that appears to work reasonably well, is estimated between real housing prices, real aggregate income, loan-to-gdp ratio and real after-tax lending rate using quarterly data from 1975Q1 to 2006Q2. The estimated long-run relation is utilized to estimate error-correction and vector error-correction models. The results are in line with the theory, implying e.g. that there is significant two-way interaction between housing prices and bank credit. The analysis further suggests that the adjustment process of housing prices towards the long-run relation is sluggish, less than 10% per quarter. Furthermore, the housing market no-arbitrage condition is employed to assess HMA housing prices. The no-arbitrage condition together with the econometric model suggests that there was no alarming overpricing in the HMA housing market in 2006Q2. In particular, it seems obvious that the price level was not based on high expected appreciation.

Housing price development may differ between different submarkets inside a metropolitan area, such as the HMA. Hence, the second essay examines housing price co-movement between different areas within the HMA. As a comparison, housing price co-movement between various cities in Finland is studied as well. Special emphasis is given to the implications of the regional housing price co-variation for housing portfolio diversification potentials.

In the essay, the HMA is divided into six submarkets based on geographic and housing market factors. The risk diversification potentials within the HMA and across the country are analyzed based on quarterly housing price indices over 1987-2006. Since a boom-bust cycle occurred during the early sample, the sample is divided into two sub-samples in the correlation analysis.

Expectedly, co-movement between different housing markets was tighter during the early sample, when macroeconomic variables were likely to dominate the price development, than during the second sub-sample, when the relative importance of local factors has probably been substantially greater. In both sub-samples the correlation coefficients grow significantly when the investment horizon is extended. While quarterly correlations suggest that notable diversification gains are obtainable through geographical diversification inside the HMA, the longer-term figures indicate that the diversification benefits are, in fact, negligible. Also the correlation figures between the cities are close to one in the long horizon.

Nevertheless, according to the cointegration analysis housing prices are much more tightly linked within the HMA than between the cities across the country. Hence, as expected, also the long-term diversification potentials inside the HMA seem to be weaker than across the country. In any case, the results show that short-run correlations give a wrong picture concerning geographical diversification opportunities of a housing portfolio. Moreover, housing portfolio diversification gains obtainable through geographical diversification appear to be relatively small in Finland. This is because in the long run co-variation of housing prices between distinct regional housing markets seems to be strong in spite of the local nature of housing markets.

Since strong dynamic interrelations appear to exist between regional housing markets, a question arises whether housing price movements in some regions lead housing price changes in the other areas. Therefore, the third article studies the diffusion of housing price movements between different Finnish regions. To start with, possible reasons why housing appreciation in economic centres may lead appreciation in surrounding areas are discussed theoretically. The reasons include structural differences and economic interdependence between regions as well as informational factors. In the empirical part, vector autoregressive and vector error-correction models using quarterly data from the Finnish housing markets from 1987 to 2006 are estimated. The results show that housing price changes in the HMA, the main economic centre in Finland, Granger cause housing price movements in the other regions in Finland. Furthermore, housing appreciation in regional centres clearly leads appreciation in the surrounding provinces. Inside the HMA, instead, housing price changes in the suburbs have Granger caused price movements in the city centre. Cointegrating relationships between regional housing markets are also detected, suggesting that price growth in the centres can be restrained by increasing supply in the surrounding areas.

Also financial asset prices may affect housing price dynamics. Therefore, stock and bond prices are incorporated in the analysis in the fourth essay. The aim of the essay is to study the long- and short-term interdependences between the Finnish stock, bond and housing markets using time series econometrics. The reasons to assume that significant interdependences exist between the financial asset markets and the housing markets are first contemplated. Also the implications of the possible interrelations between the asset prices are discussed. Cointegration analysis suggests that there is a structural break in the relationship between stock and housing prices in the early 1990s. The article suggests that the break in the long-run relation between stock and housing markets is mainly due to the increased foreign ownership in the Helsinki Stock Exchange (HEX). The increased influence of foreign investors on HEX has been a consequence of the abolition of restrictions concerning foreign ownership of Finnish stocks, which took place in 1993. In line with the theory and previous research, it is found that stock appreciation clearly Granger caused housing price changes during 1970-1993. Since 1993, in turn, stock appreciation seems to have Granger caused housing only through a cointegrating long-run relation. Because of the dynamic linkages between stock and housing markets, it appears that diversification benefits between well diversified housing and stock portfolios are only small in Finland, especially in the long horizon. Co-movement of bond price changes with stock and housing appreciation, instead, is found to be weak.

In the fourth article it is further noted that up until the early 1990s Finnish housing market followed the booms and busts in the stock market. It appears that this seemingly inevitable phenomenon of the almost simultaneous cycles has vanished or at least weakened. If the conclusion is correct, this may have a major impact on the macroeconomic volatility.

A number of phenomena concerning housing price dynamics have been investigated in the four essays. Nevertheless, a large number of questions are left for future research. For instance, the articles are unable to say anything certain concerning informational efficiency of the housing markets (using the definition according to which an efficient market is a market with no opportunities for constantly gaining above normal returns). Hence, it would be of interest to study if above normal returns can be gained in the housing markets, taking account of the substantial transaction and information costs involved in direct housing investments, using past information. It could also be worthwhile to examine in more depth the implications of housing price predictability and of the linkages between housing and financial assets for strategic portfolio allocation. Moreover, of importance are the dynamics between housing prices and vacant lot prices. Detailed analysis in this area is still extremely scarce even internationally. Furthermore, this research studies housing price determination and the possible overvaluation of housing in one metropolitan area only. As there are a great number of distinct regional housing markets in Finland, the results concerning the HMA cannot be straightforwardly applied to the other cities. Thus, it would be valuable to study housing price determination also in the other Finnish regions. Each of the four potential themes mentioned also have practical relevance. This list of important future research subjects concerning housing price dynamics is, of course, far from comprehensive.

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ASSESSING PRICES AND PRICE DYNAMICS IN THE HELSINKI HOUSING MARKET

Abstract

This paper studies housing price dynamics in the Helsinki Metropolitan Area (HMA) using quarterly data from 1975Q1 to 2006Q2. Special attention is given to analyzing if residential property in the HMA is overvalued. First, different ratios between housing prices and fundamental variables affecting housing prices are calculated. Then, a long-run relationship between real housing prices, real aggregate income, loan-to-GDP ratio and real after-tax mortgage rate is estimated. The long-run relation is utilized in error-correction and vector error-correction models to examine the short-run housing price dynamics. The housing market no-arbitrage condition implies that in 2006Q2 housing was fairly priced in the HMA, whereas the econometric analysis suggests that there was a slight overvaluation in the market. The adjustment speed of housing prices towards the long-run relation is sluggish, less than ten percent per quarter. The study also shows that there is a significant two-way interaction between bank lending and housing prices.

Keywords: Housing prices, dynamics, cointegration, error-correction model, bubble, lending

1 INTRODUCTION

Over the last few years there has been a lot of debate all over the world on the existence of bubble in several housing markets. It has been constantly claimed that housing is overvalued in a number of countries, including Australia, Belgium, France, The Netherlands, Ireland, Italy, Spain and the United States. In some countries housing price growth has stopped recently, and in some cases price level has even dropped somewhat. Also in the biggest cities in Finland housing prices have risen rapidly after the mid-nineties. In the Helsinki Metropolitan Area (HMA)[1] the real housing price level increased by some 120% from the end of 1995 to the second quarter of 2006. The real price level has reached the peak level of the bubble that arose in the late 1980s and burst in the early 1990s, and the question has occurred on whether the housing prices in the HMA are at an unsustainably high level.

History has shown that big bubbles can develop not only in the stock markets but in the housing markets as well. The fact that the real housing prices are currently at the level of the peak of the bubble in the late 1980s does not, however, necessarily imply that housing in the HMA is overvalued at the moment. Indeed, some experts have argued that the price level is not particularly high taking account of the fundamentals. There are a number of factors that may have caused a growing trend in the fundamental value of housing in the HMA. Additional evidence that relates the current housing price level to the fundamental determinants is required to properly assess if housing is overvalued.

As Leung (2004, p. 250) puts it, "*conventional housing economics and urban economics for its part virtually ignore interaction between housing markets and the macroeconomy*". Housing price movements, however, are not only affected by the general economic conditions but are also likely to have substantial effects on the macroeconomy. There are several reasons why policy makers should be concerned about housing prices. Firstly, housing composes the majority of many households' wealth, and the "wealth effect" of housing on consumption is significant (see e.g. Case et al. 2001, Benjamin et al. 2004, Campbell and Cocco 2004). Hence, a decline in housing price level leads to less consumption. Secondly, a drop in housing prices is likely to have

[1] The HMA consists of three cities – Helsinki, Espoo (including Kauniainen) and Vantaa – located next to each other.

a negative effect on housing construction, and thereby on aggregate output and employment. In addition, housing price development affects the financial sector significantly (see e.g. Goodhart and Hofmann 2007). Housing price changes appear to have a substantial impact on bank lending. Furthermore, a notable fall in housing prices would affect the banking sector by inducing unanticipated losses for mortgage lenders, which could strain the financial system.

In Finland these factors together could lead to substantial adverse consequences on the macroeconomy even if housing prices were to decrease considerably only in the HMA, since the HMA comprises one fifth of the Finnish population. Therefore, it is of great interest and importance to study housing price dynamics in the area and to assess whether the price level in the area is sustainable, i.e. consistent with economic fundamentals.

Unfortunately, it is far from straightforward to evaluate if housing is fairly priced. In particular, the data on the fundamental variables are problematic and the measurement of the expected housing appreciation is complicated. In this study the housing market no-arbitrage relation is employed to assess housing prices. In addition, econometric analysis is conducted to estimate a long-run relation towards which housing prices are expected to adjust. The estimated long-run relation is utilized to estimate error-correction and vector error-correction models based on which the adjustment dynamics of housing prices are studied.

The next section proceeds with delineation of the empirical model and of the data used in the study. This is followed by a review of the relevant literature. Section four discusses three different ratios, especially the no-arbitrage relation, that are used to assess housing prices. The fifth part presents results from the econometric analysis. Finally, the conclusions are derived.

2 EMPIRICAL MODEL AND DATA

In many studies the dynamics of national level housing prices are examined. Often it is more reasonable to focus on a single metropolitan area in an empirical analysis, however. This is because dwellings within a metropolitan area can be regarded as relatively close substitutes for one another. Thus, housing prices within a metropolitan area should react similarly to changes affecting the overall market. In other words, metropolitan area is a reasonable definition for a housing market.[2] By contrast, within a country there are many distinct areas whose dwellings are not close substitutes for each other. Therefore, this study concentrates on examining the housing price formation within a single metropolitan area, namely the HMA. This section presents the models that are estimated and tested in the econometric part of the article.

2.1 Motivation and data of the long-run model

Following Hofmann (2004) and Goodhart and Hofmann (2007, from now on GH) the empirical long-run relation is estimated between real housing prices (*P*), real income (*Y*), outstanding loan stock divided by GDP (*L*) and the real interest rate (*IR*):

$$P_t = \beta_1 * Y_t + \beta 2 * L_t + \beta_3 * IR_t + e_t. \qquad (1)$$

In (1) betas are the coefficients for the fundamental variables explaining long-run development of real housing price level. The error term, e_t, is expected to be stationary, i.e. the four variables in the model are expected to be cointegrated so that the deviation from the long-run relation cannot drift away from zero in the long run.

The main aim of GH is to study the long- and short-run determination of outstanding bank credit. In this article, on the contrary, the purpose is to model housing price dynamics within a single metro area. Therefore, the point of view and the data used differ somewhat from GH. While GH state reasons for the dependency of credit demand on housing prices (see p. 148), this study outlines the role of the loan stock as a source of information concerning a

[2] For further reasoning behind the appropriate geographical definition of a property market, see e.g. DiPasquale and Wheaton (1996, pp. 24-25).

number of the fundamentals that are expected to affect housing prices significantly.[3]

Household borrowing is likely to be dependent on the expected permanent income. Increase in the perceived permanent income induces households to consume more today to smooth the consumption stream over the life cycle. Desire for more current consumption, in turn, is likely to increase households' borrowing. Borrowing may also reflect households' income uncertainty – the more uncertain the households are the less they are expected to borrow (precautionary saving). In addition, it is reasonable to assume that current and expected future level of interest rates affect household borrowing. Hence, movements in household borrowing are expected to give information about both income and interest rate expectations as well as about income uncertainty. This information is of relevance, since the expectations and uncertainty are expected to affect housing prices significantly.[4]

Furthermore, household borrowing is likely to reflect changes in the liquidity constraints faced by households. An increase in the availability of credit may increase the demand for housing if households are borrowing-constrained. Therefore, loan stock variable may cater for the substantial changes in the availability of credit during the sample period, which have probably influenced housing demand notably (see the discussion below in section 2.3).

The loan-to-GDP ratio is used as a measure of bank lending (*L*). The ratio represents the whole country. As housing markets are local in nature, regional variables would be more appropriate in the analysis. Unfortunately, data on the loan stock and GDP in the HMA are not available. Nevertheless, Hekman (1985) argues that national variables can provide an accurate measure of economic influences if they are moving in the same direction as the regional economic variables. McGough et al. (2000) found that the regional GDP in Helsinki area is strongly correlated with the national GDP. This is expected, since the HMA is the main economic centre in Finland and comprises over one-fifth of Finnish population and an even greater share of the national GDP. In line with this, Karakozova (2004) found that national variables are useful in predicting office returns in Helsinki. All in all, it seems sensible to assume that changes in the national loan-to-GDP ratio represent well the changes in the regional ratio. The utilized loan data measure the whole outstanding housing and consumption debt of Finnish households. Both loan and GDP data are supplied by Statistics Finland.

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[3] The key determinants of housing price level and dynamics are discussed in detail in section two of the introductory chapter.
[4] Negative impact of income uncertainty on housing prices is reported e.g. by Haurin (1991) and Diaz-Serrano (2005a and 2005b).

GH added GDP in their model as the income variable. A more appropriate income measure for a single metropolitan area is the aggregate income in the region. In this study, the aggregate income variable (*Y*) is the whole population in the Helsinki Region[5] multiplied by the disposable income per capita in Helsinki. Thus, *Y* caters for the influence of both population and income growth on the housing price development. Due to the multicollinearity between the population and income, the variables are not incorporated to the model separately. Introducing the population and income per capita variables individually to the estimations would lead to insensible results.

The population of the whole Helsinki Region (approximately 1,25 million in 2006) is employed instead of the population of the HMA (980 000), since the whole Helsinki Region belongs to the same functional working area. That is, it is reasonable to assume that population growth in the whole area has influenced housing price development in the HMA. The income per capita data are based solely on Helsinki, since long enough time series are not available for the rest of the region. Hence, it is assumed that income development has been similar to Helsinki in the whole region (the population of Helsinki is approximately half of the total population of the region). Since the income data is annual, the quarterly values have been estimated based on the quarterly nationwide income level index. It is reasonable to believe that this produces a fairly good approximation for the quarterly income figures of Helsinki. The population and nationwide income data are published by Statistics Finland whereas the Helsinki disposable income data are reported by the City of Helsinki Urban Facts.

The long-run model also includes the real interest rate (*IR*). The theory expects the real interest rate to affect both housing demand and lending significantly. Because housing price dynamics are the focus of the econometric analysis, the interest variable used in this study is the real after-tax lending rate faced by households[6], since mortgage interest payments are deductible in taxation (see section 2.3 for more details).

The average lending interest rate is used instead of the average mortgage interest rate because the average lending rate series is substantially longer. The

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[5] The Helsinki region forms a LAU 1-area (formerly NUTS-3). Note that the population is "cleaned" of the effect of the change in the Act in the Municipality of Domicile that took place in the early 1990s. The cleaned series is based on the calculations of Seppo Laakso and Pekka Vuori.

[6] The average lending interest rate of deposit banks in Finland 1975-2002 concerning the whole outstanding loan stock (source: Statistics Finland) and the average lending interest rate of deposit banks and other credit institutions in Finland 2003-2006 concerning the whole outstanding loan stock (data source: Bank of Finland) are utilized in the analysis. After-tax nominal mortgage rate is counted as i(1-T), where T is the average marginal income tax rate in Finland from 1975 to 1992 and the capital tax rate from 1993 onwards. The real rate is computed by subtracting the inflation rate, measured by increase in the cost of living index, from the nominal after-tax lending rate. The source for the national average marginal income tax rate during 1975-1976 is Salo (1990) whereas the data over 1977-1992 is provided by the Finnish Ministry of Finance.

lending rate proxies well for the mortgage rate.[7] One complication in the model is that the borrowing for consumption is not dependent on the after-tax lending rate but on the before-tax rate. This should not be a major problem, though, since housing loans comprise on average almost 90% of the total household debt. The share of housing loans has not changed notably during the sample period.

As mentioned, *L* takes into account the interest rate movements and expectations concerning future interest rates to some extent. Furthermore, as GH (p. 37) state, real interest rate is usually considered to be mean-reverting. Hence, especially if the role of expected interest rate movements on housing demand is notable, i.e. if housing prices include notable forward-looking components regarding the real interest rate, it is anticipated that the coefficient of *IR* is relatively small. That is, if *IR* is indeed mean-reverting, then the housing demand of forward-looking agents with long planned holding periods of housing should not react strongly to changes in the prevailing level of real interest rate. In fact, in the Finnish case real interest rate does not enter the long-run relation significantly according to GH.

Ideally, the housing price index itself should be quality adjusted. Unfortunately, hedonic housing price index exists for the HMA starting only from 1987. Therefore, similarly to DiPasquale and Wheaton (1994) and Riddel (2004), an average sales price (per square meter) index and a hedonic price index are joined to have a substantially longer sample period.[8] The use of average transaction prices prior to 1987 may be problematic if the average quality of dwellings sold in different quarters differed notably during the early sample period. Nevertheless, it seems reasonable to believe that the price movements displayed by the average sales prices track the true price development well. The housing price statistics are published by Statistics Finland and both indices are based on transactions of privately financed flats in the secondary market. The indices based on flats represent housing price movements in the HMA well, since the share of flats of all the dwellings in the area is high (at the end of 2005 the share was some 75%).

The long-run relation does not contain any supply side variables. Potential changes in the supply side, such as alterations in the zoning policies, are extremely hard to take into account in an econometric time series analysis.

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[7] The correlation coefficient between the average lending rate and the average mortgage rate (source: the Bank of Finland) is .99 from 1989Q3 to 2006Q2. Correlation between the differences is .89.

[8] Another option would have been to use the average sales price index throughout the sample period. It seems more reasonable to use quality-adjusted index for part of the sample period than not to use it at all, however. In any case, there is no significant difference between the average sales price series and the hedonic index series (see Figure A1 in the Appendix): quarterly correlation is .90 even between the differenced series. Indeed, the results would not change significantly even if the average sales price index was employed for the whole sample.

Therefore, it often has to be assumed in empirical research on housing price dynamics that there have not been significant changes in the supply side that would affect the long-run relation for housing prices. In the literature, typically, the only supply variable included in the empirical models is construction cost index. The influence of construction costs on housing price growth in the HMA has been negligible, since the real construction costs have been almost constant (compared to the other variables) during the sample period. Furthermore, the inclusion of construction cost index to the long-run relation would not lead to sensible results.[9] Hence, it is assumed in the econometric analysis that housing demand (represented by *Y*, *L* and *IR*) has driven housing prices and that the supply curve has not altered notably. This assumption is supported by the fact that the estimated model, reported in section 5, appears to work well.[10]

Obviously, there are complications in the data as discussed above. These complications may distort the estimated coefficients slightly. However, it is reasonable to believe that the data approximates well for the true behavior of the variables incorporated in the analysis.

Note that all the variables employed in the econometric analysis are deflated by the cost of living index, i.e. only real variables are used. Furthermore, natural logs of *P*, *Y* and *L* are used. Table A1 in the Appendix presents summary statistics of the differenced series employed in the econometric analysis.

2.2 Short-run model

There is substantial empirical evidence starting from Case and Shiller (1989) showing that it takes a long time for the housing market to adjust towards the fundamental price level after a shock. Because of the sluggish adjustment of the housing market, lagged variables are often needed when estimating the dynamics of housing price movements. Another reason why lagged variables may be required comes from the fact that also many of the fundamental variables are autocorrelated even in differences.

Because the lagged values of the variables are expected to contain informative value with respect to housing price dynamics and to predictions of future price movements, vector error-correction model (VECM) and error-

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[9] Also a housing stock variable (dwelling per household) was tried in the estimations. The inclusion of the variable led to some insensible parameter estimates. Anyhow, the inclusion of the variable did not notably change the estimated long-run level for housing prices.

[10] The assumption and results are also in line with the finding of e.g. Case and Shiller (2003) according to which income alone explains patterns of home price changes since 1985 in all but eight U.S. states.

correction model (ECM) are estimated in the econometric section. These models take account of the adjustment towards the long-run relation as well as of the other short-run dynamics. Equation (2) presents the VECM that is estimated:

$$\Delta X_t = \alpha' e_{t-1} + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \mu + \Psi D_t + \varepsilon_t, \tag{2}$$

where X_t is a four-dimensional vector containing P_t, Y_t, L_t and IR_t, and X_t is $X_t - X_{t-1}$, $t = 1,\ldots,T$. Γ_i, in turn, is 4 x 4 matrix of coefficients for the lagged differences of the stochastic variables at lag i, k-1 is the number of lags of the differenced variables included in the model, μ is a four-dimensional vector of intercepts, D_t is a three-dimensional vector of centered quarterly seasonal dummies, Ψ is a 4 x 3 coefficient matrix and ε_t is a four-dimensional vector of independently and identically distributed errors. Finally, $\alpha' e_{t-1}$ caters for the adjustment of the variables towards the long-run relation. α is a vector of speed of adjustment parameters of which at least one has to be different from zero if the variables are cointegrated. e_{t-1}, in turn, is one period lagged deviation of housing prices from the estimated long-run relation, i.e. $e_{t-1} = P_{t-1} - \beta_1 {*} Y_{t-1} - \beta_2 {*} L_{t-1} - \beta_3 {*} IR_{t-1}$.

VECM is useful in examining the impact of a shock to one of the variables on the other variables and on the variable itself, since it takes the interactions between the variables into account. For prediction purposes, however, it is often useful to estimate a substantially more parsimonious ECM. In this study, also the stock market is included in the dataset when estimating ECM for housing price movements. Stock price movements can reflect changes in the economic fundamentals or in risk premiums as well as directly influence housing demand through the wealth effect. Indeed, previous literature suggests that stock price movements have predictive power with respect to future housing appreciation (see e.g. Jud and Winkler 2002). The stock price index utilized is the OMXHCAP index, which depicts stock price development in the Helsinki Stock Exchange.[11]

The actual price level can deviate from the long-run relation for a number of reasons. In fact, because of the inability of both demand and supply for housing to adjust rapidly, e_t is expected to differ somewhat from the long-run relation most of the time even if there is no bubble in the market. Typical cycle in the housing market originates from a positive shock to housing demand. As supply is inelastic in the short run, demand increase leads to price growth. Prices may grow notably above the long-run relation before the supply is able to adjust properly. The possibly backward-looking expectations may

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[11] OMXHCAP was formerly called HEX-portfolio index. Prior to 1990 OMXHCAP corresponds to the Unitas index.

occasionally generate even price bubbles – high expectations regarding future price growth can fulfill themselves by augmenting housing demand and thereby driving price level away from the market fundamentals. According to Stiglitz (1990, p. 13) "*if the reason that the price is high today is only that the selling prices will be high tomorrow – when 'fundamental' factors do not seem to justify such a price – then a bubble exists*".[12]

Eventually, the growing new construction begins to enter the market restraining housing appreciation. Price growth stops and price level may even start to drop. Backward-looking expectations are likely to reinforce this process. Because of the construction lag, the amount of new housing construction often keeps growing, although housing appreciation has halted or prices have even started to decrease. Ultimately, price level ends up below the long-run relation and housing construction diminishes. That is, due to the inflexible supply in the short horizon and backward-looking expectations housing prices may oscillate around the long-run relation.

In (2), the error-correction term, $\alpha' e_{t-1}$, caters for the fact that, in the long-horizon supply is able to adjust and housing prices should equal their fundamental level. Due to the backward-looking features of expectations the lagged differences of housing appreciation often work as a counterforce for the error-correction term.[13]

2.3 Institutional changes and development of the variables

As Figure 1 shows, there has been substantial volatility in real housing prices as well as in the other variables included in the long-run relation. Part of the volatility may be accounted for by the institutional changes that have taken place during the sample period. Evidently, regarding housing prices also the sluggishness of the response of the supply side on changing demand has significantly contributed to the volatility as discussed above. In any case, *P*, *Y* and *L* are trending upwards in the long run. On the contrary, real construction costs (*C*) have been fairly stable.

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[12] In this study the term "bubble" refers to a substantial deviation of the actual housing price level from the level justified by the market fundamentals.

[13] Abraham and Hendershott (1996) call the error-correction term the "bubble-burster" and the lagged appreciation the "bubble-builder".

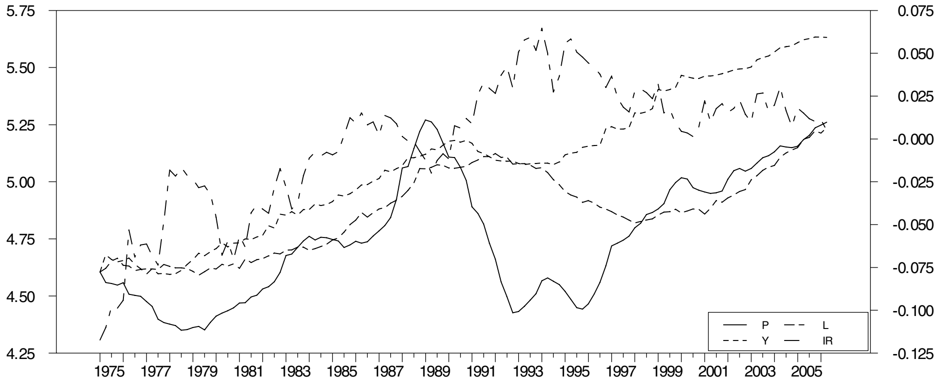

Figure 1 Development of *P*, *Y*, *L*, *C* and *IR* (right scale) during 1975Q1-2006Q2

Both population and income have increased rapidly in the area.[14] Only in the early 1990s the real income level dropped somewhat. The upward trend in the loan-to-GDP ratio is largely due to the far-reaching process of liberalization of the credit markets since the late 1980s. Financial deregulation together with recent innovations in the Finnish credit institutions have loosened the financial constraints faced by households as well as increased the supply of credit to households.

Housing finance in Finland has traditionally been dominated by a small number of banks. Up to the mid-eighties the banking system was highly regulated with tightly controlled and rigid lending rates. Low, administratively controlled, lending rates together with foreign capital controls caused credit rationing. This system was fairly stable until the early 1980s. In 1986 the Bank of Finland gradually deregulated the banking system and the ceilings on average lending rates were abolished. Availability of housing loans for households became significantly easier than earlier.

During the credit rationing housing loans had relatively short repayment periods. Still at the beginning of the 1980s the average loan maturity was 8-10 years and the required down payment ratio was as high as 20%-30% of the purchase price. The financial deregulation resulted in lower down payment ratios, induced a huge growth of credit and led to a housing market boom and finally to a housing price bubble.

Eventually the bubble burst at the beginning of the 1990s. This phenomenon can well be seen from Figure 1. Several reasons contributed to the drastic drop in housing prices. Supply increased notably as the construction that responded to the increased housing price level started to

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[14] Population of the Helsinki region increased by 37% during the sample period. The real income per capita, in turn, more than doubled.

enter the market. At the same time demand for housing started to decline. In the early 1990s demand collapsed due to the rising real interest rates and because of the deep recession of the Finnish economy.

After the deregulation the importance of market based interest rates increased and the interest rates on housing loans became more and more dependent on international financial markets. As the inflation rate decreased at the same time, the real after-tax lending rate became permanently positive. In the 1970s and 1980s the real after-tax lending rate had been constantly negative.

The maturities of housing loans have kept increasing since the late 1980s. Consequently, the liquidity constraints of households have eased, which has lead to a sharp growth in the loan-to-GDP ratio during the last ten years. The importance of the income, wealth and credit constraints on housing demand has been established e.g. by Barakova et al. (2003) concerning the US market. It is assumed in the econometric section that L reflects the impacts of the increased loan maturities and decreased down payment ratios on the liquidity constraints faced by households. Note that L responded to the collapsing housing prices and to the severe recession in the early 1990s as well as to the rapid economic growth since the late 1990s with delay.

Also the rental market has been regulated in Finland for long periods. Lifting in rent ceilings started in the late 1980s and rent regulation was finally released in several stages during 1992-95. The influence of the rental control is hard to take account of in the time series analysis. No specific variable taking the effect of rental control into consideration is included in this study. Nevertheless, the econometric analysis implies that the estimated long-run relation has stayed relatively stable despite the changes in the rental market. The possible effect of the abolishment of the rental regulation is that the long-run level for real housing prices would currently be somewhat higher than the one based on the estimated model.[15]

Capital gains on owner-occupied dwellings have been in most cases tax-exempt during the whole sample period. However, capital gains received by a housing owner who has not lived in the dwelling for at least two years on end have been taxed. Interest payments on mortgages were wholly tax-deductible up to 1974, after which the rules of tax deductions have been changed several times by setting an upper limit or excess limit to the sum of annual deduction. Until 1992 the interest payments were deductible in income taxation. Hence, the after-tax interest rate was determined by marginal income tax rate. Since

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[15] During rental market regulation rental prices were restricted to be somewhat smaller than pure market prices would have been. Hence, rental price level (relative to the demand side factors) may have increased somewhat after the rental market deregulation. This, in turn, may have led to higher housing prices.

the tax reform in 1993, instead, a taxpayer has in practice been able to deduct the interest expenditure multiplied by the capital income tax rate from her taxes. The capital income tax rate, which has varied between 25% and 29%[16], has been substantially lower than the average marginal income tax rate, thereby increasing the real after-tax interest rates on housing loans.[17] It is reasonable to assume that *L* and *IR* are able to cater for the effects of the changes in the deductibility rules on housing prices.

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[16] For the first-time dwelling-buyers the deduction rate has been 30 percent since 1993. Also the deduction ceiling has varied, in 2006 it was 1400€ (if there were one or more children in the household, the maximum deduction was higher, though).
[17] During 1972-1992 the average marginal income tax rate varied between 41.4% and 52.8%.

3 RELEVANT PREVIOUS STUDIES

Most studies analyzing housing price dynamics have their basis in the stock-flow model of the housing sector. The traditional stock-flow assumption was that the housing market would clear quickly. Recently, however, most empirical studies have allowed for gradual price adjustment. The change has taken place due to the strong empirical evidence of sluggishly adjusting housing prices found in many papers. Note also that the empirical analyses have typically contained only construction costs or no variables whatsoever to cater for the supply side.

The often cited results of Case and Shiller (1989 and 1990) implied that housing markets are typically inefficient and adjust slowly to changes in the market conditions. The paper by Mankiw and Weil (1989) highlighted the importance of demographic variables, the age distribution of the population in particular, on housing prices. In line with the findings of Case and Shiller (1989 and 1990), Mankiw and Weil detected that housing prices respond slowly to changing demographic forces.

The perceived slow adjustment of housing prices brought forth the idea that there exists a long-run relation towards which housing prices adjust slowly. Among the first ones to question the traditional stock-flow assumption that the housing markets clear quickly and to cater for the existence of a long-run relationship in empirical analysis were DiPasquale and Wheaton (1994). Employing two-stage least squares estimation on nationwide annual data from the US they found evidence that it takes several years for the market to adjust to its new long-run equilibrium. Assuming backward-looking price expectations their results implied that the price level adjusts only 29% of its deviation from the long-run equilibrium value in the first year after the shock. Using rational expectations the estimated figure was as small as 16%.

Also Abraham and Hendershott (1996) developed a model that allows for lagged adjustment process. They divided determinants of real house appreciation into two groups: one that explains changes in the equilibrium price level and another that accounts for the adjustment dynamics and deviation from the equilibrium price. Both groups were able to explain a little over two-fifths of the variation in real housing price movements in 30 US cities using annual data and a sample period from 1977 to 1992. Together the groups were able to explain three-fifths.

Recently, cointegration analysis has been utilized in some studies to examine the existence and composition of a long-run relationship between housing prices and fundamental variables. In the cointegration analyses both the Engle-Granger method (e.g. Hort 1998, Harter-Dreiman 2004), and the Johansen method (e.g. Holly and Jones 1997, Meese and Wallace 2003) have been employed.

Using annual panel data from Swedish urban areas over 1967-1994, Hort (1998) included construction costs, user costs, aggregate income, proportion of population aged between 25 and 44, the ratio of households' net lending to disposable income and interest subsidies for housing construction in the estimated cointegrated long-run relation. Hort's results suggest that housing prices adjust as much as 84% per annum towards the fundamental level. Also Harter-Dreiman (2004) employed annual panel dataset, covering a number of US metropolitan areas from 1980 to 1998. She incorporated only housing price level and the personal income in the long-run relation. The analysis implies a 22% annual adjustment speed. Holly and Jones (1997), in turn, utilized annual national level time series from the UK covering a period from 1939 to 1994. Their long-run model for real housing prices contained real income, proportion of population aged 20-29, housing stock, loan-to-income ratio and the real mortgage interest rate. The results of Holly and Jones propose that adjustment is faster when housing prices are above (17% annually) than below (2%) the long-run relation. Finally, Meese and Wallace (2003) studied house price dynamics in Paris using monthly data over 1986-1992. They found that housing prices adjust to a long-run relation that includes construction costs, real income, employment and real interest rate. The study suggested that the speed of adjustment of housing prices to the equilibrium is as fast as one-third per month.

Riddel (2004) contributed to the literature by constructing a multiple error-correction model based on annual US data from 1964 to 1998. Her approach made it possible to decompose disequilibrium into that generated by supply-side disturbances and that arising from changes in demand conditions. Riddel included a number of variables in the long-term equations: rent index, income and user costs in the long-run housing demand model, and short-term interest rate, GDP, vacancy rate and construction costs in the long-term supply model. Housing price level was naturally included in both demand and supply equations. The results imply that prices adjust relatively fast to demand-generated disequilibrium (63% a year). Although the estimated response to a supply-generated disequilibrium (34% a year) is relatively large, it is not statistically significant.

Recently, Hofmann (2004) and Goodhart and Hofmann (2007) have considered the relationship between bank lending and property prices employing quarterly data over 1980-1999. Hofmann reports a cointegrating long-run relation between real property prices, loan-to-GDP ratio, real GDP and the real interest rate in all of the 16 developed countries (including Finland) incorporated in the analysis. The property price index used in the study is a combination of housing and commercial property. Goodhart and Hofmann, using a set of 18 industrialized countries, in turn, find a significant two-way causality between housing prices and bank lending. In the Finnish case the response of loan stock to a shock to housing prices is found to be insignificant, though. The econometric analysis further indicates that real housing prices are, as expected, positively affected by real GDP growth and negatively influenced by rise in the real interest rate. Finally, the results suggest that housing price increase augments real economic activity.

Liang and Chao (2007), in turn, study the causalities between property prices and bank lending in China. Based on quarterly data over 1999Q1-2006Q2 their analysis implies that there exits unidirectional causality running from bank lending to property prices. A potential problem with the analysis is the short sample.

Case and Shiller (2003), McCarthy and Peach (2004), Himmelberg et al. (2005), and Smith and Smith (2006) have taken part in the ongoing debate on whether there is a price bubble in the US housing markets. All these articles criticize the views according to which it is evident that housing is overvalued. The importance of taking into account the relevant fundamentals when evaluating the possible overvaluation in the market is emphasized in the papers. Case and Shiller also present a method rarely used when studying the threat of a bubble, a questionnaire survey. Their conclusions are mixed – on one hand fundamental variables have driven housing appreciation, on the other hand there are some signs indicating overvaluation in some markets. McCarthy and Peach employ a version of the standard stock-flow model incorporating an error-correction process to take account of the slow adjustment of the housing market. They include housing stock, permanent income (proxied by consumption) and user cost in the long-run equilibrium. Their main conclusion is that the most widely cited evidence of a bubble is not persuasive because it fails to take account of the developments in the housing market over the past decade. According to McCarthy and Peach the recent price climb in the US can be explained by decline in the interest rates and strong economic growth. Himmelberg et al., basing the analysis on the equilibrium condition between rental price level and the user cost of housing, present similar conclusion concerning most of the metro areas in the US.

Smith and Smith, in turn, employ a present value model and claim that housing is actually undervalued in a number of metro areas.[18]

There is also relevant literature using data from the Finnish housing markets and even from the HMA, the very area focused on in this study. Papers by Takala and Pere (1991), and Koskela et al. (1992), using quarterly data over 1970-1990 and 1970-1989, respectively, indicate that the changes in the Finnish financial system during the 1980s affected housing prices significantly. In addition, the results of Koskela et al. are consistent with the view that rising marginal tax rate increased housing prices by decreasing real after-tax interest rate in the 1970s and 80s.

Kosonen (1997) employs a framework similar to Abraham and Hendershott (1996). Using quarterly data from the Finnish housing market from 1979 to 1995, Kosonen reports a long-run relationship between real housing price level, real disposable income and real after-tax interest rate. The results imply that approximately 15% of the deviation between actual price level and the equilibrium price is removed within a quarter due to housing price adjustment.

Barot and Takala (1998) claimed that national housing price index and the consumer price index should move proportionately in the long-run (i.e. that real housing price level is stationary). The statistical tests, employing quarterly data over 1970-1998, gave some evidence of cointegration between nominal housing prices and consumer prices in Finland and in Sweden. Nevertheless, in countries where population is growing and the largest urban areas constantly gain net migration and where the real income is trending upwards, it is highly unlikely that real housing prices would stay constant in the long run. The expectations of growing real housing prices are emphasized when single growing metro areas, such as the HMA, are concerned.

Kuismanen et al. (1999) examine the determinants of housing prices in the HMA. The results indicate that demographic variables as well as income, user costs and unemployment rate affect housing prices significantly. The signs are expected – positive for the two former and negative for the two latter variables. Non-stationary variables in levels are used in the analysis. The existence of cointegration between the variables is not tested, however.

Laakso (2000), in turn, using annual panel data of 85 Finnish sub-regions from 1983 to 1997, found that regional housing price movements are positively affected by job and income growth and negatively influenced by an increase in the real after-tax interest rate and in the vacancy rate. The model for the Helsinki region, nevertheless, implied that only changes in the number of jobs and in vacancy rate affect housing price movements statistically

[18] Part 5.2 and 6.1 contain more discussion (and criticism) concerning the assumptions used in McCarthy and Peach (2004), Himmelberg et al. (2005), and Smith and Smith (2006).

significantly. This surprising result is probably due to the small number of observations in the estimation.

Recently Huovari et al. (2005) claimed that housing prices in the HMA relative to income and interest rates are high compared with history. Thus, they predicted that the real price level in the area will decrease by some 13 percent from 2004 to 2007. Similarly to Kuismanen et al. (1999), Huovari et al. use level variables but do not test for the existence of stationary long-run equilibrium relationship. Another recent study (Girouard et al. 2006), instead, suggests that housing is fairly valued in Finland.

Giving support to the backward-looking elements in expectations, in all of the error-correction models reviewed above the coefficient for at least the previous period's lagged price change is significant and large. For instance, the reported coefficients for the previous year's appreciation is approximately .8 in DiPasquale and Wheaton (1994), .6 in Hort (1998) and .3 in Harter-Dreiman (2004). Furthermore, Takala and Pere (1991) and Kosonen (1997) get .25 and .5, respectively, as the coefficient for one quarter lagged price increase in Finland.

Abraham and Hendershott (1996) and Harter-Dreiman (2004) also exhibit evidence suggesting that the coefficient for lagged price change is substantially greater in cities with more constrained housing supply. According to Abraham and Hendershott the value of the coefficient for previous year's price growth is .19 in the less constrained US cities, whereas it is .52 in the more supply restricted metro areas. The corresponding figures reported by Harter-Dreiman are .12 and .34

To summarize, the relationship between housing prices and fundamental variables has been relatively widely studied. In some papers, the existence of a long-run equilibrium between housing prices and fundamental variables has been assumed, and slow adjustment to this equilibrium has been allowed in the empirical analysis. Nevertheless, usually the existence of a long-run equilibrium between non-stationary variables, i.e. the stationarity of the long-run model, has not been tested appropriately.

The aim and contribution of this paper is to utilize relatively long sample, 126 quarterly observations, and cointegration analysis to formally test for the existence of a long-run relation between metropolitan real housing prices, real aggregate income, loan-to-GDP ratio and real after-tax mortgage rate. Furthermore, error-correction and vector error-correction models are estimated to study the short-run dynamics.

4 DIFFERENT RATIOS TO EVALUATE HOUSING PRICES

Before turning into the econometric analysis, this section assesses HMA housing price level based on various ratios. The over- or undervaluation in the housing market is often assessed by using simple ratios between housing prices and fundamental variables, such as the price-to-income ratio or the price-to-rent ratio. The use of either of these simple ratios has got considerable problems and may lead to misleading results. The problems with the two ratios are discussed below. In addition, the relation between the user cost of housing and rental price level – a ratio that is theoretically more justified than the other two ratios – is introduced.

4.1 Price-to-income and price-to-rent ratios

Figure 2 exhibits the price-to-income ratio in the HMA (*P/Y*), i.e. average housing price level per m^2 divided by annual disposable income per capita, and the price-rent-ratio (*P/E*), i.e. average housing price level per m^2 divided by average annual rent. The dotted lines show the average level of the ratios during the sample period.[19]

During the "bubble" of the late 1980s both ratios were substantially above their average levels. Then, in the early 1990s, the ratios dropped well below their long-run averages. Since then the price-to-income ratio has climbed up indicating overvalued housing. In 2006Q2 the average flat price per m^2 equaled approximately 8% of the average annual disposable income. On the contrary, the price-to-rent ratio is in its long-term average in 2006Q2. Thus, these two often used measures give different answers to the question on whether housing is overvalued. This is one reason, why more formal analysis is needed to make reliable conclusions. Another reason is that there are also other factors that affect the housing price level.

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[19] The base quarter used to calculate the quality-adjusted price level series is 2005Q4. In 2005Q4 the average sales price of flats in the HMA was 2645 €/m^2.

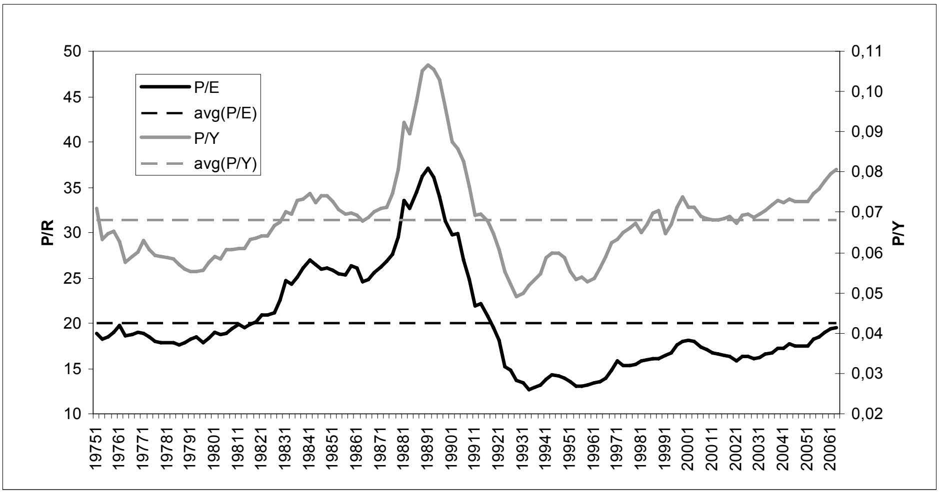

Figure 2 Price-to-income ratio (right scale) and price-to-rent ratio (left scale)

The price-to-income ratio works as a kind of "affordability index" of housing. However, there is no particular reason to assume that *P*/*Y* should be constant over time. As explained in the introductory part of this thesis, the evolution of *P/Y* depends on the elasticity of housing supply as well as on the driving factors behind the growth or contraction of the metropolitan area. Furthermore, the institutional changes during the sample period may have influenced the *P/Y* ratio significantly. Hence, it is problematic to use *P/Y* to evaluate the prevailing housing price level.

Theoretically, the use of the price-to-rent ratio is somewhat more justifiable. There are reasons to assume that housing price and rental price levels are tightly linked. First, for owner-occupants the rental level exhibits the cost they would face if they did not own the dwelling. In other words, rental price is an implicit positive cash flow for the owner-occupants. Second, for investors rent represents the incoming cash flow from the housing investment. Hence, the rental price growth affects the demand for both owner-occupied and rental housing positively.

Due to the institutional changes there might have been structural changes in the relationship between housing prices and rental prices. For instance, in the 1970s and 80s, even before the bubble of the late 1980s, the *P/E* figure was notably higher than it has been during the last 15 years. This may be due to the expectations of the rental market deregulation to a great extent. Moreover, there are factors, such as the interest rates and expectations concerning income and population growth in the area, which affect the ratio significantly. Some of these factors are likely to be highly persistent. Therefore, the equilibrium price-to-rent ratio is expected to alter notably over time and is not likely to be stationary. Indeed, the non-stationarity of neither P/Y nor P/E can be rejected according the Augmented Dickey-Fuller test.

4.2 No-arbitrage condition

One option to assess if housing is fairly priced is the "no-arbitrage" relation between the user cost of housing and rental prices. The theoretical basis of the no-arbitrage condition lies on the asset market approach of housing markets introduced by Poterba (1984).[20] The no-arbitrage condition states that the user cost of owner-occupied housing (U)[21] should equal the rent (P^R) of similar housing. More specifically:

$$U_t = P_t\,[\sigma_t\,(1 - T_t)r^m{}_t + (1\text{-}\sigma_t)r^f{}_t + \lambda_t + M_t - i_t] = P^R{}_t, \qquad (3)$$

where M_t denotes the maintenance costs of housing and i_t stands for the expected nominal rate of future housing appreciation. M_t includes property taxes and depreciation. Here, depreciation refers to the maintenance and repair costs that are necessary to maintain constant quality of the structure. The rest of the term in the parenthesis expresses the opportunity cost of capital. In general, only a fraction σ of the value of a house is financed by mortgage. Then, the cost of the mortgage is σ times the after-tax mortgage rate, $(1 - T)r^m$, where T is the tax deductibility of mortgage interest payments in taxation and r^m is the before-tax mortgage rate. The opportunity cost of the capital tied in the house is completed by the risk-free interest rate (r^f) on the part of the dwelling financed by equity plus the additional risk premium (λ) to compensate homeowners for the higher risk of owning vs. renting.[22] Note that all the variables in (3) are in nominal terms. An inflation correction is carried out in the model by the inclusion of the expected *nominal* housing appreciation.

Although the equation is typically used to evaluate housing price level from the point of view of owner-occupied housing, the idea also applies for investment housing. Main difference is that, unlike in the owner-occupant

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[20] Poterba (1984) focuses on the price of housing structures only. Nevertheless, the same basic idea should apply (and has often been applied) to housing prices consisting of both the structure and the site.

[21] Here the user cost, U, refers to the total money value of the user cost.

[22] Englund et al. (1995) incorporate also a term catering for the effect of housing ownership on the wealth tax. In Finland, owner-occupied housing is not taxed in the wealth taxation. Hence, assuming that if the capital was not invested in housing, it would be invested in an investment form that is taxed in the wealth taxation, the wealth tax reduces the user cost of owner-occupied housing (there is an extra tax benefit). However, the rules regarding the wealth tax are complicated in Finland, and it would be highly problematic to try to include a wealth tax benefit term in (10) in an empirical application.

case, the capital gains tax is imposed on the rental returns (net of maintenance costs and interest payments on the loan that is borrowed to buy the dwelling) and on the housing appreciation when the dwelling is sold. Also the average risk premium may differ between the owner-occupants and investors. As most of the privately financed dwellings are owner-occupied in the HMA, the owner-occupants' view is taken in the forthcoming analysis.

The no-arbitrage relation can be used to illustrate the main problem with the price-to-rent ratio. From the equivalence condition in (3) we get:

$$P_t / P^R{}_t = 1/[\sigma_t (1 - T_t) r^m{}_t + (1 - \sigma_t) r^f{}_t + \lambda_t + M_t - i_t] = (P/E)^{eq}{}_t. \quad (4)$$

From (4) it is evident that the "equilibrium" *P/E*, denoted as $(P/E)^{eq}$, is the larger the lower is the risk-free opportunity cost of capital and the greater is the expected future housing price growth. Furthermore, also the risk premium and maintenance costs of housing affect the equilibrium *P/E* ratio. The discount rate in the parenthesis in (4) cannot, in general, be assumed to be stable over time or stationary. Hence, one cannot make reliable conclusions on whether housing is fairly priced or not solely by comparing the *P/E* ratio with its long-term average value.

Unfortunately, there are several complications with the empirical application of the no-arbitrage relation. First of all, due to the high transaction costs and low liquidity of housing as well as due to households' liquidity constraints, in reality, there can be slight divergence from the presented relation in the short run even if the market participants are fully rational. In particular, if households are tightly credit constrained, user cost may be lower than the rental cost for sustainable periods. If credit constraints are not significant, instead, the relation should hold in the long run. The transaction costs are far from straightforward to take account of and are therefore usually ignored in the empirical analyses employing the no-arbitrage relation as well as in the forthcoming analysis. A related problem is the measurement of an appropriate investment horizon – after all, due to the transaction costs and relatively low liquidity of housing it is reasonable to assume that, in general, the planned investment horizon of housing is relatively long. As DiPasquale and Wheaton (1994, p. 4) state, "*The expected price term refers to current or next period price inflation only if there are no transaction costs to altering housing consumption. When transaction costs impede mobility, the price term must consider planned holding periods*".

Secondly, the measurement of the risk premium and of the expected appreciation is difficult. Specifically, how should one estimate these two variables and are these variables constant through time? In addition, also the measurement of the other variables may include some difficulties. The problems are similar to the other methods to assess housing prices and, as in any empirical analysis, incorrect measurement of the variables may give rise to misleading conclusions. Nevertheless, careful analysis and data selection enables one to make relatively reliable evaluation based on the no-arbitrage relation on whether housing is fairly priced.

Notice also that the discount factor may differ notably between households. In the empirical analysis below the attractiveness of owner-occupation is assessed from the viewpoint of both existing owner-occupants and of potential first-time home-buyers that are living in rental housing. In practice, the separation is of importance only concerning the values of σ and T. The debt-to-value ratio is, in general, substantially greater for the first-time buyers than for the households that already are owner-occupants. T, in turn, has been slightly higher for first-time buyers, who buy a home for their own use, than for the other owner-occupants since 1993. A great number of the existing owner-occupants can utilize the higher T, however, because they have taken their outstanding mortgages to buy their first home.

Despite the complications, the relation between the user cost and rental prices has been utilized in a number of papers studying housing price dynamics or examining the fairness of housing prices. The assumptions employed in the literature are discussed below together with the data and presumptions used in the forthcoming calculations in this study. One problem in some of the papers presented here (e.g. in DiPasquale and Wheaton 1994, McCarthy and Peach 2004 and Girouard et al. 2006) is the use of national level data. It is highly likely that at least some of the variables in the discount factor substantially vary between different regions and cities within a country.

Expected appreciation

Typically, simple, often somewhat arbitrary, assumption concerning the expected appreciation have been used in the literature. Poterba (1992) and Girouard et al. (2006) assume that expected housing price increase equals the expected rate of overall inflation. Poterba approximates the expected inflation as the arithmetic average and Girouard et al. as the moving average of the inflation rate in the five preceding years. Englund et al. (1995), in turn, employ the average annual housing appreciation during the 1980s and Himmelberg et al. (2005) the average real growth rate of housing prices from 1940 to 2000 as the expected capital gain.[23] Himmelberg et al. include also a forward-looking component by using long-term instead of short-term interest rate in the user cost formula (see Himmelberg et al. 2005, p. 11). Furthermore, Smith and Smith (2006) use the same arbitrary values (in the base case 3%)

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[23] Unlike the other studies mentioned here, Himmelberg at al. (2005) use real risk-free interest rate and expected real housing appreciation, instead of the nominal figures.

concerning the expected appreciation for a number of different areas in the US, even though the actual expectations are likely to differ substantially between the areas. DiPasquale and Wheaton (1994), instead, calculate, what they call, rational expectations. Even these “rational” expectations are based solely on historic values of the fundamental variables.

The purely backward-looking expectations utilized in several papers may induce misleading conclusions when assessing prevailing housing prices. Past housing appreciation or overall inflation do not necessarily represent well the rational expectations. For example, if housing prices have risen rapidly during the past few years and are currently notably above the fundamental level, backward-looking expectations based on relatively short history imply fast housing inflation also in the future. On the contrary, rational agents should take the prevailing overpricing into account. That is, rational agents would cater for the adjustment of housing prices towards the fundamental level and, therefore, the forward-looking expectations would predict a substantially lower appreciation figure.

Nevertheless, because it is extremely difficult to evaluate correctly the rational expectations at a given point of time, it is understandable that mainly backward-looking expectations have been employed in the literature. In particular, the longer the horizon is, the harder it is to predict the development of the fundamental price level. Hence, assuming that the expectations with respect to the population and income growth in the area are not notably different from the historical population and income growth and that nothing radical is expected to happen in the real interest rate level, it is reasonable to employ the average appreciation during a long period in the past.[24] In the case historical averages are utilized, it should be noted that *i* should be based on the average real, not nominal, appreciation. This is because inflation figures were substantially higher in the past than today.

In the analysis below, three different assumptions are employed: the first two assume a constant real expected appreciation at zero and at 1.6% (the average during 1970Q1-1999Q4), whereas the third model presumes “perfect foresight”. The perfect foresight model assumes that households have perfectly foreseen the changes in the housing prices at a one year horizon.

Maintenance costs

The maintenance costs are typically assumed to be a constant fraction of housing prices – in Englund et al. (1995) and in Poterba (1991) *M* equals 5.5%

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[24] “Long” period refers to a time span of preferably several decades, or at least a period which includes several economic cycles. The use of an average appreciation that is based on a couple of preceding years only may cause significant problems, as discussed above.

and 4%, respectively, whereas in Girouard et al. (2006) $M+\lambda$ is set to a constant 4%. Furthermore, even though M is likely to vary substantially between different areas, Himmelberg et al. (2005) assume that M equals 2.5% in all the cities they have included in their analysis.

However, generally it is not reasonable to assume that the maintenance costs are a constant share of the value of housing. Typically, in a growing metropolitan area the appreciation of land accounts for a significant part of the housing price growth. As it is, in general, only the structure that depreciates, it is likely that M decreases in the long run in a growing metro area.

In this study, the base value for the proxy for M is the average per square meter maintenance cost of privately financed flats in the HMA in 2005 divided by the average sales price of flats in the same year. The variation in M in time is calculated based on the multi-storey housing section of the property maintenance cost indices published by Statistics Finland. Hence, M is allowed to vary in time. During the sample period M has been at most 2.9% of the value of housing (in 1980), whereas in 2006 the figure was only about 1.5%.[25] The decline in the figure is not surprising, since most of the increase in housing prices in the HMA has been due to growth in the value of land (see Oikarinen and Peltola 2006).

Risk-free opportunity cost of capital

In the literature, usually the after-tax mortgage interest rate has been assumed to equal the risk-free opportunity cost of the capital tied in owner-occupied housing (see e.g. Poterba 1991, Englund et al. 1995, McCarthy and Peach 2004, Girouard et al. 2006). At the same time the ratio of the mortgage to the value of a house has been assumed to be 100%. An exception is the analysis by Himmelberg et al (2005), where the risk-free opportunity cost of capital is measured as the ten-year US Treasury rate. Himmelberg et al. use the mortgage rate only to calculate the tax benefit. Also they employ a 100% debt-to-value ratio, however.

In reality, the debt-to-value ratio of most owner-occupiers is substantially below one. Even the first-time home-buyers often need a down-payment. Hence, the use of a 100% ratio is likely to exaggerate the tax benefits and may thereby distort the calculated user cost downwards. The distortion is

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[25] For some readers these figures may seem too small. There is a possibility that the actual depreciation is slightly greater than implied by the statistics used. Nevertheless, the employed figures take account of the repairs needed to keep constant quality at least to some extent, and it is reasonable to assume that the possible divergence from the actual δ does not affect the results notably. Furthermore, the fact that the changes in the maintenance costs (€/m^2) are approximated by the national index should not create notable problems, since the maintenance cost development has been relatively uniform throughout the country.

emphasized if the housing price level is evaluated from the viewpoint of the households that already are owner-occupants. In Finland, for instance, the average mortgage-to-value ratio was approximately 25% in 2006.[26] In the first-time home-buyer case, in turn, a 90% ratio is employed in this study.

Another problem is whether to use the average interest rate on the new mortgage withdrawals or on the whole outstanding mortgage stock. Evidently, in the calculations concerning potential first-time buyers it is sensible to use the rate on new withdrawals. Concerning the owner-occupants, on the contrary, the average rate is a more prominent stand point. T is set to equal the average marginal income tax rate prior to 1993 and the capital income tax rate or 30% (first-time buyers) from 1993 onwards. Furthermore, it is assumed that the deduction ceiling is not binding in either of the groups. Finally, the 12 month Euribor is used as the risk-free interest rate.

Risk premium

Also the risk premium is typically assumed to be constant in the empirical applications. Both Flamin and Yamashita (2002) and Himmelberg et al. (2005) assume a risk premium of 2%. Poterba (1991), instead, uses a 4% risk premium, while Englund et al. (1995) and McCarthy and Peach (2004) do not include a separate risk premium at all. Himmelberg et al. claim that even the 2% risk premium may be overly high. Indeed, there are some factors that may decrease λ. Firstly, households might derive extra utility from owning a house (e.g. ability to customize the interior or pride of ownership). Secondly, also renters confront uncertainty – typically, tenants can expect to have to move more frequently than owner-occupants, and the future development of rental prices is uncertain. In fact, owner-occupation may work as a hedge against the risk of unanticipated future rental price movements (see Sinai and Souleles 2005). On the other hand, the risk premium should be the greater the higher the debt-to-value ratio is, since the use of debt increases volatility of the return on equity.

The assumption of constant risk premium does not include similar problem to the constant M. That is, although the risk premium may vary in time, there is no reason to believe that the risk premium is either growing or decreasing in the long run. Anyhow, a perfect model would allow the risk premium to vary over time. Because it is extremely difficult to estimate time varying risk premium reliably, a constant risk premium is assumed also in this study. Due to the rental market liberalization, λ is assumed to be greater prior to 1993 than currently. Following Flamin and Yamashita (2002), in the owner-occupant

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[26] Unfortunately, there was no sufficient data to estimate the loan-to-value ratio for the HMA. Hence, the national figure is employed.

case the post 1992 λ is set to 2%, whereas the pre 1993 λ equals 3%. As the risk premium is likely to be the larger the greater the debt-to-value ratio is, the corresponding risk premiums for the potential buyers are 2.5% and 3.5%, respectively. Obviously, a problem with the risk premiums in this study as well as in the previous literature is that they are somewhat arbitrary.

Himmelberg et al. (2005) note that the risk premium is likely to be larger in cities with high housing prices. The rationale behind this is that in cities with high housing prices the value of developed land is generally high relative to the construction costs. As the value of land is, in general, substantially more volatile than the construction costs (see e.g. Somerville 1999, Davis and Heathcote 2005, Oikarinen and Peltola 2006), housing prices are likely to be more volatile in cities with high housing (i.e. land) prices.

User cost vs. rental cost in the HMA

In the basic form, the no-arbitrage relation includes only nominal variables. To be able to utilize the constant real appreciation assumptions, an “inflation adjusted” version is used. That is, the following formula, which can be derived from (3) and includes real appreciation expectation instead of nominal, is employed to estimate the user costs:

$$U_t = P_t[-\sigma_t T_t r^m{}_t + R^f + \sigma_t(r^m{}_t - r^f{}_t) + \lambda_t + \delta_t - I_t]. \qquad (5)$$

In (5), R^f refers to real risk-free interest rate and I denotes for expected real housing appreciation. When measuring R^f, it is assumed that the households expect the overall inflation rate to equal the inflation rate during the preceding year (in the perfect foresight case, however, the households are assumed to have a perfect foresight also regarding future inflation).

The “equilibrium” and actual housing price levels are compared by dividing the estimated annual user cost by the annual rental payments. If the user cost-to-rent ratio is substantially above (below) one, the model implies that housing is overvalued (undervalued).

In some cases such a direct comparison is not possible. For instance, Himmelberg et al. (2005) compare the ratio between equilibrium and actual P/E values with its long-term (25 years) average, since their data does not allow for direct comparison. Given that in the long run U should equal P^R, it may be reasonable to assume that the long-run average, indeed, shows the equilibrium. However, if there are price bubbles during the sample period, the estimated long-run average may be distorted.

Following the previous literature, the considered investment horizon is one year. A year is a considerably shorter period than the typical holding period of housing. However, the one-year horizon does not mean that the house will necessarily be sold after a year. It is merely the planning horizon employed in the calculations. The relatively short horizon makes the calculations simple. Nevertheless, due to the high transaction costs and low liquidity of housing as well as due to the liquidity constraints faced by a number of households, the actual market prices may diverge somewhat from the presented relation even if the market participants are fully rational. A large divergence, however, would imply an existence of a bubble, assuming that the employed data is sufficiently reliable and the presumptions are realistic.

One further potential shortcoming with an analysis employing the no-arbitrage condition is the comparability of the housing price and rental price series. Here, the rental price series represent the average rent per m^2 in privately financed rental dwellings in the HMA. For consistency, also the housing price data utilized is non-quality adjusted. One problem is that the general quality of owner-occupied housing may well exceed that of rental housing. Because of this, the perceived price-to-rent ratio may exceed the actual one. In addition, the rental data are on an annual basis until 2002. Thus, the quarterly changes are approximated according to the "living, heating and light" part (1989-1999) and to the "rental cost" part (2000-2002) of the nationwide cost of living index. Finally, the rental price series represents the whole privately financed stock of rental dwellings, not only flats. This should not matter significantly, however, since some 90% of the privately financed rental dwellings in the HMA are flats.

Keeping in mind the complications and assumptions discussed above, the user cost-to-rental cost ratios are pictured in Figures 3 and 4. The curves cover 1989Q3-2006Q2, since the data on the mortgage rates is not available prior to June 1989 and also the measurement of some of the other variables is problematic in the 1970s and 80s.

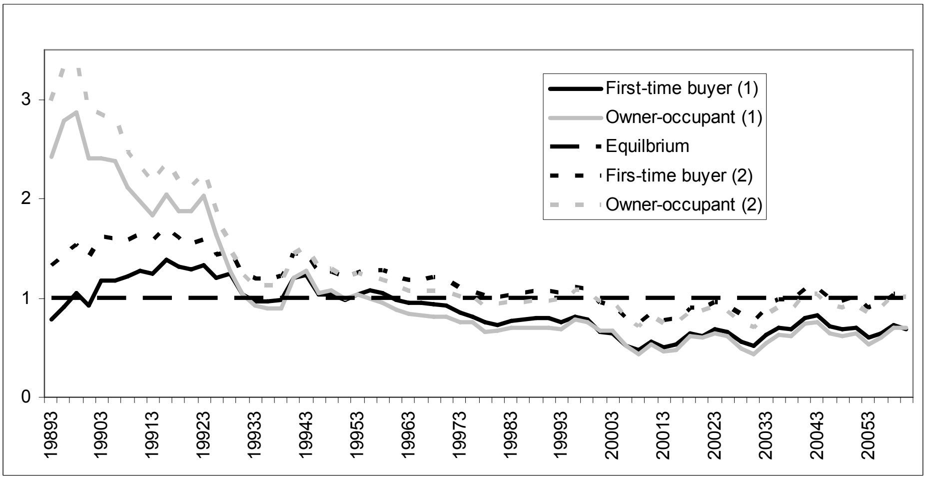

Figure 3 User cost-to-rent ratios based on the constant 1.6% (1) and 0% (2) real appreciation assumptions

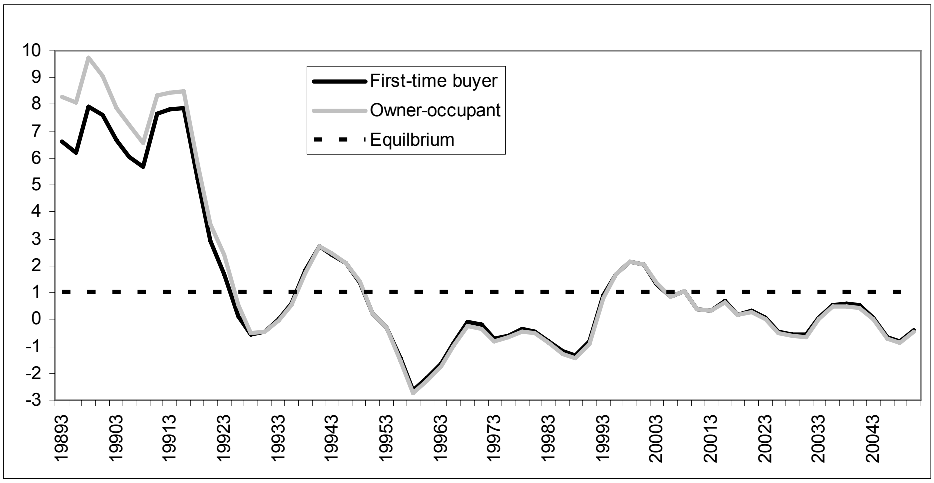

Figure 4 User cost-to-rent ratios based on the perfect foresight assumption

The notable divergence between the first-time buyers' curves and the average owner-occupants' curves before 1993 is due to the high level of nominal mortgage rate together with the approximately 50% tax deductibility of mortgage interest payments. Since 1993 both the deductibility and the mortgage rate level have been substantially lower, and the curves of potential home-buyers and owner-occupants have moved close to each other. While the calculations indicate that housing was overvalued in the late 1980s and early 1990s, the analysis suggests that in 2006 housing was not overpriced.

There is no particular reason to believe that the expected population and income growth in the HMA would notably differ from the past growth figures.

The real interest may be at a somewhat higher level in the future than in 2006, however. Hence, in 2006Q2 the 1.6% real appreciation figure may have been too optimistic. Nevertheless, even the assumption of no real appreciation justifies the price level in the end of the sample. In fact, according to the constant real price assumption the perceived price level is almost exactly equal to the fair housing price in 2006Q2. Furthermore, in 2006Q2 the user cost-to-rent ratio was slightly below its average of 1993Q1-2006Q2, i.e. the period when rental prices have not been controlled in the privately financed sector. Notice that, as the discount factor was relatively small in 2006 (mainly due to the low real interest rate level), the "fair" housing price level was expected to be relatively sensitive to changes in the real interest rate, in the risk premium or in the expected appreciation.

Because of the volatility of housing appreciation, the curves produced by the perfect foresight model are much more volatile than the other curves. The perfect foresight assumption is probably highly unrealistic. Nevertheless, the message told by this model is that since 1993 the user cost of owner-occupied flats has been on average only a little over zero. This implies that, on average, households have underestimated the future housing price growth rate after 1992. That is, households have probably not been able to foresee the substantial population and income growth in the HMA and the considerable decline in the interest rates. On the other hand, considering the whole period from 1989 to 2006 one would have been better of by living in rental compared to owner-occupied housing, assuming that the underlying assumptions and employed data are adequate. This is due to the price bubble at the turn of the decade together with the low, administratively controlled rental prices before 1993.

It is unrealistic to assume that the expected housing appreciation is constant through time. For instance, the constant expected appreciation figures do not take into account the expected future changes in the interest rates. Therefore, the appreciation expectations employed here might lead to somewhat misleading conclusions. Notice also that none of the ratios presented in Figure 3 seem to be stationary. The perfect foresight assumption in turn, cannot be used to assess current housing prices since future appreciation is not yet known. Furthermore, while the perfect foresight model is clearly forward-looking, it is unrealistic and may lead to false views concerning past housing prices. For instance, the model leads to a conclusion according to which housing was significantly undervalued in 1987. Clearly, the conclusion is not based on the fundamentals in 1987 but to the housing price bubble that peaked in 1989.

In any case, the calculations show that the current price level is not based on expectations of rapid future appreciation. Figure 5 pictures the expected real annual appreciation implied by the model (i.e. the value of I_t with which U_t=$P^R{}_t$). As it became clear above, the implied expected appreciation equaled zero in 2006Q2. Obviously, this does not support the existence of a bubble. Instead, a bubble might be implied if current prices were founded on great expected appreciation.

It is interesting to notice that during the peak of the bubble in 1989 the price level did not necessitate huge real appreciation expectations for those who had large debt-to-value ratios. This is probably one explanation for the fact that the bubble grew so large as the financial deregulation led to an increase in the average mortgage-to-value ratio of the households.

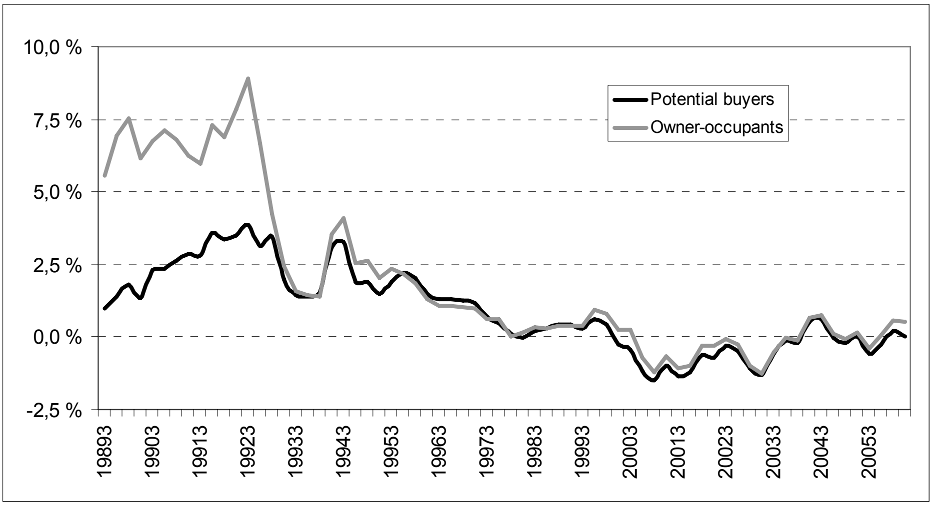

Figure 5 Expected appreciation implied by the no-arbitrage relation

5 ECONOMETRIC ANALYSIS

Because of the complications with the ratios presented in the previous section, econometric analysis can be used to get further information to assess housing prices. A benefit of the following econometric analysis is that it gives information regarding HMA housing price dynamics as well. This information can be utilized e.g. to forecast future housing price movements. Quarterly data over 1975Q1-2006Q2 are utilized in the econometric analysis.

Cointegration analysis employing the Johansen (1996) methodology is used to investigate if there exists a stationary long-run relation between real housing prices, real aggregate income, loan-to-GDP ratio and the real after-tax lending rate. Cointegration means that there exists a stationary linear combination between the (non-stationary[27]) variables, so that the variables cannot drift apart in the long run.[28] Previously Hofmann (2004), using data over 1980-1999, found that real property prices, real GDP, credit-to-GDP ratio and real interest rate form such cointegrating relation in all of the 16 industrialized countries (including Finland) that he incorporated in the analysis.

After the investigation of the long-run relation, short-run housing price dynamics are examined. Both error-correction (ECM) and vector error-correction models (VECM) are estimated. In addition, innovation accounting is conducted and forecasts are derived based on the estimated models.

5.1 Long-run relation

The Johansen Trace test statistics based on a VECM with two lags in differences, centered seasonal dummies and an unrestricted constant are reported in Table 1. The lag length of the model is grounded on the Hannan-Quinn Information Criteria and likelihood ratio tests for residual autocorrelation at one and four lags. Note that the reported values are small-sample corrected Trace values as suggested by Johansen (2002).

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[27] The augmented Dickey-Fuller unit root test results are reported in Table A2 in the Appendix.
[28] More detailed information about cointegration and the Johansen methodology is presented in section 6 of the introductory chapter.

Table 1 Johansen Trace test statistics

Hypothesis	r=0	r≤1	r≤2	r≤3
Trace statistics	53.1	23.8	5.4	1.2
P-value	.01	.21	.77	.26

The Trace statistics clearly suggest that there is one stationary linear vector between the four variables. Expectedly, both income and interest rate can be restricted to be weakly exogenous.[29] On the other hand, because of the potential two-way interaction between housing prices and credit, it is not unanticipated that *L* appears to adjust towards the long-run relation. The estimated long-run relation is as follows (standard errors in the parenthesis):

$$P = .418{*}Y + .505{*}L - .011{*}IR$$
$$(.120) \quad (.230) \quad (.010)$$

The model is reasonably close to the one estimated by Hofmann (2004) for the whole country using data from 1980 to 1999.[30] Note that real interest rate is not statistically significant in the long-run relation. This is congruent with the findings of Hofmann. Furthermore, although the ADF test suggests that *IR* is stationary, the long-run relation would be stationary even without *IR* in the model. Hence, it is obvious that the existence of a stationary relation based on the Johansen test is not due to *IR*.[31] In any case, *IR* is included in the long-run model, since the theory expects that credit demand as well as housing demand is dependent on the prevailing interest rate (e.g. Goodhart and Hofmann 2007, p. 90). In line with the theory, Hofmann estimated real interest rate to be significant in the long-run relation for all of the other 15 industrialized countries included in their study except for Finland.

The small size and insignificance of *IR* may well be due to the informational content of the loan-to-GDP ratio. As discussed above, it is expected that *L* takes the current and expected future interest rate into account at least to some extent. Especially if the role of the expected interest rate movements on housing price level is notable, i.e. if housing prices include notable forward-looking components regarding the real interest rate, it is anticipated that the effect of current interest rate is relatively small. In fact, as Goodhart and Hofmann (2007, p. 37) state, real interest rate is usually

[29] P-value of setting both *Y* and *IR* weakly exogenous is .31 in the small-sample corrected LR test suggested by Johansen (2000).
[30] The model estimated by Hofmann (2004) is as follows: $P = .294{*}GDP + .595{*}L - .005{*}IR$. Hofmann's study employed a property index that included both housing and commercial property.
[31] In general, any stationary variable included in the Johansen test would lead to finding an additional stationary relation.

considered to be mean-reverting. If *IR* is indeed mean-reverting, then the housing demand of forward-looking agents with long planned holding period of housing should not react strongly to changes in the prevailing level of real interest rate. In the empirical literature the impact of a %-point interest rate change on housing prices is generally estimated to be larger than the 1.1% reported in this study. Nevertheless, a value of less than 1% in the HMA is reported by Kuismanen et al. (1999). Furthermore, Hofmann estimated a coefficient of 0.5% in Finland.

As Hoffman notes, the start of the European Monetary Union (EMU) may have given rise to a structural break in the system. Hence, both recursive and backward recursive estimations are employed to investigate the stability of the long-run relation and of the adjustment speeds of *P* and *L*.[32] The recursive estimation does not show evidence of structural break due to EMU or to any other reason. Thus, it seems reasonable to assume that the estimated long-run relation holds despite the several institutional changes during the sample period.

Figure 6 shows that real housing price level has deviated substantially from the estimated long-run relation during the sample period. Figure 7, in turn, exhibits a major explanation for the large deviations. Figure 7 shows the deviation of *P* from the long-run relation together with the finished new housing construction.[33]

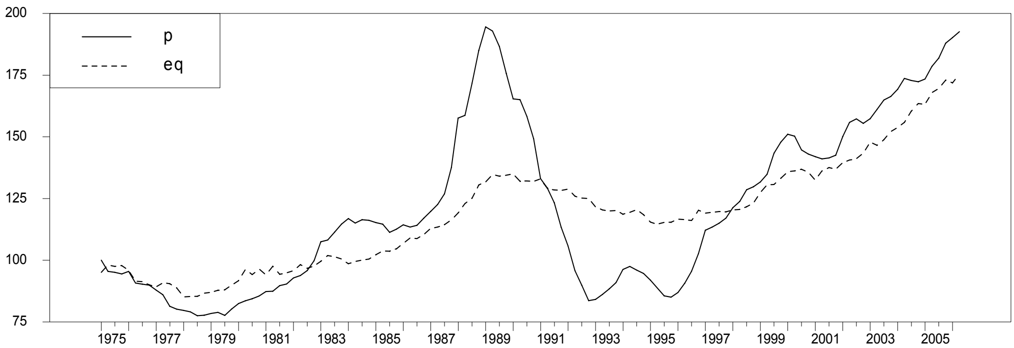

Figure 6 Actual real housing price index (p) and the fit from the estimated long-run relation (eq)

[32] The recursive estimations are conducted with the program CATS2 (see Dennis 2006, pp. 93-112).
[33] Due to the substantial seasonal variation and other volatility in the construction series, the centered moving average (with width of eight quarters) of the finished construction is shown in Figure 7.

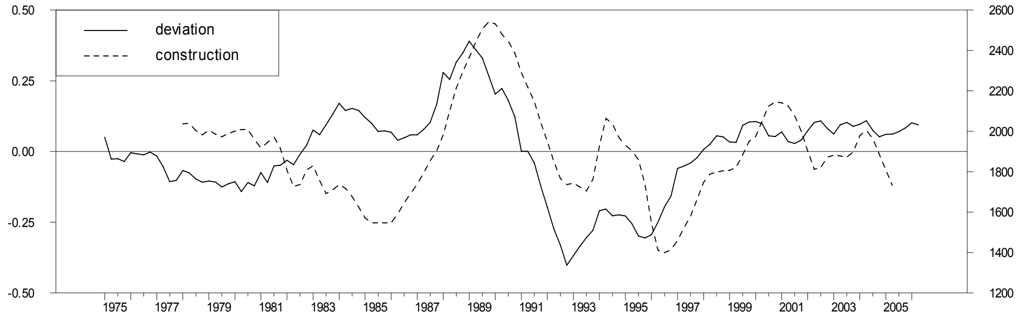

Figure 7 Deviation of real housing price level from the long-run relation (left scale) and new housing construction (right scale)

Price level was relatively close to the long-run relation until the late 1987. The financial market liberalization resulted in overheating in the housing market and in 1989Q1 real housing price level peaked being some 40% over the long-run relation. Because of the delay from the construction decision to the completion of new housing, housing supply reacted to the growing demand in the housing market with a notable lag. Eventually, the price bubble burst but the amount of new finished construction continued to increase. Finished housing construction topped almost a year after housing price level had already started to fall. Housing prices overreacted downwards in the early and mid 1990s. This overreaction was amplified by the delayed adjustment of supply. Three years after the peak of the bubble, i.e. at the end of 1992, *P* was about 40% below the estimated long-run level.

In 1996 real housing price level started to rise again. Since then *P* has increased by some 120% (the situation in 2006Q2). Figure 7 shows that, again, housing supply responded with lag. The real price level has been slightly over the long-run relation continuously since 1998 suggesting that housing supply has still not fully adjusted to the growing housing demand. In 2006Q2 *P* was little less than 10% over the long-run relation. The deviation from the relation is not larger than that, even though *P* has climbed to the level of the peak of the bubble in the late 1980s, since population and income have grown substantially in the HMA and because the liquidity constraints have eased notably due to smaller down-payment ratios, longer loan maturities and lower mortgage rates.

Of course, there may have been structural changes in the supply side that are not catered for by the estimated model. The recursive analysis, however, implies that the estimated relation still holds in the long run. In any case, it is evident that the sluggish adjustment of housing supply has greatly magnified the cycles in housing prices, just as suggested in section 2.2.

The fact that housing seems to be slightly overpriced according to the econometric long-run model is not necessarily in conflict with the results of the analysis employing the no-arbitrage relation. The estimated long-run relation implicitly incorporates the assumption that the housing supply adjusts accordingly when housing prices are over the long-run relation. In addition, the loan-to-GDP ratio is expected to contain information about future expectations regarding income growth and movements in the real interest rate. In the no-arbitrage relation the adjustment of supply and other future expectations can be taken into account only through the expected appreciation component. Based on the estimated econometric long-run relation even the assumption of constant real housing price level over the next few years might be overstated.

Note, however, that the estimated model does not automatically suggest that the real housing price level should drop in the future in order to get back to the long-run relation. Real housing prices can, for instance, stay still, and the divergence from the long-run relation can vanish due to (possible) growth in *Y* and *L*. At least in nominal terms housing prices are typically rigid downwards. Since 1975 the only period when nominal housing prices have notably dropped in the HMA is the period after the bubble of the late 1980s. Note also that the complications with the data may lead to slightly flawed coefficient estimates in the long-run model.

Anyhow, the econometric model and the analysis based on the no-arbitrage relation together suggest that in 2006Q2 there was no alarming overpricing in the HMA housing market. In particular, it seems obvious that the price level was not based on high expected appreciation.

5.2 Short-run dynamics

The coefficients of the long-run relation exhibited above indicate what happens to the real housing prices in the long horizon if one of the explanatory variables changes by one unit and all the other explanatory variables are held constant. However, the explanatory variables are likely to be dependent on each other and also on housing prices. Hence, as pointed out by Lutkepohl (1994), it is often unrealistic to assume that in the real world the actual long-run effects are expressed entirely by the coefficients in the long-run relationship.

To take into account the interrelations between the variables VECM including *P*, *Y*, *L* and *IR* is estimated[34]. The VECM, including two lags in

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[34] The model is summarized in Table A3 in the Appendix.

differences and seasonal dummies, incorporates the slow adjustment of housing prices and bank lending towards the long-run relation as well as the short-run linkages between the variables and autocorrelation in the variables.

The speed of adjustment of real housing prices towards the long-run relation is estimated to be 7.2% per quarter. This is well in line with the findings of Takala and Pere (7%) and Kosonen (15%) regarding national housing prices, and indicates that it takes ten quarters before half of the deviation of housing prices from the long-run relation is vanished due to the adjustment of *P*. The 7% quarterly adjustment speed corresponds to an annual adjustment of about 20%. That is, housing price adjustment is highly sluggish.

Also the loan-to-GDP ratio appears to adjust towards the long-run relation. This is not surprising since there is likely to be a significant two-way interaction between housing prices and bank lending (see e.g. Goodhart and Hofmann 2007, pp. 148-149). The estimated adjustment speed of *L* is 3.6% per quarter. The figure is reasonably close to the corresponding national value of 5.8% reported by Hofmann (2004).

The ordering of the variables in the innovation accounting is done similarly to Hofmann (2004) and Goodhart and Hofmann (2007), i.e. the ordering is the following: *Y*, *P*, *L*, *IR*. It is therefore assumed that aggregate income does not contemporaneously respond to innovations in any of the other variables, but may affect all the other variables within the quarter. This ordering also assumes that housing prices are rather sticky, so that they are not contemporaneously influenced by changes in household borrowing or the mortgage rates. Real interest rate is allowed to respond within a quarter to shocks in any of the other variables. The ordering reflects the common assumption that interest rate changes are transmitted to the economy with lag.

Figure 8 plots the impulse response curves of real housing price level to one percent positive shock to the aggregate disposable income, to the loan-to-GDP ratio and to the housing prices themselves as well as to one %-point shock to the real after-tax lending rate. The responses are shown up to 40 quarters from the initial shock.

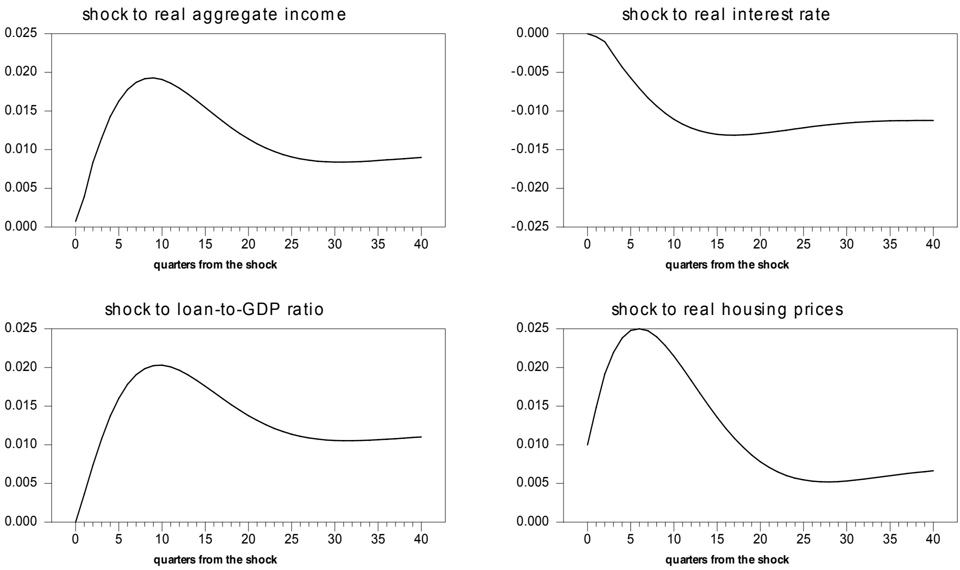

Figure 8 Impulse response functions of real housing prices to one unit shock in each of the variables in the long-run model

The impulse response functions indicate expectedly that it takes a long time for the housing market to fully adjust to a shock. The housing price adjustment after a shock in the fundamentals is congruent with the theoretical considerations in section 2.2 in the introductory chapter of the thesis. After a positive shock housing prices underreact at first, failing to fully incorporate the new information. Price level keeps rising, however, and at some point overshoots. Eventually, as the supply responds to the housing price growth, housing prices start to gradually adjust towards the new long-run equilibrium. It appears that it takes as long as approximately two years before the downwards adjustment begins.

Note that in line with the suggestion of Lutkepohl (1994) the long-run impacts of shocks to Y and L on housing prices differ notably from the ones implied by the coefficients of the long-run relation. It appears that the substantially greater long-run response of P to a shock in Y or L indicated by the impulse responses than by the long-run coefficients is to a large extent due to the two-way interaction between housing prices and lending. While Y does not respond to a shock in the other variables notably, L seems to be influenced substantially by a shock to Y or to P (see Figures A1 through A3 in the Appendix). An increase in lending augments housing demand, which in turn further amplifies lending. A direct shock to L can occur, for instance, due to loosening in the households' liquidity constraints (lower down-payment ratios or longer maturities) or because of changes in current or expected interest rate.

Interestingly, the estimated impulse response of *L* after a shock in *P* differs remarkably from the one reported by Goodhart and Hofmann (2007, p. 152). The estimations of GH do not support the assumption that housing prices notably influence lending in the Finnish case. The divergence between the results reported in this study and the results of GH may be due to the difference in the sample periods. GH employ a substantially shorter sample period, i.e. 1980-1999, than the one in this paper.

The response of real housing price level to a shock in real interest rate exhibited in Figure 8 is similar to the one presented in GH (see p. 155). The long-run effect of one %-point rise in the real after-tax interest rate is only about one percent based on the model. Such a faint overall influence of the interest rate on housing price level is somewhat surprising.

Note that the lower the discount factor presented in (4) is, the greater the impact of a %-point interest rate increase on housing prices should be. Hence, the reported coefficients for the interest rate are *average* responses of real housing prices to an increase in the real after-tax lending rate. It is likely that in the current environment with relatively low lending rate the negative influence of an interest rate increase on real housing prices is greater than the one implied by the model.

To get additional information concerning the importance of different variables in housing price determination, variance decomposition is conducted based on the VECM (the decomposition for *P* is shown in Table A4 in the Appendix).[35] The variance decomposition proposes that in the long run housing prices are equivalently driven by *Y* and *L*. Innovations in these two variables together explain little less than 40% of the long-run forecast error of *P*. Again, the influence of *IR* appears to be rather small, about 5% in the long horizon. More than half of the forecast error variance seems to be due to shocks to *P* itself even in the long-run.[36]

Finally, two different error-correction models are estimated for the HMA real housing price movements. These ECMs are shown in Table 2. Lagged changes of the variables are used in ECM1 so that the model can be utilized for prediction purposes. ECM2, instead, includes also contemporaneous changes.

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[35] The forecast error variance decomposition shows the proportion of the movements in a series that are due to its "own" shocks versus shocks to the other variables in the model (Enders 2004, p. 280).

[36] Interestingly, the model suggests that housing price movements explain more than half of the development of the loan-to-GDP ratio as well.

Table 2 Error-correction models for real housing price movements[37]

	ECM1			ECM2	
Constant	.006	(.004)		.006	(.004)
ΔP_{t-1}	.381**	(.103)		.372**	(.097)
ΔP_{t-2}	.184**	(.077)		.211**	(.071)
ΔY_{t-1}	.204*	(.110)		.197*	(.104)
ΔL_t				.414**	(.125)
ΔL_{t-1}	.325**	(.138)		.298**	(.131)
$\Delta stock_{t-1}$	.119**	(.025)		.111**	(.024)
Q2	-.020**	(.006)		-.022**	(.006)
Q3	-.014**	(.005)		-.016**	(.005)
Q4	-.002	(.005)		-.003	(.005)
D1988Q1	.098**	(.008)		.095**	(.080)
$p_{t-1}-p^e_{t-1}$	-.043**	(.017)		-.064**	(.018)
Adjusted R^2	.629			.655	
	p-values			p-values	
Reset	.78			.28	
J-B	.67			.14	
LM(1)	.14			.08	
LM(4)	.32			.11	
LM(4)-heter	.00			.00	

ECM1 shows that the HMA housing price movements are highly predictable at least in the relatively short horizon – more than 60% of the quarterly variation in housing price movements can be explained by the lagged variables only. The corresponding figures reported in the empirical literature for national and local housing markets in the other countries typically vary between 40% and 70% (see e.g. Abraham and Hendershott 1996, Lamont and Stein 1999, Capozza et al. 2002, Riddel 2004, Harter-Dreiman 2004). Employing Finnish data, Takala and Pere (1991), Kosonen (1997) and Laakso (2000) get fits around 65%. Note that a dummy variable, which takes value one in 1988Q1, is included in the model. By far the sharpest real price rise (13.6%) in the whole sample took place in 1988Q1. Without the dummy the residual in 1988Q1 is extremely large and the normality of the residual series is rejected at the one percent level of significance. Hence, the dummy is needed in order to fulfill the normality assumption concerning the residuals.

Also the ECMs imply that housing prices adjust towards the long-run equilibrium level sluggishly. According to ECM2 only about 6% of the

[37] Standard errors in parenthesis. * and **, respectively, denote for statistical significance at the 10% and 5% level. *Q2*, *Q3* and *Q4* are the three seasonal dummies. The standard errors are based on a covariance matrix that is computed allowing for heteroscedasticity as in White (1980). J-B stands for the Jarque-Bera test fo residual normality, LM(1) and LM(4) are the Lagrange-multiplier tests for residual autocorrelation at lag lengths one and four, and LM(4)-heter is the fourth order Lagrange-multiplier test for heteroscedasticity in the residuals.

deviation between the actual prices and the long-run relation vanishes during a quarter due to the adjustment of the price level. Holly and Jones (1997) found the adjustment in the UK housing market to be asymmetric. That is, they report results according to which the downwards adjustment of real housing prices is more rapid than the upwards adjustment. There are some sign of similar adjustment dynamics in the HMA. The difference between the upwards and downwards adjustment is not statistically significant and Schwarz Bayesian Information Criteria do not recommend the inclusion of two different speed of adjustment parameters to the model, though.

Anyhow, given the slow adjustment of housing prices towards the fundamental level, the large coefficients for the one and two quarter lagged housing appreciation may enable an emergence of a substantial over- or undervaluation in the HMA housing market. The significant lagged appreciation reflects the existence of backward-looking elements in the expectations formation.

In line with the findings of Jud and Winkler (2002), the results suggest that current stock appreciation can be used to predict future housing appreciation. The coefficients suggest that one percent higher stock appreciation predicts about 0.1% greater housing price growth in the following quarter. Stock price movements may reflect changes in the market risk premium. On the other hand, stock appreciation may also influence housing prices through the wealth effect, as suggested by Jud and Winkler. In any case, the significance of the lagged movements in *Y*, *L* and stock prices supports the claims that housing demand adjusts to new information slowly.

The perceived real housing price movements (continuous curve) together with the prediction based on ECM1 are presented in Figure 9.

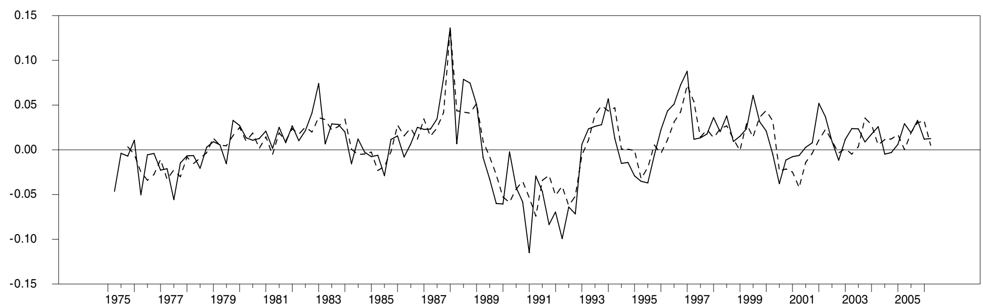

Figure 9 Actual real housing price movements and fit from ECM1

It is probably more reasonable to utilize the parsimonious ECM1 for prediction purposes than the VECM that incorporates a large number of variables, since a large number of the coefficient estimates in the VECM are imprecise (in the sense that standard error is large relative to the coefficient). The preliminary information published by Statistics Finland indicates that real housing price level continued to rise in the HMA during 2006Q3-2006Q4. The increase was approximately 3%. ECM1 is not able to predict this kind of rapid price increase – the model predicts an increase of 0.7%. For the whole year of 2006 the out of sample forecast of the model (using data over 1975Q1-2005Q4) is a 6.6% real housing appreciation. According to the preliminary information the actual figure is 8%. From 2006Q2 to 2007Q2 the model anticipates a real price growth of 1.3%.[38] In 2007Q2 housing price level would still be some 8% over the long-run relation.[39]

[38] The short-run movements of L are predicted based on an estimated ECM model ($\Delta L_t = .004 + .248*\Delta L_{t-2} - .038*E$, where E is the deviation of L from the long-run relation). Changes in Y, IR and stock prices, in turn, are predicted by ARIMA models.

[39] The implications and prediction of a model that is based on annual data are similar to those of the quarterly models reported in the section. The only notable difference is the substantially larger speed of adjustment parameter of housing in the annual model. The annual model is summarized in the Appendix.

6 SUMMARY AND CONCLUSIONS

The real housing price level more than doubled from the end of 1995 to the second quarter of 2006 in the Helsinki Metropolitan Area (HMA). This, together with the constant claims of the existence of housing price bubbles in many countries all over the world, has raised the question of whether housing is substantially overvalued in the HMA. This question is of importance because housing price movements in the HMA are not only affected by the general economic conditions but are also likely to have substantial effects on the Finnish macroeconomy.

The long-run equilibrium level of housing prices is affected by a number of variables. The often used simple methods to analyze the sustainability of housing price level, such as the price-to-income ratio and the price-to-rent ratio, ignore many of the factors that drive housing prices. Furthermore, institutional changes may alter the relations between housing prices and variables, such as income and rent level, driving them. Therefore, more detailed and rigorous analysis is needed to evaluate the existence of overvaluation in the housing market. One option is to employ the no-arbitrage relation between the user cost of housing and the rental price level.

Also the no-arbitrage relation has got its complications. Hence, an econometric analysis is conducted to study the HMA housing prices in more detail. One benefit of the econometric analysis is that it gives information regarding housing price dynamics by providing estimates for the magnitude of the impacts that the changes in different driving factors have on housing prices. In this study, a cointegrating long-run relation is estimated between real housing prices, real aggregate income, loan-to-GDP ratio and real after-tax lending rate using a quarterly dataset from 1975Q1 to 2006Q2. The estimated model appears to work well despite the several institutional changes during the sample period.

Neither the analysis utilizing the no-arbitrage relation nor the econometric model give evidence of substantial overpricing in the HMA housing market. The estimated long run model, though, indicates a slight overvaluation in 2006Q2. The econometric analysis suggests that during the last ten years the considerable growth in the real disposable income and in the population of the HMA together with the loosening in the liquidity constraints faced by households have rapidly increased the long-run equilibrium level of housing prices.

Accordant with the previous literature, the estimated error-correction models imply that housing prices adjust towards their long-run relation sluggishly. It is found that less than 10% of the deviation between the actual price level and the long-run estimated long-run relation vanishes during a quarter due to the housing price adjustment. The analysis also indicates that housing price dynamics involve backward-looking elements. Because of the backward-looking features and of the sluggish adjustment of housing supply, housing price movements are highly predictable and a notable over- or under-pricing of housing may emerge after a shock to the fundamentals. Moreover, the econometric analysis indicates that there is a significant two-way interaction between housing prices and household borrowing. Also the speed of adjustment of credit towards the long-run relation is slow, suggesting that the deviation of housing prices and credit from the long-run relation can be quite persistent.

Even though the results suggest that there is no bubble in the HMA housing market, housing prices in the area may drop notably during the next few years. A significant decline in real housing prices could originate from adverse shock to economic fundamentals or to psychological factors. In any case, assuming that the population and income level in the HMA keep growing in the future, the real housing price level is expected to increase further in the long horizon. Due to the scarcity of land in desirable locations, it is inevitable that in a growing metropolitan area the real housing price level increases. One might see the price growth as a natural and desired counterforce to centralization in Finland. On the other hand, some economists claim that the success of the HMA is crucial to the whole Finnish economy and, thereby, may see the inflexible housing supply in the HMA as a threat to the whole macroeconomy.

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APPENDIX 1 ANNUAL MODEL

Estimated long- and short-term models based on annual data 1975-2005

Johansen Trace test statistics:

Hypothesis	r=0	r≤1	r≤2	r≤3
Trace statistics	44.8	19.5	7.0	1.5
P-value	.09	.47	.59	.23

Long-run relation: $P = .326{*}Y + .742{*}L - .013{*}IR$

Error-correction model (standard-errors in parenthesis):

Constant	-.024	(.025)
ΔP_{t-1}	.560**	(.181)
ΔY_{t-1}	.733	(.575)
ΔL_t	.960**	(.443)
$p_{t-1}-p^e_{t-1}$	-.529**	(.150)
Adjusted R^2	.459	
	p-values	
Reset	.22	
J-B	.20	
LM(1)	.36	
LM(4)	.06	
LM(4)-heter	.58	

Forecast for real housing appreciation in 2006: 7.7%
Actual real housing appreciation in 2006: 8.0%
Forecast for real housing appreciation in 2007: 1.7%

APPENDIX 2 ADDITIONAL TABLES AND FIGURES

Table A1 Summary statistics of the differenced series[40]

Variable	Geometric mean (annualised)	Standard deviation (annualised)	Jarque-Bera (p-value)	1st order autocorrelation
Real housing prices	.005	.037	.000	.663**
Real aggregate income	.008	.019	.000	.067
Loan-to-GDP ratio	.005	.017	.617	.267**
Real after-tax lending rate	.001	.010	.000	-.055
Real stock prices	.012	.099	.447	.425**

Table A2 Augmented Dickey-Fuller test results[41]

Variable	Level (lags)	Difference (lags)
Real housing prices[c,s]	-1.70 (2)	-3.81** (1)
Real aggregate income[c,2]	-.32 (4)	-2.35* (3)
Loan-to-GDP ratio[c]	-0.18 (2)	-4.38** (1)
Real after-tax lending rate[s]	-2.91**(4)	-5.99** (3)
Real stock prices[c]	-.92 (5)	-4.66** (4)

[40] * and ** denote for statistical significance at the 5% and 1% level, respectively.
[41] [c] and [s] indicate that a constant and seasonal dummies, respectively, were included in the test for the level. Seasonal dummies are included also in the test for the differenced *IR*.

Table A3 Summary of the estimated VECM model

Explanatory variable	Dependent variable			
	ΔY_t	ΔP_t	ΔL_t	ΔIR_t
Constant	.007**	.007	-.004	.002
ΔY_{t-1}	-.096	.276*	.061	-.043
ΔY_{t-2}	.066	.290*	.123	-.026
ΔP_{t-1}	.095	.498**	.022	-.042
ΔP_{t-2}	.072	.218*	-.071	-.058
ΔL_{t-1}	-.052	.319*	.043	.018
ΔL_{t-2}	.016	.185	.268**	-.010
ΔIR_{t-1}	-.068	.031	-.051	-.153
ΔIR_{t-2}	-.092	.038	-.093	-.182*
Q1	.014**	.010	-.001	-.002
Q2	.016**	.017*	-.004	.001
Q4	.013**	-.003	.001	.000
e_{t-1}		-.072**	.036**	
Adj. R^2	.24	.57	.32	.16
LM(1) (system)	.39			
LM(4) (system)	.07			
Jarque-Bera	.00	.05	.71	.01

Table A4 Decomposition of variance for real housing price level[42]

Step	*Y*	*P*	*L*	*IR*
1	.002	.998	.000	.000
2	.020	.968	.012	.000
5	.086	.857	.056	.002
10	.138	.751	.103	.008
20	.179	.649	.149	.025
40	.194	.578	.178	.050

[42] The variance decomposition is derived based on the Choleski decomposition where the order of the variables is: $Y - P - L - IR$.

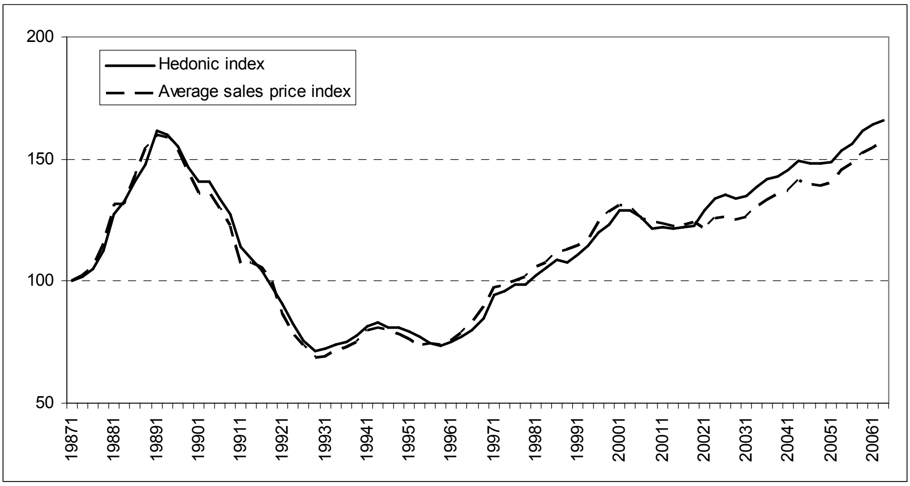

Figure A1 Average transaction price index and hedonic price index 1987Q1-2006Q2

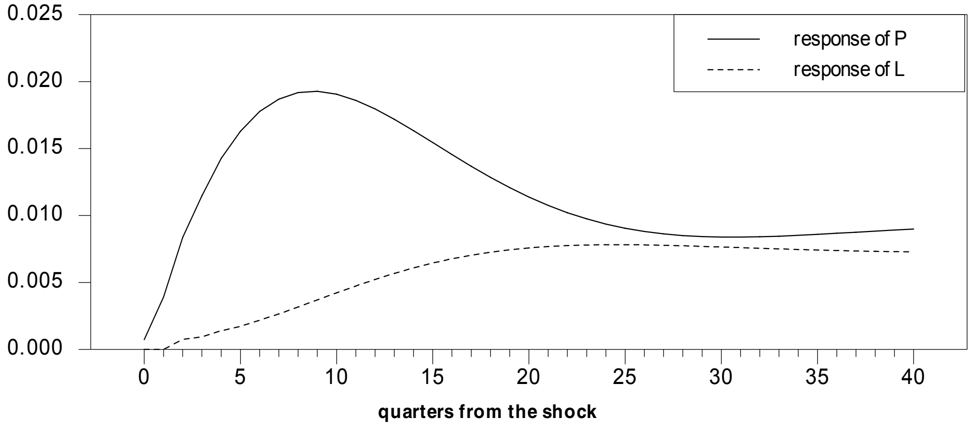

Figure A2 Impulse responses of real housing prices and loan-to-GDP ratio to one percent positive shock to real aggregate income

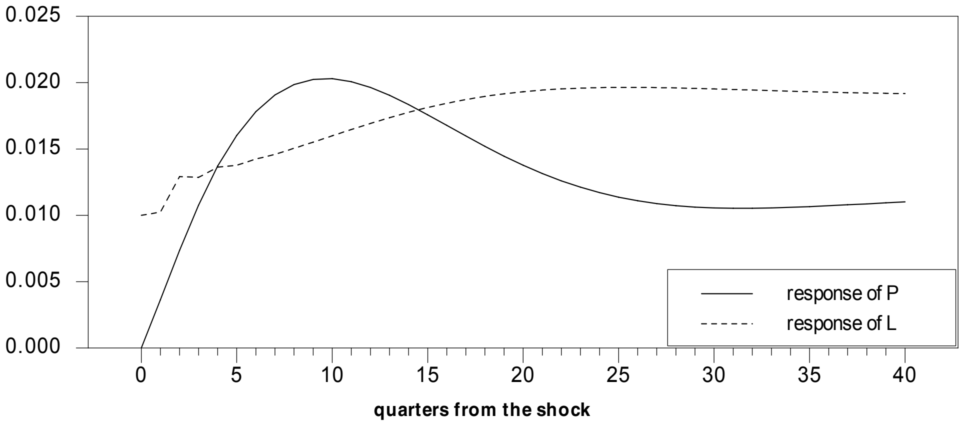

Figure A3 Impulse responses of real housing prices and loan-to-GDP ratio to one percent positive shock to loan-to-GDP ratio

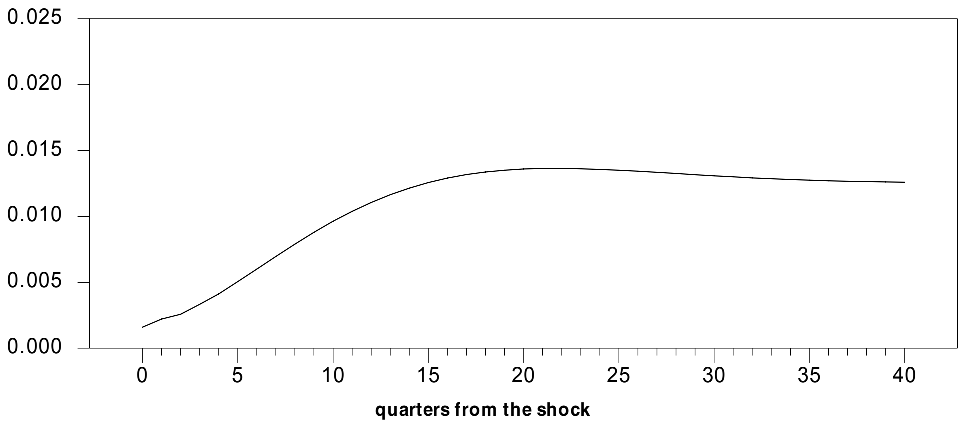

Figure A4 Impulse response loan-to-GDP ratio to one percent positive shock to real housing price level

HOUSING PORTFOLIO DIVERSIFICATION POTENTIALS IN THE HELSINKI METROPOLITAN AREA

Abstract

This study aims to examine geographical housing portfolio diversification potentials in the Helsinki Metropolitan Area (HMA) in the short and long run. The data used in the analysis consist of hedonic quarterly housing price indices from 1987 to 2006. The risk diversification potentials inside the HMA are analysed by dividing the HMA into six submarkets. As a comparison, diversification potentials between cities across Finland are examined. The correlation analysis illustrates that it may be misleading to employ short-term correlation figures when evaluating housing portfolio diversification potentials. Housing is, typically, a long-term investment and, while quarterly correlations might indicate the existence of substantial diversification opportunities, the actual long-run diversification prospects may be small. In the HMA and across the cities added in this study, the correlation figures approach one as the observation window is lengthened. This indicates weak long-term diversification potentials. Expectedly, the cointegration analysis shows that housing prices are more tightly linked between the HMA submarkets than between the cities. This finding suggests that the diversification prospects inside the HMA are somewhat weaker than across the country. Nevertheless, since it seems that also housing price co-movement between the cities is relatively strong, 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.

Keywords: Housing, investment, diversification, cointegration

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 a given risk level. The diversification 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, in different areas inside one country or in different submarkets within 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 as well as due to distinct political risks in different countries. Regional differences in social and economic structures can make regional diversification obtainable also inside a country.

The idea of diversification possibilities within 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 submarkets. 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 the HMA, which includes four different municipalities, i.e. Helsinki, Espoo, Vantaa and Kauniainen, there are altogether about one million inhabitants, which makes the area by far the largest urban area in Finland. Due to the size and existence of heterogenous subareas in the HMA, it may be assumed that the diversification possibilities inside the area are more significant than in any other urban area in Finland. Furthermore, a major part of Finnish housing investments, especially of the investments of the large institutional investors, is located in the HMA. The fact that the co-movement between housing returns in 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 HMA using quarterly data from 1987 to 2006. 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 relatively illiquid asset.

The presented problems do not eliminate the diversifying possibilities of a housing portfolio as such. Nevertheless, the illiquidity and high transaction costs of housing make direct housing investments mainly long-horizon investments. The inefficiencies mentioned above are likely to have also other consequences. 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 and Lynch 1999, Lynch and Balduzzi 2000, Barberis 2000, Campbell and Viceira 2002). Due to the inefficiencies, it is probable that housing returns in Finland are predictable. Therefore, a long-term investor should probably not make the same choices as an investor that has got a shorter horizon. Furthermore, return predictability makes the traditional unconditional mean-variance analysis inefficient 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 a long-run relationship that long-horizon diversification potentials are negligible.[1]

Indeed, housing returns between many areas may exhibit long-term relationships. Long-run movements in returns for housing are expected to be tightly linked especially within a coherent regional housing market such as the HMA. In general, co-movement between housing returns in distant cities or regions is likely to be somewhat weaker. Hence, despite the possible diversification benefits within a metro area, long-run diversification potentials are expected to be greater between remote regional housing markets. The reasons for the expected tighter relation between nearby submarkets than between distant regional markets are discussed more rigorously in sections 2.4 and 6.2 of the introductory chapter of the thesis.

A major part of this study is especially devoted to examining if housing returns co-move more strongly in the long horizon within the HMA than between different cities in Finland and to evaluating the implications of the long-run linkages on portfolio diversification potentials. The purpose of this study is not, however, to analyse in detail the impact of the predictability in regional housing returns on optimal housing portfolio allocation.

The long-term relationships are analysed employing cointegration tests. Cointegration between two markets implies that the markets are tied together by some common factor or factors so that the long-term diversification benefits gained by holding housing from both of the 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 also given to the specification of deterministic variables in the cointegration tests. This has not been done in similar studies before. It is argued 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 which cointegration tests are applied to examine the long-run relationships between housing prices 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.

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[1] Among those studies are e.g. Grubel and Fadner (1971), Taylor and Tonks (1989) and Allen and 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 and Worzala 1995).

The benefits of geographic diversification of a 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 on, 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. The results have been encouraging. Economic-based diversification has been found to be a superior diversification strategy (e.g. Mueller and 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. One of the first studies 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. 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 the area.

3 DATA

The empirical analysis is mainly based on housing price data. This is due to the lack of rental and cost data from four of the sub areas in the HMA. Furthermore, the rent and cost data are only at an annual level from the cities. It is reasonable to assume, however, that price movements work as a good proxy for total returns when analyzing diversification potentials of housing. This hypothesis 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, during 1987-2005 the annual total return correlations between the ten Finnish cities included in the analysis of this article have practically been the same as the capital return correlations.[2] The influence of the rental gains on optimal portfolio allocation may be greater than on the correlations, though, since the level of rental yield is likely to vary between different regions.

The data used to examine the intracity diversification effectiveness consists of the hedonic housing price indices of six subareas in the HMA published by Statistics Finland. The areas are Helsinki-1 (HE1, practically the centre of the HMA), Helsinki-2 (HE2), Helsinki-3 (HE3), Helsinki-4 (HE4), Espoo (ES)[3] and Vantaa (VAN). The division of the submarkets is based on somewhat arbitrary boundaries, and the submarkets are not necessarily defined in an optimal way for diversification purposes. Nevertheless, it is reasonable to use this division because it is the only one for which there are hedonic indices available. The use of non-quality adjusted price series could result in misleading results.

The geographical division into submarkets is presented in Figure A1 in the Appendix. Notice that while the submarkets differ considerably in geographic size, the variation in the size of the markets for flats, i.e. the number of flats in the submarkets, is relatively small. With the exception of HE4, which is by far the smallest market (about 10 000 flats), each of the submarkets contains some 50 000 to 60 000 flats. Furthermore, all the submarkets are not geographically coherent. This is because the division into submarkets is based not only on geography but also on an expensiveness classification by Statistics Finland.

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[2] On average the capital return correlation between the cities is .894, while the total return correlation is .892. The standard deviation of the differences of the individual correlation figures is .003.
[3] The considerably smaller town, Kauniainen, located inside Espoo is included in the Espoo figures.

To get a benchmark for the intracity diversification attractiveness, the diversification possibilities gained by investing in ten cities in Finland are analyzed as well. Also the price data regarding the cities are based on the hedonic indices of Statistics Finland. The cities are not divided into several submarkets, i.e. each city is viewed as one asset in the analysis. The cities vary greatly by location – from the HMA and Turku on the southern coast to Rovaniemi in Lappland. Moreover, the analysis includes cities whose economic structures and recent economic performance differ substantially. Hence, it would be expected that notable diversification gains are obtainable between these cities. Note also that all the cities in the analysis are provincial capitals because, in general, large real estate investors are reluctant to invest in areas other than regional centres.

There are several 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, to some extent, the heterogeneity problem that is associated with housing price data even if hedonic indices are employed. 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 price series that are based on all the housing transactions might give a wrong picture about the correlations between the areas: there are significant differences in the composition of the total housing stock in different areas. Thus, big part of the differences in returns might actually indicate possibilities for diversification by property type, not potential benefits from geographical diversification, which is the target of interest in this study.

All the price indices are quarterly and cover 1987Q1-2006Q3. Quarterly capital returns are 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. Cost of living index is used to deflate the prices. Furthermore, the annual total returns, utilized in the construction of the efficient frontiers, are calculated as:

$$R_t = \ln[(P_{t+1} + D_t - C_t)/ P_t], \qquad (2)$$

where R_t is the total return in year t, and D_t and C_t, respectively, denote for rental cash flow and maintenance costs during year t. Furthermore, in (2) P_t (P_{t+1}) refers to the average (non-quality adjusted) housing price level in the first quarter of year t (t+1). The maintenance costs in different cities are the average (per m^2) maintenance costs of flats reported by Statistics Finland.[4] Statistics Finland is the source of the city level average rental prices as well. The rental price figures represent the whole stock of free-market rental dwellings, not only the flats. Nevertheless, it is reasonable to believe that the rental data represents the rental prices of flats well, since large majority of the rental dwellings in the cities are flats. A further complication is that there is no rental data concerning the HMA sub-markets other than Espoo and Vantaa prior to 1997. The rental price levels for 1993-1996 in Helsinki-1 through -4 are estimated based on the annual change in the rental prices in the whole city of Helsinki. The calculated total returns cover 1993-2005.

Descriptive statistics concerning the real capital returns in each of the areas are presented in Table 1. According to the Jarque-Bera test, the assumptions of normality can be rejected only in two of the 16 series. All the series are strongly serially correlated, though. Also the capital returns in the three smaller cities (Vaasa, Joensuu and Rovaniemi) that do not appear to be first-order autocorrelated are significantly autocorrelated with longer lags.

Table 1 Descriptive statistics of quarterly real housing price changes from 1987Q1 to 2006Q3[5]

Area	Mean (annualised)	Standard deviation (annualised)	Jarque-Bera (p-value)	First order autocorrelation
HMA	.027	.085	.12	.707**
Tampere	.032	.079	.38	.628**
Turku	.022	.076	.16	.533**
Lahti	.019	.077	.23	.601**
Jyväskylä	.019	.078	.31	.304*
Kuopio	.026	.084	.00**	.274*
Vaasa	.016	.070	.28	.012
Joensuu	.022	.077	.21	.081
Oulu	.025	.067	.31	.418**
Rovaniemi	.014	.085	.00**	.122
Helsinki-1	.037	.101	.09	.445**
Helsinki-2	.029	.087	.07	.623**
Helsinki-3	.021	.086	.06	.585**
Helsinki-4	.017	.088	.07	.674**
Espoo	.024	.091	.05	.563**
Vantaa	.018	.090	.10	.720**

The fact that housing prices have been more volatile in the HMA than in the other Finnish regions and that volatility has been greater in the centre of the

[4] The maintenance costs are not reported at city level. The figure reported for the larger area where a particular city is located is used as the cost estimate for the city.
[5] * and ** signify significance at 5% and 1% level, respectively.

HMA than in the suburbs is not surprising. Volatility is expected to be the greatest in areas with the most inelastic housing supply. Empirical evidence from the US market accordant with the theory is reported by e.g. Abraham and Hendershott (1996). Housing supply is obviously more constrained in the HMA, especially in the centre, than in the other parts of Finland because of the relative scarcity of available land at favourable sites. Nevertheless, Table 1 suggests that real housing price movements have almost been as volatile in some relatively small cities as in the HMA. This surprising result is probably due to the fact that the hedonic indices are unable to track as much of the variation in the quality of dwellings transacted in the smaller cities as in the HMA due to the substantially smaller number of observations. That is, the quarterly figures probably exaggerate the volatility in small cities such as Rovaniemi. This view is supported by the fact that annual volatility is notably lower in both Kuopio and Rovaniemi than in the HMA.

Also the average price growth figures are in line with the theory. Housing prices have generally increased more in the cities that have grown the most in employment and population. The more rapid housing price appreciation in the centre of the HMA than in the suburbs, in turn, can be attributed to the lack of vacant land for new housing development in the centre. The restrictions on the height of the buildings in the centre are likely to fortify this effect. That is, in the other submarkets housing stock is able to respond more strongly to the growing demand.

Figures A2 and A3 in the Appendix show the development of the real housing price level in the cities and in the HMA submarkets. Obviously, both macroeconomic factors and factors specific to certain regional housing markets have driven housing prices during the sample period. During the early sample the influence of the macroeconomic factors dominated housing price movements. The extensive increase in housing prices from the early 1987 to the early 1989 all around Finland was to a great extent a consequence of the financial deregulation that took place in the late 1980s. Eventually the bubble of the late 1980s burst and housing prices declined dramatically all over the country. The drastic drop in housing prices was mainly due to two factors – housing prices climbed far beyond their long-run fundamental level during the boom and an abnormally deep recession took place in Finland in the first part of the 1990s. Furthermore, in 1993 the tax codes regarding the deductibility of mortgage interest payments and the capital income tax rate were altered substantially. Because of the major role of the macrofactors, during 1987-1993 housing price movements correlated extremely strongly between different regions.

Notice that in the forthcoming empirical analysis 1993Q1 is selected as the starting point for the second sub-sample. This is because a visual inspection of the housing price series and the equilibrium-errors from the cointegration analysis suggest that in most cases the break in the dynamics occurred at the beginning of 1993. This is also supported by the correlation coefficients.[6]

After the recession, housing prices started to increase again in most parts of the country. The macroeconomic forces, evidently, have had an important role in the housing price development in different regions since the early 1990s as well. However, regional housing price development has been substantially more heterogenous during the last 10-15 years than during the early sample. This is probably to a large extent due to the considerable differences in the performance of regional economies since the recession. Divergence between the development of regional economies has led to substantial differences in the employment growth, which in turn have caused massive migration from the peripheral regions to a few rapidly growing areas, such as the HMA. Hence, the different income and population growth rates have induced notable deviations between regional housing price growth rates.

[6] On average, the correlation figures are larger in 1987-1992 and in 1993-2006 than in 1987-1993 and in 1994-2006.

4 EFFICIENT FRONTIER AND CORRELATION ANALYSIS

In this section, correlation matrices are calculated and efficient frontiers are constructed using quadratic non-linear programming with a short-selling constraint. The correlations and frontiers are based on historical housing appreciation. As discussed in the previous section, it is reasonable to believe that the correlation coefficients based on capital returns are an accurate approximation of the correlations of the total returns. Because the correlation figures in 1987-1992 differ substantially from those in 1993-2006 and because the bubble and the deep recession in the early sub-sample were unique events not likely to be repeated[7], correlations during the early- and late sub-samples are reported separately. For the purposes of the efficient frontier analysis, also annual total returns are estimated for each market using data from 1993 to 2005. Because of the small number of observations and the other complications with the data, the efficient frontier analysis should be considered cautiously.

Correlation coefficients between quarterly real housing appreciations are presented in Tables 2 and 3. As expected, all the correlations are notably smaller in the second sub-sample than in the early part of the sample. The reported correlations between the cities are sufficiently low to indicate substantial diversification potentials. Also the correlations between the HMA submarkets have been relatively low since 1993 suggesting that significant diversification gains are obtainable through intracity diversification in the area, at least in the short run. Not surprisingly, the intracity correlations are higher than the correlations between different cities, though. The average figures between the submarkets (.66 in the second sub-sample) are not that much larger than those between the HMA and the other cities (.55), however. This implies that, taking account of the information and management efficiencies that can be gained by concentrating investments in only one metropolitan area, from the viewpoint of an investor having a housing portfolio in the HMA it may be unattractive to expand the portfolio to other Finnish regions.

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[7] The financial deregulation and the collapse of the Soviet Union, by far the most important trade partner of Finland until the early 1990s, were one-off events.

Table 2 Quarterly real housing appreciation correlations between the cities

1987-1992	HMA	Tampere	Turku	Lahti	Jyväskylä	Kuopio	Vaasa	Joensuu	Oulu	Rovaniemi
Tampere	.92	1								
Turku	.89	.85	1							
Lahti	.93	.87	.85	1						
Jyväskylä	.83	.79	.88	.82	1					
Kuopio	.85	.81	.88	.89	.84	1				
Vaasa	.69	.75	.74	.67	.73	.63	1			
Joensuu	.75	.80	.70	.72	.79	.72	.59	1		
Oulu	.84	.80	.77	.86	.64	.84	.54	.65	1	
Rovaniemi	.68	.65	.64	.56	.67	.69	.49	.63	.56	1
Average	.82	.80	.80	.80	.78	.79	.65	.70	.72	.62
1993-2006										
Tampere	.81	1								
Turku	.73	.71	1							
Lahti	.53	.49	.48	1						
Jyväskylä	.51	.53	.67	.20	1					
Kuopio	.66	.61	.62	.40	.56	1				
Vaasa	.35	.24	.28	.34	.37	.28	1			
Joensuu	.39	.41	.41	.13	.44	.32	.01	1		
Oulu	.56	.48	.64	.51	.49	.52	.37	.31	1	
Rovaniemi	.38	.39	.21	.50	.35	.34	.18	.37	.39	1
Average	.55	.52	.53	.40	.46	.48	.27	.31	.47	.35

Table 3 Quarterly real housing appreciation correlations between the HMA submarkets

1987-1992	Helsinki-1	Helsinki-2	Helsinki-3	Helsinki-4	Espoo	Vantaa
Helsinki-2	.88	1				
Helsinki-3	.88	.98	1			
Helsinki-4	.89	.92	.92	1		
Espoo	.87	.94	.94	.89	1	
Vantaa	.85	.94	.92	.95	.90	1
Average	.87	.93	.93	.91	.91	.91
1993-2006						
Helsinki-2	.66	1				
Helsinki-3	.61	.73	1			
Helsinki-4	.53	.70	.74	1		
Espoo	.40	.70	.63	.62	1	
Vantaa	.53	.71	.76	.77	.77	1
Average	.55	.70	.70	.67	.63	.71

The quarterly correlations presented above may lead to misleading conclusions, since direct real estate investments are typically extremely long-term investments. The fact that, in general, 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. 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 the longer horizon housing prices in different geographical areas may be much more tightly linked than the quarterly correlations indicate. Thus, there is a need to analyze the longer-term relationships between housing prices in different areas. In most of the related 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, rolling correlations, i.e. overlapping observation windows, are used in this study. Even the use of six-month returns increases the average correlations notably: the average correlations are .96 and .88 for the HMA submarkets and the cities across Finland, respectively, during the first sub-sample and .82 and .64 in the latter sub-sample. When employing annual returns, the corresponding figures are as high as .98 / .95 and .92 / .82. The correlations continue to grow as the observation period is lengthened even further. The annual figures are shown in Tables 4 and 5.

Table 4 Annual real housing appreciation correlations between the cities

1987-1992	HMA	Tampere	Turku	Lahti	Jyväskylä	Kuopio	Vaasa	Joensuu	Oulu	Rovaniemi
Tampere	.99	1								
Turku	.98	.98	1							
Lahti	.99	.99	.98	1						
Jyväskylä	.95	.95	.98	.96	1					
Kuopio	.98	.98	.99	.99	.97	1				
Vaasa	.94	.94	.95	.94	.94	.94	1			
Joensuu	.97	.98	.98	.98	.97	.98	.92	1		
Oulu	.97	.97	.93	.97	.88	.95	.87	.95	1	
Rovaniemi	.93	.91	.95	.91	.93	.94	.86	.93	.89	1
Average	.97	.97	.97	.97	.95	.97	.92	.96	.93	.92
1993-2006										
Tampere	.93	1								
Turku	.87	.93	1							
Lahti	.81	.89	.88	1						
Jyväskylä	.74	.88	.87	.84	1					
Kuopio	.87	.94	.88	.92	.87	1				
Vaasa	.71	.81	.74	.72	.80	.82	1			
Joensuu	.65	.78	.82	.81	.82	.77	.61	1		
Oulu	.76	.84	.82	.87	.81	.89	.76	.75	1	
Rovaniemi	.73	.84	.75	.86	.85	.88	.76	.72	.81	1
Average	.79	.89	.84	.84	.83	.87	.75	.75	.81	.80

Table 5 Annual real housing appreciation correlations between the HMA submarkets

1987-1992	Helsinki-1	Helsinki-2	Helsinki-3	Helsinki-4	Espoo	Vantaa
Helsinki-2	.97	1				
Helsinki-3	.97	.99	1			
Helsinki-4	.96	.98	.99	1		
Espoo	.96	.99	.99	.99	1	
Vantaa	.95	.99	.99	.99	.99	1
Average	.96	.98	.99	.98	.98	.98
1993-2006						
Helsinki-2	.92	1				
Helsinki-3	.88	.96	1			
Helsinki-4	.85	.94	.97	1		
Espoo	.81	.92	.93	.95	1	
Vantaa	.82	.92	.96	.97	.95	1
Average	.86	.93	.94	.94	.91	.92

The dependence of the correlations on the investment horizon is illustrated in Figure 1. The correlation figures highlight a couple of interesting observations. Firstly, the correlations grow substantially as the investment horizon is prolonged. Similar findings have been reported in many studies concerning stock market data starting from Grubel and Fadner (1971). In fact, correlations get close to one as the investment horizon is lengthened. This implies that long-run diversification potentials are much worse than suggested by quarterly correlations and that benefits gained from geographical diversification of housing portfolio are negligible in the long run. Secondly, in the long horizon the correlations between the cities across the country are almost as large as those between the subareas inside the HMA. Thus, 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 in some other city. Thirdly, the variation in the correlation coefficients between different areas decreases considerably as the observation periods get longer (see Figure 2).[8]

It is expected that the submarkets within a metro area are tightly linked even in periods with no extreme macroeconomic fluctuations, since the same local factors are likely to affect price movements in various submarkets. Hence, the fact that the correlation differences between the first and second sub-samples are smaller between the HMA submarkets than between the cities is accordant with the expectations.

[8] The reduction in the correlations and the increase in the standard deviation concerning the cities in the first sub-sample, as the observation window is extended from four to five years, are likely to be due to the extremely small number of observations (4) when five-year correlations are employed.

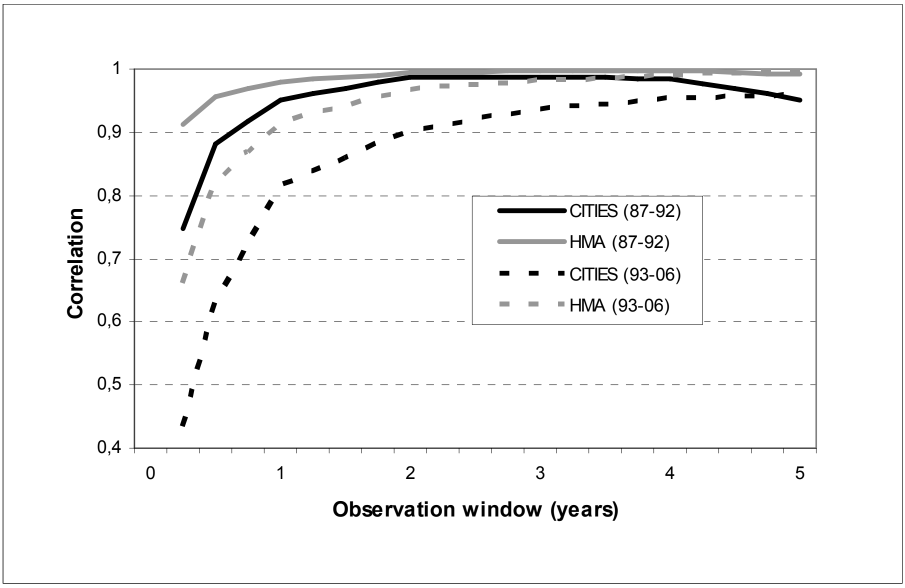

Figure 1 Average real return correlation using different observation windows

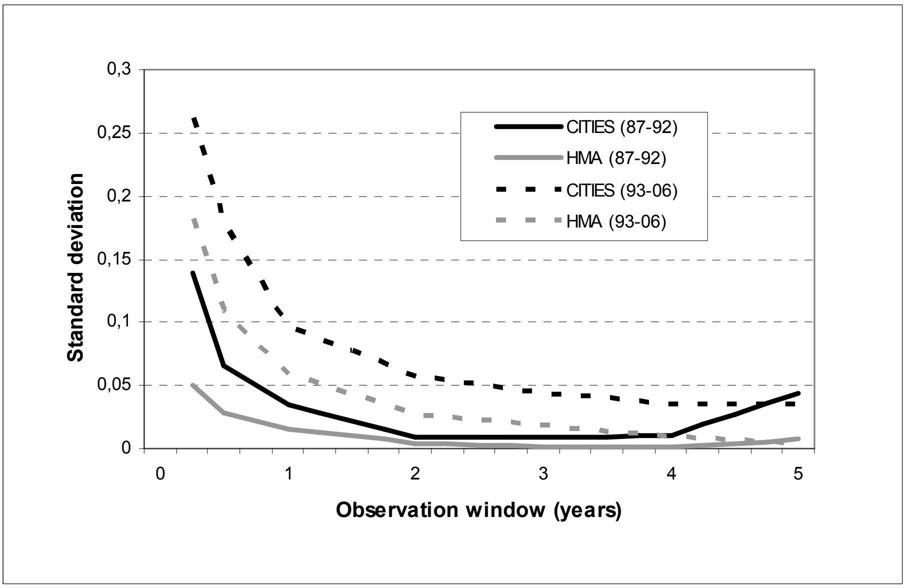

Figure 2 Average standard deviation of the return correlations using different observation windows

To get some further light into the potential diversification benefits, figures 3 through 5 present efficient frontiers based on annual returns during 1993-2005. According to Figure 3 diversifying within the HMA offers modest gains, at most a little less than one %-point reduction in the expected standard deviation. As expected, for the cities the potential amount of risk diminution through diversification is somewhat larger.

Figure 5, in turn, suggests that at the one-year investment horizon notable diversification gains are obtainable by adding housing from other cities to a portfolio consisting of only HMA housing. The black continuous curve represents the frontier when altogether 15 markets are considered (the nine cities outside the HMA and the six HMA submarkets) and the grey line is the frontier for the HMA submarkets. The division of the HMA into multiple submarkets moves the frontier of the cities (dotted curve) only slightly upwards, and it appears that, based on the historical data, an investor could concentrate his HMA portfolio only in Helsinki-1 without losing notable diversification opportunities. Interestingly, the share of the HMA in the minimum variance portfolio is zero when the HMA is considered as a single market, whereas the areas in the HMA have, in total, a weight of about 13% in the minimum variance portfolio when the HMA is divided into six markets.[9] Thus, the use of aggregated data may lead to misleading conclusion about optimal portfolio weights.

The efficient frontiers shown here are based on a relatively short sample from 1993 to 2005. The 1987-1992 period is excluded from the analysis because of its exceptional nature. Even though there may be crisis periods also in the future, it is unlikely that boom-bust cycles of the magnitude of the late 1980s and early 1990s will again take place. Nevertheless, one problem with the short sample in the efficient frontier analysis is that the period lacks any notable downturns in the economy. Hence, the expected returns that are based on history are likely to exaggerate the actual expected returns and the standard deviations may well be misleadingly low. Furthermore, it should be noted that the frontiers assume an investment horizon of one year. At longer horizons the diversification possibilities seem to be weaker and the relative riskiness of different areas may change.

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[9] Weights in the minimum variance portfolio formed by the ten cities: Vaasa 75% and Joensuu 25%. The annualised standard deviation and return for the minimum variance portfolio: 3.4% / 9.4%. Weights in the minimum variance portfolio formed by the nine cities outside the HMA together with the HMA submarkets: Vaasa 61%, Joensuu 26% and Helsinki-1 13%. The annualised standard deviation and return: 3.3% / 9.7%.

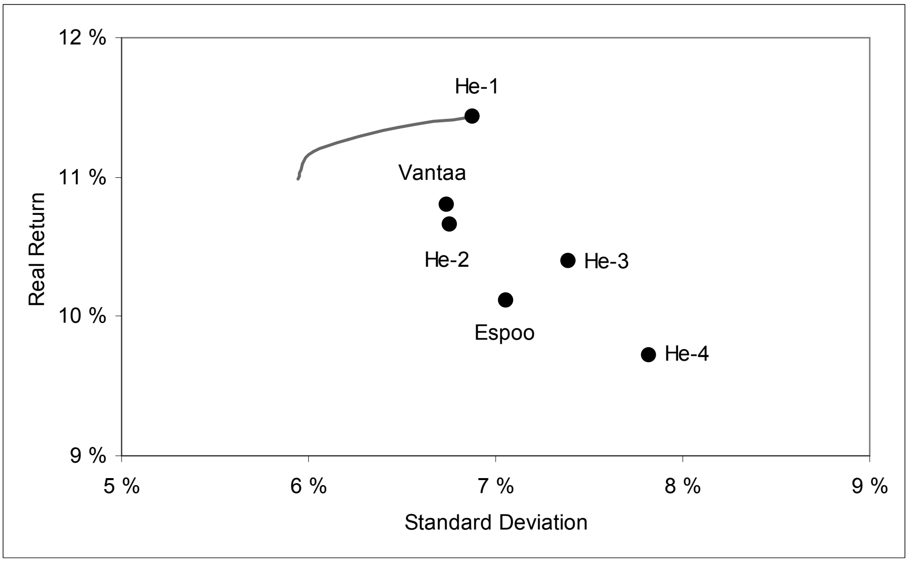

Figure 3 Efficient frontier for housing portfolio consisting of the HMA submarkets

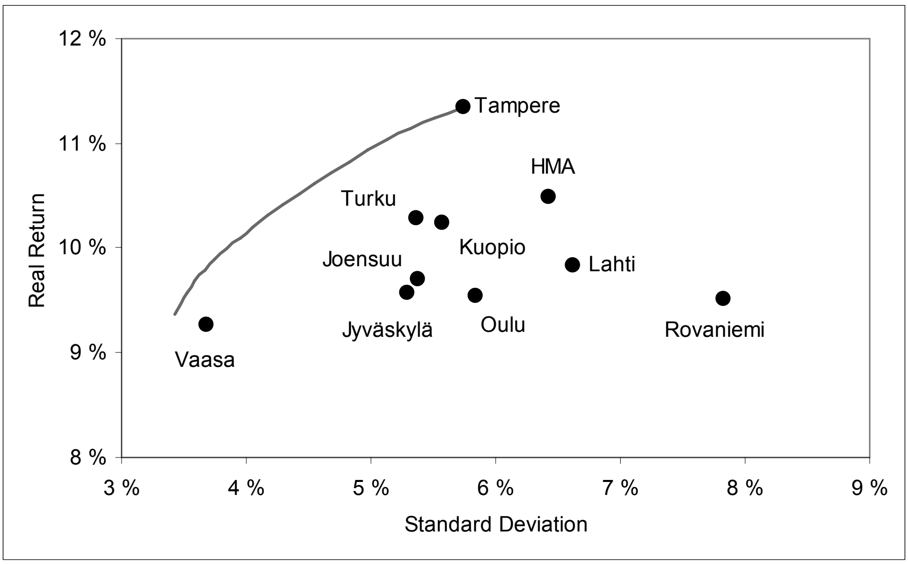

Figure 4 Efficient frontier for housing portfolio consisting of the cities

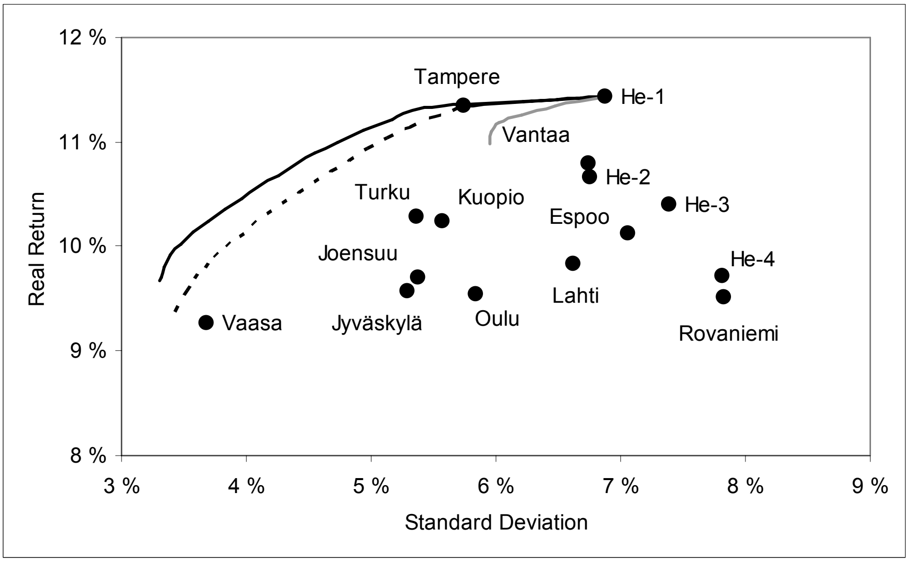

Figure 5 Efficient frontier for portfolio consisting of cities outside the HMA and of the HMA submarkets

All in all, the above analysis indicates that the long-horizon geographical diversification prospects are negligible within the HMA and small across the whole country as well. The strong long-run co-movement between the cities implies that the macro determinants have a major role in the long-term housing price formation regardless of the region. In the relatively short run, instead, notable diversification opportunities appear to be obtainable especially by investing in different cities. During a crisis period, i.e. periods when macro factors are typically dominant with respect to housing price development, even the relatively short-term diversification possibilities seem to be negligible both within the HMA and across the country.

Moreover, the observed relationship between the correlations using different observation windows suggests that there are lead-lag relations between housing price movements in different areas. This is the case even though “noise” in the housing price data may explain some part of the contradiction between short- and long-term correlations. The correlation figures also imply that the prices are predictable using previous price data. 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 may no longer be efficient — ignoring the predictability causes utility costs (see e.g. Balduzzi and Lynch 1999).

5 COINTEGRATION BETWEEN THE MARKETS

The finding that the long-run correlation figures are close to one suggests that there may be tight long-run relations between the housing prices in different markets in the sense that the prices are cointegrated. If two price series are cointegrated, then the prices are firmly linked in the long horizon through a stationary long-run relation. Since long-term relationships between housing markets have implications for portfolio diversification, it seems worthwhile to study the housing price co-movement between different areas further by employing cointegration analysis.

Cointegration is expected to exist between two regions whose dwellings are close substitutes for one another. Often dwellings are relatively good substitutes within a single metropolitan (or commuting) area such as the HMA. Cointegration, however, does not necessitate that dwellings in the areas are close substitutes. That is, cointegration between two markets implies that the cash flows and discount factors of housing in the two areas are determined by the same economic fundamentals, i.e. by some common factor or factors, so that the regional housing price levels co-move tightly at least in the long horizon. Hence, even though it is highly unlikely that two distant housing markets work as substitutes for one another, cointegration can also take place between housing prices in two distant cities. Cointegration between two remote cities is probably driven by similarities in the economic bases (and thereby in income and population development) of the regions together with the importance of the macro level variables on housing prices. In general, cointegration between distant housing markets is likely to be an exception rather than a rule.

5.1 Cointegration and diversification

Obviously, correlation between different areas is the factor determining the diversification potentials whether there are cointegrating relations between the areas or not. However, of importance is the fact that the existence of cointegration between two series that are integrated of order one means that in the long run correlation between differences of those series must approach one (see e.g. Cochrane 2001, p. 423).[10] 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, although some authors have claimed otherwise. Diversification gains are made obtainable by the possibility of temporary deviations from the long-run relation. 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 breaks in the long-term relationship may create some diversification possibilities between two cointegrated markets.

Correlation may be close to one even if the price levels are not cointegrated. For example, it is unlikely that housing prices in most of the cities in this study are pairwise cointegrated with each other even though almost all of the five-year correlation figures are close to one. Nevertheless, even if the historical correlations between cointegrated housing markets A and B are practically the same as between non-cointegrated markets X and Y, it seems likely that the future diversification potentials are greater between the markets that do not have a stationary long-run relation. It is well known that correlation coefficients may change substantially in time, whereas the cointegrating relation, especially if it is due to the substitution effect between nearby housing markets, is expected to last. In other words, because there are no strong economic forces that tie the price movements in X and Y together, it is more likely that the future price development in X deviates notably from that in Y.

5.2 Methodology

Pairwise cointegration tests are performed for all possible submarket pairs and all possible city pairs using the Johansen procedure (see Johansen 1996). Multivariate cointegration tests are not applied. This is because the aim is to find out if diversification potentials between any two areas are impaired by a tight long-term relation. Furthermore, carrying out multivariate cointegration tests might lead to mistaken inferences being drawn as illustrated by Allen and MacDonald (1995). Moreover, the relatively small number of observations would impede multiple variable analysis in any case.

It should be noted that also the cointegration analysis involves some weaknesses (in addition to the possibility of structural breaks). In particular,

[10] This does not hold with all kinds of cointegrating relations, as discussed later in this section.

the Johansen tests exhibit both power and size problems. In any case, cointegration analysis is useful here as a method giving further information about the linkages between different housing markets and thereby about the long-run diversification potentials.

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, two different vector error-correction models (VECM) can realistically be considered in the pairwise tests[11]:

Model 1:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha\beta' X_{t-1} + \varepsilon_t \tag{3}$$

Model 2:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha(\beta', \beta_1)(X'_{t-1}, t)' + \varepsilon_t, \tag{4}$$

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 of the same degree. Furthermore, if the time series are stationary, testing cointegration is not sensible. Natural logarithms of quarterly price indices in each of the distinct geographical areas are used in the cointegration analysis and hence naturally in unit root tests too. For each index the base period is 1987 with the base value being 100, i.e. 4.61 in logs. According to numerous studies[12] housing prices seem to be I(1), i.e. integrated of the first degree. Visual inspection of the price indices and of the capital returns together with their autocorrelation functions suggests 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 16 series and their differences. The number of lags in the ADF tests are decided based on the 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 utilized to detect the significance of autocorrelation in the residuals. A constant term is included in each of the ADF test, since all the indices have grown notably during the sample period. Moreover, three seasonal dummies are included in the test for the level if suggested by the Akaike Information Criteria. The unit

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[11] The models correspond to equations (19) and (23) presented in section 6.1 in the Introductory Chapter of the thesis.

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

root test results are reported in Table A1 in the Appendix. Expectedly, all the series were found to be I(1).[13]

The low power of various Dickey-Fuller tests is well known. However, the ADF results are likely to be reliable here. Firstly, the power is not a problem when studying the capital returns because unit root can be rejected at one percent level of significance in all the differenced series. Secondly, 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 accordance with the theoretical reasoning of Roll (2002). Thus, it is concluded that all the series are I(1) 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. Lag length is chosen by Hannan-Quinn Information Criteria (HQ), which is typically preferred over the other information criteria (Johansen et al. 2000, p. 233). Nevertheless, more lags are included if the LM(1) and LM(4) tests do not accept the hypothesis of no serial correlation in the VECM residuals.

The choice of the deterministic components to be included in the VECM, i.e. the choice between different VECMs, 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 interrelations between different markets the selection of the deterministic factors has not been done properly.

In this study, only models with an unconstrained drift term (μ) are employed, since real housing prices seem to be trending upwards in all the included areas.[14] As suggested by Doornik et al. (1998), Model 2 is first employed. Then the Bartlett small-sample corrected Likelihood Ratio (LR) test (see Johansen 2000) is used to test if the trend can be excluded from the model.[15] If the LR test does not reject at the 10% level, Model 1 is employed

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[13] Also stationarity of the variables during 1994Q1-2006Q3 was tested. The results are similar to those concerning the whole sample.

[14] The growing trend in real housing prices is expected because the population as well as the level of real disposable income per capita has grown notably in all the cities and submarkets during the sample period. Because of the deep slump during the sample, the real price growth from 1987 to 2006 has just not been high enough relative to its volatility in many of the areas to be able to statistically reject the hypothesis that Δx equals zero.

[15] According to a Monte Carlo analysis conducted by Canepa (2006), the Bartlett corrected LR test provides, with some caution, a reliable inference when testing linear restrictions of the cointegrating vectors.

eventually. Finally, the need for seasonal dummies in the VECMs is decided based on HQ.

Cointegration with a trend in the long-run relation (Model 2) implies that price level in one area is growing faster than price level in the other area. The reason for this kind of relationship may be, for example, regional differences in population growth and in the flexibility of housing supply (see e.g. Glaeser et al. 2005). Unlike Model 1, Model 2 does not indicate that correlation between the differences of the price series must approach one as the observation window is lengthened. Nevertheless, in the kind of relations that are found between the housing price series in this study, i.e. in relations where the two coefficients in β are relatively close to each other in size and where β_1 is small (typically substantially smaller than .01), the long-run correlation coefficient approaches a figure that is extremely close to one. Furthermore, also cointegration with a trend in the long-run relation indicates that there are economic forces that tie the price movements together.

The existence of cointegration is done by comparing the estimated Trace statistics with the quantiles approximated by the Γ-distribution (see Doornik 1998). Because of the limited number of observations, the Bartlett small-sample corrected values, suggested by Johansen (2002), are employed.

The differences between the early and late sub-samples are likely to cause significant troubles in the cointegration analysis if structural breaks are not allowed for. Hence, the methodology proposed by Johansen et al. (2000) for cointegration analysis in the presence of a break at known point of time (1993Q1) is employed. More specifically, Model 2 is the base model for the test and a change in β_1 is allowed in the model. This model, which corresponds to the model $H_l(r)$ in Johansen et al., appears to be a reasonable standpoint based on the graphs of the series. The critical values are based on the response surface tables reported by Johansen et al. Furthermore, cointegration using the sample from 1993 onwards is tested separately. This is because the short-run dynamics between the series may have changed substantially and those changes may affect the cointegration test results. In the method of Johansen et al. the parameters of the stochastic components are the same for both sub-samples, while the deterministic variables may change between the sub-samples. Hence, there is a possibility that the test on the sub-sample finds cointegrating relations that the method of Johansen et al. does not.

5.3 Results

The p-values of the small-sample corrected Trace statistics in the full-sample cointegration tests (that do not allow for a structural break) between the HMA submarkets are reported in Table 6. The cases where the hypothesis of no cointegration is rejected at the 10% level of significance are bolded. Only three cointegrated relations can be found between the HMA submarkets using the whole sample. There are also a few other statistics that are close to rejection at the 10% level, however. In particular, it seems that Helsinki-3, Helsinki-4, Espoo and Vantaa may all be cointegrated with each other. This is also suggested by the fact that if X is pairwise cointegrated with Y and Z, then also Y and Z must be cointegrated.

Indeed, the results from the tests using the second sub-sample only support cointegration between all the submarkets except for HE1 (see Table 7). Furthermore, the test using the Johansen et al. (2000) methodology confirms the existence of cointegration between the submarkets and implies that also HE1 is actually cointegrated with the other HMA areas (Table 8). The results show the importance of taking the possible structural breaks into account in the cointegration analysis. The findings probably suggest that the HMA submarkets work as relatively good substitutes for one another. Because of the substitution effect, future geographical diversification potentials, at least in the long horizon, are likely to be very small in the area. Cointegration between the HMA submarkets also explains the finding that in both sub-samples all the correlations between the markets approach one as the investment horizon is lengthened.

Table 6 p-values for the hypothesis r=0 in the full-sample pairwise cointegration tests between the HMA submarkets[16]

	HE 1	HE 2	HE 3	HE 4	Es
HE 2	.67 (t,2)				
HE 3	.86 (t,1)	.72 (t,2)			
HE 4	.73 (t,2)	.71 (t,s,1)	.26 (t,1)		
Es	.68 (t,1)	.22 (t,1)	**.00 (1)**	.11 (t,2)	
Va	.82 (t,1)	.39 (t,1)	.15 (t,2)	**.03 (1)**	**.01 (t,1)**

Table 7 p-values for the hypothesis r=0 in the pairwise cointegration tests between the HMA submarkets using sample covering 1993Q1-2006Q3

	HE 1	HE 2	HE 3	HE 4	Es
HE 2	.15 (t,4)				
HE 3	.50 (t,1)	**.03 (t,1)**			
HE 4	.34 (t,1)	**.01 (t,1)**	**.03 (t,1)**		
Es	.35 (t,1)	**.09 (t,1)**	**.06 (1)**	**.04 (1)**	
Va	.13 (t,2)	**.06 (t,1)**	**.05 (t,3)**	**.05 (2)**	**.06 (2)**

Table 8 p-values in the pairwise cointegration tests between the HMA submarkets allowing for a structural break in 1993Q1

	HE 1	HE 2	HE 3	HE 4	Es
HE 2	**.00 (1)**				
HE 3	**.02 (4)**	**.01 (1)**			
HE 4	**.06 (4)**	**.00 (1)**	**.00 (1)**		
Es	**.02 (4)**	**.00 (1)**	-	**.00 (1)**	
Va	**.00 (1)**	**.00 (1)**	**.00 (3)**	-	-

[16] In the parenthesis t denotes for a trend term in the long-run model, i.e. the use of Model 2, and s signifies that seasonal dummies were included in the model. Furthermore, the figures in parenthesis denote for the number of lags included in the VECM, and p-values lower than 10% are bolded.

Expectedly, the cointegration analysis suggests that housing markets in the cities are less interdependent than the HMA submarkets. If the whole sample is used and a structural change is not allowed, none of the pairwise tests between the cities reject the hypothesis of no cointegration, as can be seen in Table 9. However, Tables 10 and 11 indicate that catering for the structural break in 1993 housing prices appear to be tightly related in the long-run between a few cities. Specifically, it seems that housing prices in the HMA, Tampere, Jyväskylä and Oulu are cointegrated with each other. It is logical that housing prices in these four cities of all the cities included in the analysis are tightly linked. The linkage probably stems from the similarities of the economic bases in the four cities together with the importance of macro factors in housing price formation. One notable similarity between the four cities is the importance of the ICT-sector on the recent development of the regional economies. Jobs in the ICT-sector have substantially increased in all the four regions during the sample and account for a significant part of the total employment in the areas today.

It seems that the similarity of the economic bases is a more important factor concerning the housing price co-movement than the location. For example, there are many cities that are geographically much closer to the HMA than Jyväskylä and Oulu, but whose housing price development has deviated substantially more from that of the HMA than the development in Jyväskylä and Oulu. This gives support to the idea of diversification based on the regional economic structures.

Table 11 claims that there are also a couple of other cointegrating relations between the cities. Those relations, however, are hard to explain and are not consistent – if Joensuu is cointegrated with Turku and Vaasa, then also Turku and Vaasa should be cointegrated (which clearly does not seem to be the case).[17] Therefore, it appears that better long-run diversification benefits can be expected if housing from cities other than Tampere, Jyväskylä and Oulu is added to a portfolio including HMA housing.

Expectedly, geographical diversification across cities seems to offer better diversification prospects than diversification within the HMA. The possible information and management efficiencies gained by concentrating housing investments in only one metropolitan area should be kept in mind, however. Giving the large historical long-term correlations between the cities and the information and management efficiencies, it might be attractive to an investor to concentrate Finnish housing investments in the HMA or in some other city. This may be the case especially if the portfolio is relatively small.

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[17] This emphasizes the fact that one cannot completely rely on statistical tests such as the Johansen test. There is always some probability that mistaken inference is being made.

Table 9 p-values for the hypothesis r=0 in the full-sample pairwise cointegration tests between the cities

	HMA	Ta	Tu	La	Jy	Ku	Va	Jo	Ou
Ta	.27 (t,4)								
Tu	.40 (2)	.43 (2)							
La	.69 (1)	.62 (2)	.55 (t,1)						
Jy	.72 (s,2)	.48 (t,s,2)	.47 (s,2)	.53 (2)					
Ku	.47 (s,1)	.30 (s,1)	.68 (2)	.70 (t,s,2)	.85 (s,2)				
Va	.47 (1)	.21 (t,4)	.40 (2)	.74 (1)	.44 (2)	.18 (s,3)			
Jo	.31 (s,1)	.37 (t,4)	.35 (s,2)	.67 (2)	.58 (s,2)	.87 (s,2)	.43 (s,1)		
Ou	.17 (2)	.36 (2)	.46 (1)	.65 (1)	.65 (t,2)	.46 (s,1)	.30 (2)	.33 (s,1)	
Ro	.43 (1)	.28 (2)	.83 (1)	.53 (2)	.50 (2)	.70 (s,2)	.72 (1)	.95 (1)	.56 (2)

Table 10 p-values for the hypothesis r=0 in the pairwise cointegration tests between the cities using sample covering 1993Q1-2006Q3

	HMA	Ta	Tu	La	Jy	Ku	Va	Jo	Ou
Ta	.26 (t,s,2)								
Tu	.62 (t,s,1)	.91 (t,1)							
La	.26 (t,s,1)	.11 (t,3)	.83 (d,2)						
Jy	**.08 (t,s,2)**	**.10 (t,3)**	.27 (s,3)	.81 (d,1)					
Ku	.44 (t,s,1)	.79 (t,1)	.64 (d,2)	.19 (d,1)	.69 (d,s,2)				
Va	.34 (t,s,2)	.65 (t,2)	.59 (d,2)	.37 (d,1)	.45 (t,3)	.60 (d,2)			
Jo	.45 (t,s,2)	.65 (t,1)	.68 (t,s,2)	.80 (d,s,1)	.75 (t,2)	.84 (d,s,1)	.47 (t,4)		
Ou	.11 (t,s,1)	.35 (t,2)	.44 (t,1)	.54 (d,1)	**.09 (d,s,1)**	.95 (d,s,1)	.32 (d,1)	.83 (d,s,1)	
Ro	.90 (t,s,1)	.41 (t,1)	.93 (d,s,1)	.56 (t,3)	.33 (t,s,3)	.46 (d,s,3)	.29 (t,1)	.97 (d,1)	.46 (t,4)

Table 11 p-values in the pairwise cointegration tests between the cities allowing for a structural break[18]

	HMA	Ta	Tu	La	Jy	Ku	Va	Jo	Ou
Ta	.11 (3)								
Tu	.76 (1)	.51 (1)							
La	.20 (1)	.39 (3)	.32 (1)						
Jy	**.02 (s,2)**	**.00 (2)**	.95 (2)	.35 (2)					
Ku	.89 (s,1)	.17 (s,2)	.17 (s,1)	.33 (s,2)	.21 (s,1)				
Va	.68 (s,1)	.81 (1)	.81 (1)	.17 (1)	.28 (2)	.83 (1)			
Jo	.17 (s,1)	.18 (s,2)	**.02 (s,4)**	.60 (s,2)	.18 (s,2)	.16 (s,1)	**.04 (s,4)**		
Ou	**.00 (1)**	**.01 (1)**	.54 (2)	.85 (2)	**.00 (s,1)**	.53 (s,1)	.13 (1)	.17 (s,3)	
Ro	.89 (1)	.52 (4)	.98 (1)	.13 (1)	.58 (2)	.67 (s,1)	**.01 (1)**	.78 (3)	.56 (1)

[18] Some of the reported p-values correspond to the hypothesis r≤1 instead of r=0. This is because in some cases where the hypothesis r=0 is rejected at the 10% level the potential long-run relation is clearly implausible and seems to suggest rather that one of the indices included in the test is close to stationary.

6 SUMMARY AND CONCLUSIONS

Research on housing portfolio diversification potentials within a single metropolitan area is still scarce. Furthermore, the existing literature considering diversification of real estate portfolio has mainly concentrated on examining relatively short-term correlations and thereby relatively short-horizon diversification potentials. However, direct real estate investments are typically held for long periods due to the low liquidity and high transaction costs of housing. Hence, more attention should be directed towards risk reduction potentials in the long term.

The aim of this study is to examine the risk reduction gains obtainable through geographical diversification of a housing portfolio within the Helsinki Metropolitan Area (HMA) using quarterly hedonic housing price indices over 1987-2006. As a comparison, the geographic diversification possibilities across cities in Finland are also studied. The analysis is mainly based on price indices and capital returns. It is reasonable to assume that capital return correlations work as a good proxy for total return correlations. This view is supported by the data utilized in this article.

Because of the unique nature of the early sub-sample, the sample is divided into two parts in the correlation analysis. During the boom-bust period in the late 1980s and early 1990s housing price co-movement was extremely strong within the HMA and across the country both in the short and in the long run. This is not surprising, since during such periods macro factors are typically dominant with respect to housing price development. Also after the early 1990s the long-horizon geographical diversification prospects have been negligible inside the HMA and small across the whole country as well. In the relatively short run (a couple of quarters), instead, notable diversification opportunities appear to be obtainable especially by investing in different cities. Unfortunately, catering for the typically long-horizon nature of housing investments, it is hard to take advantage of the diversification potentials. In any case, the strong long-run co-movement between the cities implies that the macro determinants have a major role in the long-term housing price formation regardless of the region.

The correlation analysis illustrates that it may be, and probably usually is, misleading to employ short-term correlation figures when evaluating housing portfolio diversification potentials. While quarterly correlations might indicate the existence of substantial diversification opportunities, the actual (long-run) diversification prospects may be small. In the HMA and across the cities added in this study, the correlation figures get close to one as the observation window is lengthened.

The linkages between distinct geographical housing markets are further studied by cointegration analysis. The analysis shows that the results and conclusions may be greatly affected by structural breaks in the data. Many cointegrating relations may not be found if the breaks are not taken account of. The HMA submarkets appear to be cointegrated with each other. This is not surprising, since in addition to the common factors driving housing prices in the whole HMA the submarkets are likely to work as relatively good substitutes for one another. Because of the tight linkages between the submarkets, future geographical diversification potentials, at least in the long horizon, are likely to be very small within the HMA.

On the contrary, with the exception of four cities (HMA, Tampere, Jyväskylä and Oulu) there do not appear to be stationary long-run relations between the cities. Hence, it is claimed that the prospects of future diversification benefits are greater across the cities (that are not cointegrated) than inside the HMA. Since there do not seem to be strong economic forces that tie the price movements in most of the cities together, it is more likely that there are notable deviations in the future price development in these cities than if the markets had a strong long-run relation.

Cointegration between the HMA, Tampere, Jyväskylä and Oulu supports the idea of economic base diversification – the economic bases in all these cities are relatively similar. Note, however, that there is not necessarily a force linking housing appreciation tightly together between the four distant cities in the future. Within the HMA, instead, it is more unlikely that the long-run dependence between various submarkets would vanish. Nevertheless, since it seems that also housing price co-movement between cities across Finland is relatively strong, it may be 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.

In any case, the analysis shows that a direct housing investor should not base his portfolio analysis on quarterly correlations. Better portfolio allocation may be conducted by taking into account dynamic interrelations between different housing markets. 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.

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APPENDIX ADDITIONAL TABLES AND FIGURES

Table A1 Augmented Dickey-Fuller unit root test results[19]

City	Level (lags)	Difference (lags)
HMA[s]	-1.70 (4)	-3.45** (5)
Tampere	-1.25 (5)	-3.27** (4)
Turku[s]	-1.77 (2)	-3.12** (1)
Lahti	-1.93 (2)	-3.00** (1)
Jyväskylä[s]	-1.64 (2)	-3.30** (1)
Kuopio[s]	-2.08 (3)	-3.80** (1)
Vaasa	-1.67 (3)	-3.03** (2)
Joensuu[s]	-1.50 (3)	-3.63** (3)
Oulu[s]	-1.66 (2)	-3.31** (1)
Rovaniemi	-2.11 (3)	-3.06** (2)
Helsinki-1[s]	-1.32 (2)	-2.66** (3)
Helsinki-2[s]	-1.12 (1)	-4.15** (0)
Helsinki-3[s]	-1.85 (2)	-3.03** (1)
Helsinki-4	-2.04 (2)	-2.80** (1)
Espoo	-1.26 (1)	-4.57** (0)
Vantaa	-1.69 (1)	-3.50** (0)

[19] * and ** denote for five and one percent level of significance, respectively, and [s] indicates that seasonal dummies were included in the test for the level

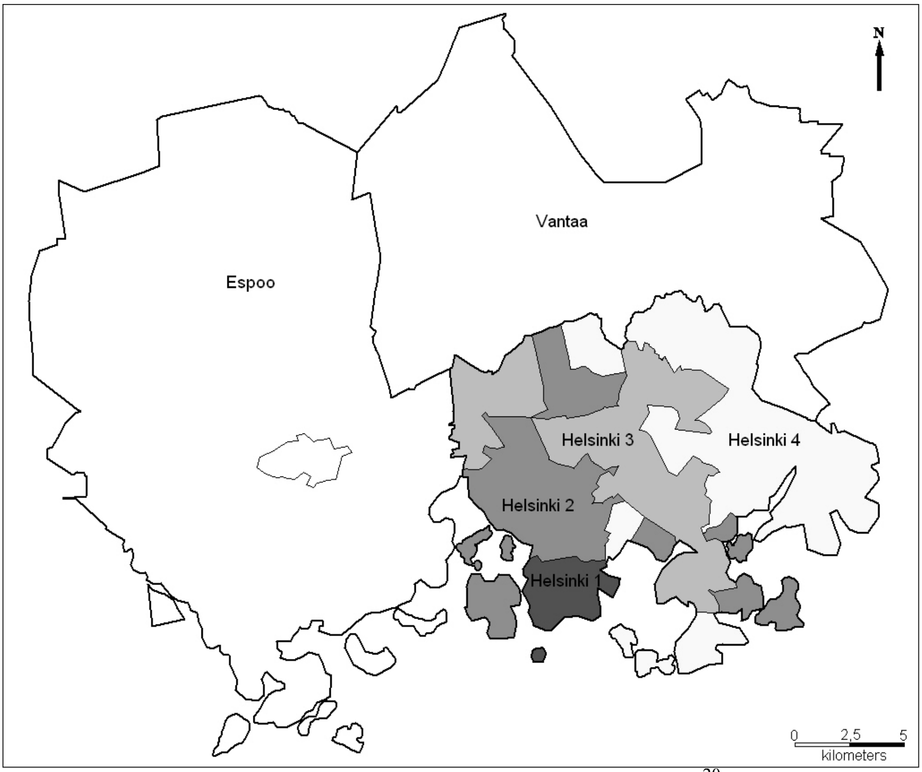

Figure A1 Geographical distribution of the HMA submarkets[20]

[20] Pohjakartta © Affecto Finland Oy, Lupa L7196/07

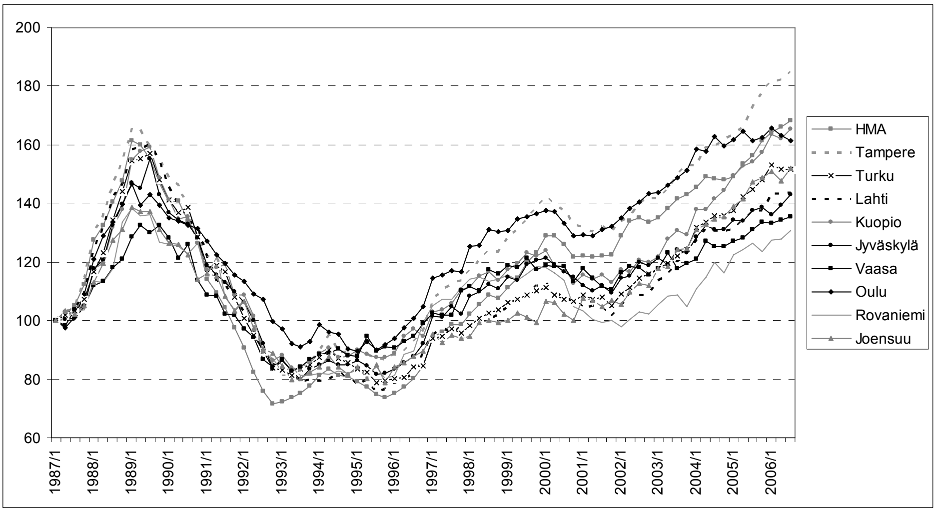

Figure A2 Real housing price indices in the cities

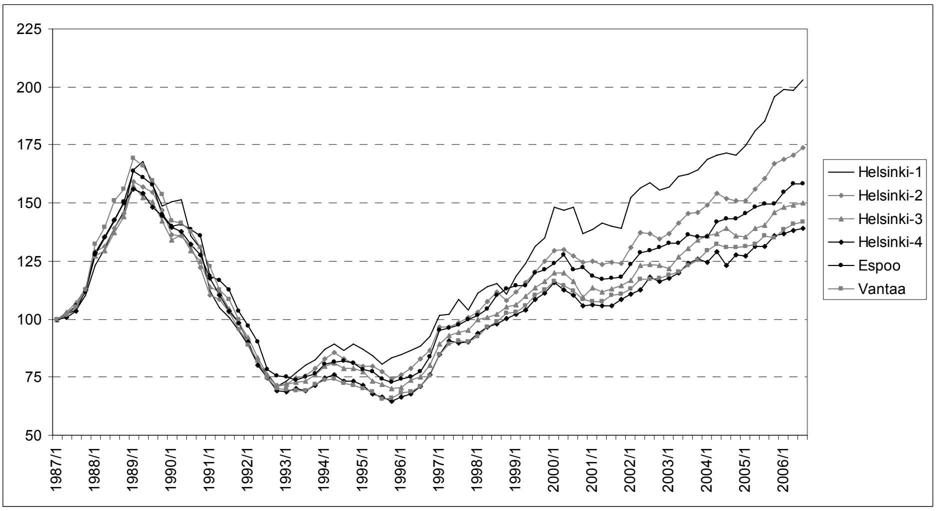

Figure A3 Real housing price indices in the HMA submarkets

THE DIFFUSION OF HOUSING PRICE MOVEMENTS FROM CENTRE TO SURROUNDING AREAS

(An earlier version of this article has been published in the Journal of Housing Research, 15 (1), 2006)

Abstract

Previous empirical research shows that there are strong interrelationships between regional housing markets. There are many reasons why housing price changes in central areas may lead housing price movements in the surrounding regions. These reasons include structural differences and economic interdependence between regions as well as informational factors. This paper studies the hypothesis that there is a lead-lag relation between housing price movements in central and surrounding areas. Vector autoregressive and vector error-correction models using quarterly data from the Finnish housing markets from 1987Q1 to 2006Q3 are estimated. The results show that housing price changes in the Helsinki Metropolitan Area, the main economic centre in Finland, Granger cause housing price movements in the other regions in Finland. Furthermore, price changes in the provincial capitals have led price movements in the surrounding provinces. Inside the Helsinki Metropolitan Area, instead, housing price changes in surrounding areas have Granger caused price movements in the city centre.

Keywords: Housing, dynamics, Granger causality, cointegration

1 INTRODUCTION

Previous research has shown that price movements in the Finnish housing markets as well as in several other countries' housing markets are predictable using historical housing price data. Nevertheless, there still appears to be little applied work on the regional housing price dynamics, despite the fact that regional housing price movements are likely to be of importance for consumer expenditure, the labour market and housing portfolio allocation. Furthermore, the predictability of price movements can be used, for example, to optimally time completion of new dwellings or transactions concerning second-hand dwellings. The dynamics of housing price movements are also of interest because they throw some light on the operation of the housing market.

It is often assumed that housing price movements diffuse from the economic centres to the surrounding regions. This view is supported by a number of empirical studies examining regional dynamics in the vector autoregressive framework (see e.g. Meen 1996, Berg 2002). The reasoning behind the leading role of main economic centres has usually been based on an assumption that business cycles hit economic centres first and peripheral areas later. There are, nevertheless, also other reasons, especially informational factors, that may cause or strengthen the leading role of the main economic regions. Inside a metropolitan area, instead, it is difficult to say straightforwardly whether the centre is likely to lead the suburbs or *vice versa*. In any case, proper empirical analysis is needed to examine if there are notable lead-lag relations between housing price movements in the centre and surrounding areas.

In this paper the dynamics between regional housing markets in Finland are examined. The relationship between housing price movements in central and surrounding areas is of a particular interest in the analysis. The aim is to study empirically if housing price changes diffuse from the central areas to the more peripheral regions, i.e. if housing price changes in central areas lead housing price movements in surrounding areas. This is done by employing vector autoregressive and vector error-correction models. The data used in the analysis are quarterly hedonic housing price indices from 1987 to 2006 concerning different housing markets in Finland. First, the dynamics between the centre and the suburbs of the Helsinki Metropolitan Area (HMA) are examined. Second, the hypothesis that housing price changes in the other parts of the country follow those of the HMA is analysed. Third, lead-lag relations between some regional centres and provinces surrounding them are also investigated.

In the next section the potential reasons for lead-lag relation between housing markets in centre and surrounding areas are discussed. After this the paper proceeds with a review of relevant literature. In the third part the data is delineated, after which the methodology used in the empirical analysis is described. This is followed by a section reporting results from the econometric analysis. In the end conclusions are derived.

2 DYNAMICS OF REGIONAL HOUSING PRICE MOVEMENTS — THEORETICAL CONSIDERATION

Housing price level may differ substantially between different regions, and different regional housing markets can be viewed as separate assets. Nonetheless, housing price changes are likely to correlate significantly between regional markets. In perfect capital markets notable lead-lag relationships between assets do not usually exist. In real estate markets, however, local nature of real estate together with substantial transaction costs, thin markets, lack of centralised information gathering and lengthy delays in information availability may well account for lagged relationships in price movements even in the absence of irrationality.

In this paper particular interest is laid on the housing price dynamics between centre areas and regions surrounding them. There are a number of reasons why it may be assumed that housing price movements in an economic centre lead housing price changes in surrounding areas. These reasons include structural differences and economic interdependence between regions as well as informational factors. The presented explanations are not necessarily suitable for analysing regional housing price dynamics within a substantially larger and more heterogeneous country than Finland, such as the US. However, within more homogenous subregions inside a large country, e.g. within single provinces or states, the reasoning should be applicable.

One potential reason to cause lead-lag relationship in housing price movements between centre and surrounding areas is the existence of regional differences in the timing of the business cycles. Business cycles usually first hit main economic centres of a country and centres of metropolitan areas. The likelihood that the central areas react first to a macro level shock is increased by the fact that financial services are usually concentrated in the centres of the major cities — financial sector is often the first one to respond to macro shocks. As a shock causes the number of jobs and the level of income to change, housing markets react accordingly. With lag the shock spreads to the surrounding areas.[1] This suggests that housing price changes in the centre area may often proxy for shocks that later affect more peripheral regions.

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[1] Naturally there are also macro shocks that hit all the regions simultaneously. This kind of shock is, for example, change in the level of real interest rates.

Another explanation for possible lead-lag relation between central and peripheral areas can be found by applying the idea introduced originally by Grossman and Stiglitz (1976). The idea is based on the assumption that there are both informed and uninformed actors in the market. Here, uninformed refers to agents who do not have even publicly available information or at least do not know how the information should affect housing prices. The more there are informed actors in the market the faster the prices are likely to fully react to a shock.

Assume, for instance, new information that positively affects the expectations of future nationwide employment and income. Having the information and knowing how it should affect housing demand in the future, informed investors are willing to buy dwellings at a higher price. Similarly of course, informed agents raise asking prices for the dwellings they are offering for sale. If all the agents in the market are informed, the price level should adjust to the new information set immediately. However, it is reasonable to believe that in all the housing markets there are a significant number of uninformed actors. For the uninformed agents 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. The bigger the share of the uninformed agents in the market the longer the adjustment process is likely to last. It may be assumed that informed actors are mainly professional investors. In Finland institutional and other professional investors concentrate their housing investments on 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 actors is larger in the housing markets of the largest centres. Provided that this is true, housing prices are likely to react faster to a shock in main economic centres than in more peripheral areas.

Findings supporting the role of informational asymmetries in creating regional lead-lag relations are reported e.g. by Clapp et al. (1995). They also suggest that, because information production is subject to positive scale economies, higher population density should foster more, better and prompter information concerning housing markets. With time this information spreads also to more sparsely populated regions. Hence, it is expected that housing price movements in densely populated centre areas lead price changes in the more peripheral regions.

The reasoning above is based on differences in economic structures or in composition and density of the actors in the housing market, and adjustment to macroeconomic shocks is seen as the driving force for lead-lag relation between regional housing price movements. It is sometimes also possible that price change in one area is at least partly caused by price change in another area. This is possible concerning two areas located relatively close to each other, i.e. areas whose dwellings are relatively close substitutes for each other. Consider, for example, the effect of migration. Migrants are typically young adults who want to live as close to the activities of the city centre as possible. Hence, migration to a metropolitan area may augment housing demand especially in the centre. Nevertheless, housing in the areas surrounding the centre is often a relatively close substitute for the dwellings located in the centre. As the housing price level rises in the centre relative to the suburbs, more of the dwellers in the centre as well as more of the new migrants are willing to move to suburbs where they can get larger dwellings with the same money.[2] This causes price level to increase in the surrounding areas with lag. In frictionless markets the length of the lag would be negligible. In housing markets, however, high transaction costs, low liquidity and lacking information may lead to notable lags in the diffusion of housing price movements.

On the other hand, causal relation between nearby areas can also be the other way around. This can be the case for example if, during a particular period, employment opportunities have grown faster in the suburbs than in the centre. Workers usually want to live near to the employment centres to avoid long commutes. Therefore, demand for housing increases in the areas where the number of jobs grows substantially. However, there are people, e.g. pensioners and students, for whom it is not particularly important to live close to the employment centres. After the relative price level has risen in the suburban areas with high employment growth, the relative attractiveness of the centre areas increases for these dwellers. Thus, the substitution effect may increase housing prices in the centre with lag. Similarly, if there is a recession in some industries that have a large number of jobs in the suburbs, housing price decrease in suburbs may lead price drop in the centre. Which way the possible causal relationship has gone during a particular period of time, is an empirical question. In any case, interdependence between nearby housing markets can generate also a cointegrating relationship between the markets.

The kind of causal relation between housing prices in different regions explained above cannot be assumed to work between areas far away from each other, i.e. between areas whose dwellings are not substitutes for each other. Nevertheless, it may also be possible that price change in one area causes price change in an area geographically far away from it. It is obvious that in the long run housing prices must reflect market fundamentals. In the short run, however, flawed beliefs concerning the fundamental value of housing as well

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[2] Empirical evidence in support of this kind of behavior is reported e.g. by Thomas (1993). Furthermore, using Finnish data Hämäläinen and Böckerman (2004) found that housing prices affect net migration negatively.

as speculation in the market are likely to have a significant effect on housing price movements.

Most of the actors in regional housing markets are not likely to have knowledge concerning the fundamental price level. Because achieving such knowledge often involves relatively high costs, for many actors it may be rational to take some reference point or benchmark based on which the "right" price level is evaluated. A prominent reference point in a relatively small and coherent country such as Finland is the national housing price index. If, for example, the national price index has risen much faster than the regional index, many actors in the regional market may form positive expectations concerning price growth in the region, even if no shock affecting regional housing market has actually occurred. The expectations may then fulfill themselves. For instance, actors in the regional market may mistakenly assume that the growth in the nationwide index has been caused by a shock that will affect regional market later. That is, many agents may be enable to distinguish changes in the national index that are caused by purely local factors in some areas, such as local employment growth, from those that are induced by shocks that have a notable effect on the whole country.

This kind of short-term interdependence between regional housing prices may be strengthened by real estate agents. Having perceived in the past that changes in the regional housing price level often follow some reference index with lag, it is probable that real estate agents base they expectations on the movements of the reference index. In the long horizon, as mentioned, the price level has to be based on the fundamental factors, however.

In the Finnish case it seems possible that the kind of causal relationship explained above could generate short-term lead-lag relation between the HMA and the other regions in Finland. This assumption is based on the fact that the national housing price figures are dominated by housing in the HMA. Furthermore, the media usually concentrate on reporting price movements in the HMA together with the national figures. So, for many actors in the market the price movements in the HMA are the ones they mainly perceive.

The endogeneity of business cycles with respect to housing wealth can strengthen causal relationship between relatively distant areas to some extent. This is due to the "wealth effect", i.e. the causal effect of changes in wealth upon consumption behaviour. Case et al. (2001) show that the effect of housing wealth upon consumption is statistically significant and appears to be more important than the wealth effect of stock market. The results of Benjamin et al. (2004) concerning US data are in accordance with Case et al.. Because of the wealth effect of housing, higher housing prices lead to higher level of consumption. Growing consumption in a given area leads to growing demand on products imported from the other areas. Thus, part of the consumption growth caused by the wealth effect “leaks” to other regions. This, in turn, causes employment and income to rise in the other areas, which leads to growing demand on housing. Through this channel housing price rise in one area can somewhat increase price level in another area with lag. It is reasonable to believe that in Finland the only area economically large enough to create this kind of notable spillover effect is the HMA.

Lead-lag relationships between regional housing prices do not necessarily imply that the markets are informationally inefficient, at least concerning all public information, i.e. semi-strong form informational efficiency. Information concerning a macro level shock comes into public knowledge often several months after the shock has occurred. Also housing price statistics and statistics concerning demographic factors are published with lag. Therefore, most of the actors in the market cannot often use relevant information to predict price level in the next quarter. The ability to predict would cause the price level in an efficient market to change already in the current quarter. Then, of course, there would be no lead-lag relationship or at any rate it should be weak.

In addition, different timing of business cycles in distinct regions may induce lead-lag relations between regional housing markets even in the absence of irrationality and imperfect and costly information. Different timing of business cycles may, at least in theory, explain also a finding that lead-lag relation between housing price changes in peripheral regions and in central areas lasts several quarters.[3] It should also be noted that, due to the high information and transaction costs involved in housing together with the illiquidity of housing, housing price predictability does not necessarily imply possibility to gain above normal returns.

To sum up, the theoretical discussion above leads to the hypothesis that future housing appreciation in peripheral areas can be predicted by current and historical appreciation in the central area. The predictive power can vary in time depending on the cause of the price movements in the centre. The theory cannot straightforwardly say whether housing price movements in the centre of a metro area are likely to lead price changes in the suburbs or *vice versa*.

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[3] This phenomenon is discussed in section 6.3 in the introductory chapter of the thesis.

3 PREVIOUS RESEARCH

Research on housing price dynamics between different regions has been relatively limited. Concerning regional housing price dynamics in Finland Booth et al. (1996) found surprisingly that Tampere is the leading city in spite of the fact that Helsinki is by far the most important economic centre in the country. Using longer time series Kuosmanen (2002), however, found evidence in support of the leading role of Helsinki. Similarly, according to Berg (2002) housing price changes in the biggest city in Sweden, Stockholm, lead house price movements in the other parts of Sweden. The findings of Kuosmanen and Berg are in accordance with the assumption that housing price movements in the biggest centres lead housing price changes in the other areas. Both of these papers concentrate in examining the short-run dynamics between the cities by employing vector autoregressive models for price changes. In neither of the studies the possible existence of long-run relationships between different regions was considered. The results of the second empirical study of this thesis, however, indicate that there are cointegrating relationships between housing prices in a number of areas in Finland, especially inside the HMA.

Long-run equilibrium relationships between regional real estate prices have been detected also in studies using data from other countries. MacDonald and Taylor (1993) found cointegrating relationships between housing prices and Tarbert (1998) between commercial property prices, in different areas in the UK. The Results of Meen (1996) are congruent with MacDonald and Taylor. Furthermore, Meen suggests that housing prices in the main economic region, i.e. South-East, lead prices in the other UK regions. Causality is not formally tested, however. There is also relevant research using data from Australia. Smyth and Nandha (2003) reported causalities and long-term relationships between Australian capital cities, and Wilson et al. (2003) found cointegration between commercial property prices in different regions in Australia. Utilising Engle-Granger and Gregory-Hansen tests Wilson et al. showed that allowing for structural breaks it is possible to find many more long-term interrelationships than when ignoring the possibility of structural breaks. That is, ignoring structural changes may lead to not finding a cointegrating relationship even though there really is one. Pollakowski and Ray (1997), in turn, found that subnational house price changes in the US are interrelated. They did not study long-term interdependences, however.

There are also some studies examining short-term housing price diffusion inside metropolitan areas. Clapp and Tirtiroglu (1994), using data from Hartford, and Clapp et al. (1995) and Dolde and Tirtiroglu (1997), employing data from Hartford and San Francisco, showed that housing price changes tend to diffuse throughout a metropolitan area. All these papers related the dynamics to imperfect information and to the informational content of price levels and movements in nearby areas. The analysis of Clapp et al. suggested that information diffusion takes up to two quarters even inside a single metropolitan area and population density is likely to quicken the information diffusion. Furthermore, some of the evidence of Clapp et al. and Dolde and Tirtiroglu seem to be consistent with explanations that admit some rational elements in regional housing price dynamics.

In summary, there has been some research on short- and long-term housing price dynamics between regions but none of the studies, at least studies mentioned above, has specifically examined (Granger) causal relationships between central and surrounding regions also catering for possible long-run interdependences. In addition, in the cointegration tests the specification of deterministic variables has not usually been done rigorously. In many cases the determination of the deterministic variables may be of great significance when doing inferences concerning the existence of long-term equilibrium relationships. This paper brings further evidence in the area by concentrating on examining causal relations between regions also in the vector error-correction framework and by justifying the use of different deterministic factors. In addition, this paper brings evidence regarding housing price dynamics within a single metropolitan area.

4 DATA DESCRIPTION

The housing price indices used in the study are based on the quarterly hedonic price indices constructed by Statistics Finland. The indices cover a period from 1987Q1 to 2006Q3 and are grounded on prices of flats sold in the secondary market. Only real indices and returns are used. Hence, the indices have been deflated using the cost of living index. Furthermore, natural logarithms of the indices are used throughout the paper.

First, two indices describing housing price development within the HMA are used. These indices are for the centre of the HMA and for the other parts of the HMA (OHMA). Second, four indices are employed to analyse the price diffusion from the HMA to the rest of the country: the HMA, the Satellites (SAT), three other growth centres in Finland (OGC) and the rest of Finland (ROF).[4] Because Statistics Finland does not offer separate OHMA, OGC or ROF indices, these indices have been constructed for the needs of this study based on the hedonic indices that Statistics Finland does provide. The method of constructing the OHMA, OGC and ROF series is explained in the Appendix. These series may not correspond perfectly to the actual price movements in the areas. Nevertheless, they are the best approximation available and the potential differences from the actual price movements are likely to be small. Finally, indices for four provincial centres and the provinces surrounding them are applied to study the dynamics between the centres and peripheral regions within provinces. The four centres and corresponding provinces are Turku - South West Finland (SWF), Tampere - Tampere Region (TR), Jyväskylä - Central Finland (CF) and Oulu - Oulu Region (OR).[5] The sample period regarding the surrounding provinces is from 1987Q1 to 2004Q4. Note that Turku is not included in the OGC, since the analysis in the

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[4] The centre of the HMA is the area Helsinki-1 defined by Statistics Finland. Other parts of the HMA cover the rest of Helsinki together with Espoo, Kauniainen and Vantaa. The Satellites refer to towns surrounding the HMA. These towns are Hyvinkää, Järvenpää, Kerava, Riihimäki, Kirkkonummi, Nurmijärvi, Sipoo, Tuusula and Vihti. Other growth centres include Jyväskylä, Oulu and Tampere. The rest of the country covers all the areas in Finland other than those mentioned above and Turku, which is the largest city in Finland after the HMA and Tampere.

[5] Statistics Finland does not publish the hedonic indices for surrounding provinces, i.e. the provinces excluding their capital cities. The reason for this lies in the reliability of those indices – the provinces outside their capital cities are geographically relatively large areas with relatively small number of observations per quarter. The provinces included in this analysis are the largest ones in population and in the number of transactions (outside of the Helsinki Region). Hence, it is likely that the “rest of the province” –indices are reliable enough to study the existence of lead-lag relations between provincial centres and surrounding areas.

previous essay suggests that housing prices in Turku have behaved somewhat differently from those in the three cities included in the OGC.

In the HMA and in all the provincial centres 40%-50% of the housing units are owner-occupied. Of all the dwellings little over 70% are flats, with the exception of Oulu where the figure is 62%. In the ROF both figures are close to 70%, whereas in the Satellites and in the surrounding provinces the share of flats is substantially smaller and the share of owner-occupied dwellings notably larger than in the centres. Investment housing in Finland is concentrated in the flats located in the centres. Hence, it may be assumed that the share of informed agents is larger in the centres than in the peripheral areas.

All the real price indices except for the HMA index are presented in Figures 1 and 2. The HMA index follows the OHMA index closely. The price development in the regional housing markets during 1987-2006 is already discussed in the previous essay.

Descriptive statistics concerning the real housing price changes in each of the areas are presented in Table 1. The Jarque-Bera test rejects the assumption of normal distribution only regarding two series. Table 1 reveals, however, that the price change series are highly autocorrelated. All the first-order autocorrelation coefficients are significant at the one percent level of significance, except for the peripheral areas in Central Finland and in Oulu Region. Note that it is expected that in the provincial centres housing prices have grown more rapidly than in the peripheral regions, since population growth rate has been substantially larger in each of the centres than in the peripheral areas and land is scarcer resource in the centres. Volatility of capital returns, in turn, has been lower in the peripheral areas.

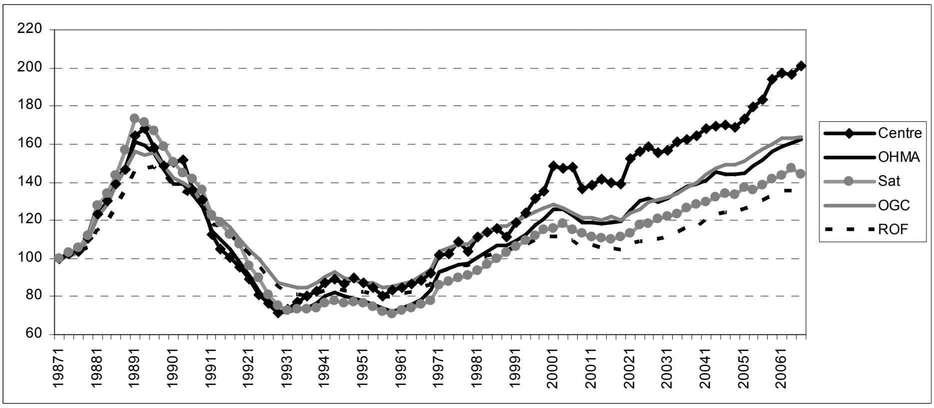

Figure 1 Real housing price indices for the centre of the HMA, OHMA, Satellites, OGC and ROF

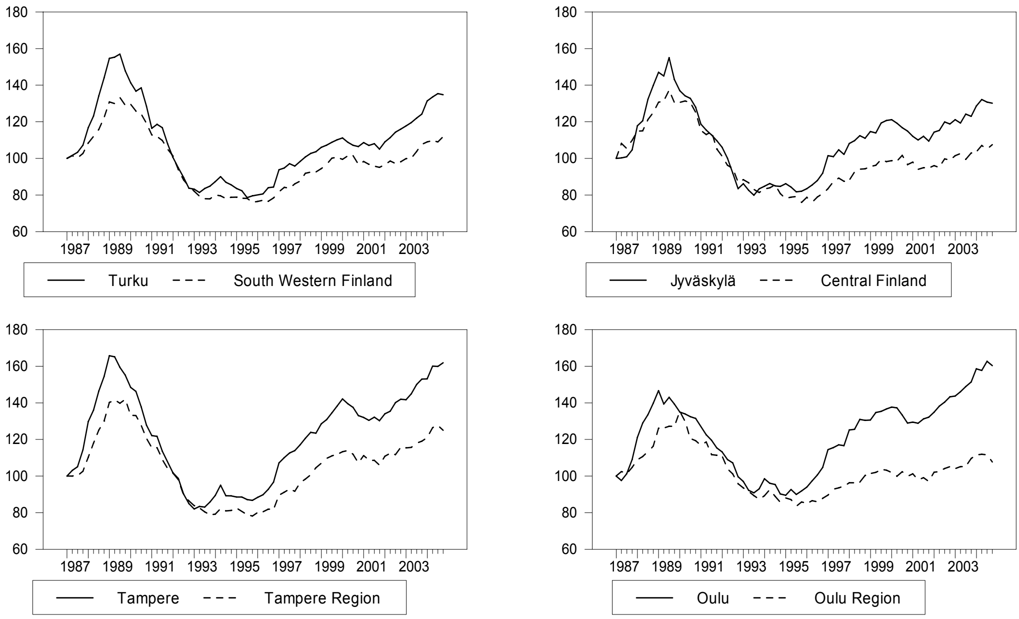

Figure 2 Real housing price indices for the provincial centres and surrounding provinces

Table 1 Descriptive statistics of the quarterly real housing price changes

Area	Mean (annualised)	Standard deviation (annualised)	Jarque-Bera (p-value)	First order auto-correlation
Centre of the HMA	.036	.101	.054	.445
Other parts of the HMA	.025	.084	.101	.721
Whole HMA	.027	.085	.116	.707
Satellites	.019	.086	.040	.704
Other growth centres	.026	.069	.256	.665
Rest of Finland	.016	.060	.100	.742
Turku	.017	.079	.391	.538
Rest of South West Finland	.006	.057	.583	.558
Tampere	.027	.082	.645	.623
Rest of Tampere Region	.013	.068	.889	.464
Jyväkylä	.015	.081	.474	.314
Rest of Central Finland	.004	.069	.237	.073
Oulu	.027	.069	.468	.433
Rest of Oulu Region	.004	.059	.589	.152

According to the ADF test all the price indices are non-stationary but for all the differenced series non-stationarity can be rejected.[6] The finding that housing prices are I(1) is in accordance with a number of studies. Since real housing prices are likely to exhibit a growing trend in majority of the included regions, a constant term is included in all the tests for the levels.[7] The unit root test results are reported in Table A1 in the Appendix.

The correlation coefficients between housing price movements of the centre, OHMA, Satellites, OGC and ROF are reported in Tables 2 and 3 using both quarterly observations and rolling annual observations. Table 2 shows the correlations during 1987-1993, while Table 3 presents the coefficients in 1994-2006. The figures are notably greater in the early than in the late sub-sample. This is expected, since housing price movements were caused mainly by macro factors during the late 1980s and early 1990s, whereas the relative importance of regional forces has been greater during the last ten years. The correlation coefficients of the centre of the HMA are smaller than the other

[6] The relatively low power of the ADF test is well known. Nevertheless, the finding that all the series are I(1) seems reliable. Firstly, the power is not a problem when studying the differences because unit root can be rejected at the 5% level of significance in all the differenced series. Secondly, none of the test statistics concerning the levels is significant even at the 10% level. Thirdly, the Johansen tests for cointegration do not indicate stationarity of any of the series. Finally, the results are expected and consistent with the theory (see Roll, 2002) and with the results in many other studies. Hence, the relatively low power of the ADF test is unlikely to have caused the acceptance of a false null of a unit root in any of the series.

[7] It is assumed that trend term is not needed in any of the unit root tests, since natural logarithms are used. Furthermore, according to the graphs and theory it is obvious that deterministic regressors are not needed when testing the stationarity of the differences. The number of lags in the tests are decided based on the general-to-specific method. Finally, seasonal dummies are included in the tested model if suggested by the Akaike Information Criteria.

reported correlations. This may due to the inflexible supply in the heart of the HMA. All the correlations figures grow as the observation period is lengthened from one to four quarters. Similar findings apply also for the correlations between the regional centres and surrounding provinces. All the coefficients are large and statistically highly significant.

Table 2 Quarterly and annual correlation coefficients of real housing price changes 1987-1992

Quarterly	Centre of the HMA	Other parts of the HMA	Satellites	Other growth centres	Rest of Finland
Centre of the HMA	1				
Other parts of the HMA	.92	1			
Satellites	.87	.97	1		
Other growth centres	.84	.95	.95	1	
Rest of Finland	.86	.96	.97	.96	1
Annual					
Centre of the HMA	1				
Other parts of the HMA	.98	1			
Satellites	.97	.99	1		
Other growth centres	.97	.99	.99	1	
Rest of Finland	.98	.98	.99	.97	1

Table 3 Quarterly and annual correlation coefficients of real housing price changes 1993-2006

Quarterly	Centre of the HMA	Other parts of the HMA	Satellites	Other growth centres	Rest of Finland
Centre of the HMA	1				
Other parts of the HMA	.72	1			
Satellites	.45	.75	1		
Other growth centres	.61	.85	.72	1	
Rest of Finland	.51	.78	.76	.88	1
Annual					
Centre of the HMA	1				
Other parts of the HMA	.91	1			
Satellites	.78	.93	1		
Other growth centres	.75	.92	.94	1	
Rest of Finland	.69	.87	.95	.97	1

Table 4 Correlation coefficients between the provincial capitals and surrounding provinces

	Turku - SWF	Tampere - TR	Jyväskylä - CF	Oulu - OR
Quarterly 1987-1992	.90	.91	.77	.52
Annual 1987-1992	.98	.97	.94	.79
Quarterly 1993-2004	.38	.66	.32	.43
Annual 1993-2004	.81	.86	.85	.86

The fact that the correlations grow as the horizon is lengthened suggests that there are dynamic interdependences between the variables. Indeed, studying the cross-autocorrelations in Tables 5 and 6 reveal that strong dynamic relations between the areas exist. Both cross-autocorrelations and own-autocorrelations are especially strong during the early sample – even the fourth-order cross-autocorrelation figures are considerable. In the late sub-sample, however, the figures are substantially smaller. The positive own-autocorrelations indicate mean-aversion in housing prices. At longer lags, however, own-autocorrelations as well as cross-autocorrelations are negative implying slight mean-reversion in housing prices. The figures turn negative somewhere between six and ten lags in the early sample, whereas the lags turn negative earlier in the latter part. The negative own- and cross-autocorrelations are much smaller in size than the positive figures at shorter lags. These findings are similar to e.g. Case and Shiller (1990) regarding the US housing markets.

The cross-autocorrelations between capitals and surrounding provinces also suggest that, expectedly, housing price movements in the capitals lead housing price changes in the peripheral areas (with the exception of Jyväskylä in 1993-2006).

Table 5 Cross-autocorrelations of quarterly real housing price changes at one- and four-quarter lags[8]

1987-1992	Centre of the HMA (lagged)	Other parts of the HMA (lagged)	Satellites (lagged)	Other growth centres (lagged)	Rest of Finland (lagged)
t-1					
Centre of the HMA	.63	.68	.68	.65	.61
Other parts of the HMA	.68	.75	.71	.70	.64
Satellites	.68	.78	.76	.77	.72
Other growth centres	.68	.76	.73	.67	.66
Rest of Finland	.71	.79	.80	.76	.74
t-4					
Centre of the HMA	.36	.35	.27	.27	.22
Other parts of the HMA	.30	.39	.25	.26	.19
Satellites	.40	.47	.44	.40	.32
Other growth centres	.35	.43	.32	.39	.33
Rest of Finland	.43	.53	.45	.47	.44
1993-2006	Centre of the HMA (lagged)	Other parts of the HMA (lagged)	Satellites (lagged)	Other growth centres (lagged)	Rest of Finland (lagged)
t-1					
Centre of the HMA	-.01*	.25*	.27*	.04	.17*
Other parts of the HMA	.37*	.53	.43	.40	.46
Satellites	.46	.60	.38	.50	.52
Other growth centres	.16*	.41	.35	.27	.37
Rest of Finland	.27*	.50	.45	.43	.48
t-4					
Centre of the HMA	.17*	-.49*	.14*	.24	.23*
Other parts of the HMA	.02*	.35	-.02	.06	.03
Satellites	-.14	-.06	.10	.03	.06
Other growth centres	-.02	-.01	-.05	.17	.12
Rest of Finland	-.01	.00	.04	.12	.13

[8] * is included in the relationships where the statistical significance of the first four lags can be jointly rejected at the 10% level based on the Ljung-Box Q-test. For instance, * indicates that the only area whose lagged values have had significant predictive power with respect to the centre of the HMA during 1993-2006 is the OGC.

Table 6 Cross-autocorrelations of quarterly real housing price changes at one- and four-quarter lags between the centres and surrounding provinces

1987-1992	City (lagged)	Region (lagged)	**1987-1992**	City (lagged)	Region (lagged)
t-1			**t-1**		
Turku	.64	.60	Jyväskylä	.41	.31
Rest of SW Finland	.67	.65	Rest of Central Finland	.36	.18
Tampere	.66	.50	Oulu	.55	.28
Rest of Tampere Region	.71	.46	Rest of Oulu Region	.52	.27
t-4			**t-4**		
Turku	.36	.17	Jyväskylä	.31	.19
Rest of SW Finland	.48	.41	Rest of Central Finland	.40	.43
Tampere	.43	.21	Oulu	.09	.11
Rest of Tampere Region	.56	.40	Rest of Oulu Region	.43	.41
1993-2006	City (lagged)	Region (lagged)	**1993-2006**	City (lagged)	Region (lagged)
t-1			**t-1**		
Turku	.08	.33*	Jyväskylä	-.03	.09
Rest of SW Finland	.41	.18*	Rest of Central Finland	.32*	-.33
Tampere	.36	.15*	Oulu	.03	.15*
Rest of Tampere Region	.30	-.01	Rest of Oulu Region	.08	-.19
t-4			**t-4**		
Turku	.10	-.02*	Jyväskylä	.19	.31
Rest of SW Finland	.19	.15*	Rest of Central Finland	.05*	.07
Tampere	.30	.18*	Oulu	.19	-.18*
Rest of Tampere Region	.20	.30	Rest of Oulu Region	.21	.01

5 METHODOLOGY

In section six the dynamic interdependences between housing prices in different areas are examined econometrically. First, the existence of a cointegrating relationships between central and surrounding areas are tested employing pairwise Johansen tests. Cointegration is tested and vector-error correction model (VECM) is estimated in the case cointegrating relationship is found due to the fact that important information concerning long-run dynamics is lost if only differenced variables are used in the analysis. Lack of cointegration implies that the dynamics are only short-run in nature. Cointegrating relationship, instead, indicates that also long-run interrelations exist.

In the Johansen tests two possible vector error-correction models are considered:

Model 1: $\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha\beta' X_{t-1} + \varepsilon_t$ (1)

Model 2: $\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha(\beta', \beta_1)(X'_{t-1}, t)' + \varepsilon_t,$ (2)

These models correspond to equations (19) and (23) in section 6.1 of the Introductory chapter of the thesis.[9] Only models with unrestricted constant are considered because *a priori* assumption for both the Helsinki centre and the OHMA indices as well as for the regional capital indices is that they exhibit a growing trend. If both models seem to be valid options, Model 2 is used as suggested by Doornik et al. (1998).[10]

The maximum lag is set so that the Hannan-Quinn information criteria are as small as possible and the residuals in the VECM do not exhibit significant serial correlation based on the LR(1) and LR(4) tests. Furthermore, since many of the series seem to exhibit seasonal variation, the need for seasonal dummies is detected in all the tests. The inclusion or exclusion of seasonal dummies is decided based on HQ.

The selection of the number of cointegrating vectors (r) is done by comparing the estimated Trace statistics with the quantiles approximated by the Γ-distribution (see Doornik 1998). Because asymptotic distributions can be

[9] The same section also includes a detailed discussion regarding the models.

[10] According to a Monte Carlo analysis conducted by Doornik et al. (1998) adopting a model with a trend in the cointegration space has low cost even when the data generating process (DGP) does not actually have one, and the cost of excluding the trend term when there should be one are markedly larger.

rather bad approximations to the finite sample distributions, the Bartlett small sample corrected values, suggested by Johansen (2002), are employed. The LR test described in Johansen (1996) is used to test for the weak exogeneity of the variables. In these LR tests Bartlett small-sample correction by Johansen (2000) is used.[11] Also the exclusion of the trend term from the long-run relation is tested by the small-sample corrected LR test.

In the case where one or more variables are restricted to be weakly exogenous so that they do not adjust to the long-run equilibrium, the methodology and asymptotic tables presented by Harbo et al. (1998) are applied to confirm the existence of cointegration (see p. 69 in the Intoductory chapter for details).

In some cointegration tests the presence of a structural break seems a valid possibility. If it seems necessary, the existence of a cointegrating relationship is further studied following the methodology proposed by Johansen et al. (2000) for cointegration analysis in the presence of a break at known point of time. The possible break divides the whole sample period to two sub-samples. The parameters of the stochastic components are the same for both sub-samples, while the deterministic variables may change between the sub-samples. The relevant asymptotic distribution in a test containing structural break depends on the number of non-stationary relations (p-r), the location of the break and the trend specification. Hence, the quantiles have to be computed separately for each case.

The stability of the estimated long-run relation is checked using the recursive estimation method (see Dennis 2006, pp. 95-112). Stability of none of the cointegrating relations found in the econometric analysis can be rejected based on the recursive analysis.

After being tested for cointegration, time series models examining the dynamics between regions are estimated. In the cases where the hypothesis of no-cointegration is accepted, a VAR model is estimated to study the dynamics. The number of lags in the VAR models is decided based on the Sim's small-sample corrected Likelihood Ratio test and the LM(1) and LM(4) tests.[12] If it is seen worthwhile, restrictions are made to the right-hand sides. These near VARs are then estimated by seemingly unrelated regressions (SUR) to improve the efficiency of the estimates. If cointegration is found, instead, VECM is estimated. Using the estimated VECMs and VARs, Granger

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[11] According to a Monte Carlo analysis conducted by Canepa (2006), the Bartlett corrected LR test provides, with some caution, a reliable inference when testing linear restrictions of the cointegrating vectors.

[12] The robustness of the results with respect to the selection of lag length was also studied by trying different lag lengths in each VAR-model. In general, the outcomes concerning Granger causalities are robust to the lag length. In each case only the "best" model is reported in the text.

causalities are tested and impulse response analysis is conducted to study the regional price dynamics further.

Granger non-causalities (GNC) between the regions are tested by a standard F-test. With cointegrated variables also equilibrium-error (EQE) is included in the GNC test, since the causality can also run through the long-run relation. The GNC tests are done using the following model:

$$\Delta X_t = \mu + \sum_{j=1}^{n} \Gamma_j \Delta X_{t-j} + e_{t-1} + D_t + \varepsilon_t \tag{3}$$

If cointegration is not present, the lagged equilibrium-error, e_{t-1}, is naturally not present in the test. Similarly, in the multiple variable model lagged EQE is not included as an explanatory factor for the variables that do not belong to the long-run relation. The number of lags (n) in the GNC test is decided based on the Sim's small-sample corrected LR test.

If the lagged differences of index x are found to have significant predictive power with respect to current change in index y, x granger causes y. It is of importance to understand that a finding that x Granger causes y does not necessarily imply that housing price movements in x cause housing price changes in y. It merely means that current and historical observations of x are statistically significant in predicting future value of y. For now on, causality refers the Granger causality in this paper.

It should be noted that many of the parameter estimates in the reported models are not significant at the commonly used significance levels. The goal is to find the important interrelationships between the variables, not the significant parameters. Furthermore, the relatively small number of degrees of freedom together with multicollinearity of the explanatory variables is likely to lead to smaller t-values.

6 RESULTS OF THE ECONOMETRIC ANALYSIS

It has been shown above that the data imply strong dynamic interdependences between housing price movements in different regions. The preliminary analysis also indicates that the dynamics of housing price movements have altered significantly during the sample period. This is probably to a great extent due to the differences during the sample period in the relative importance of macro level forces and local factors as driving forces of regional housing prices. In this section, the dynamic relations are further examined by testing for cointegration and Granger causalities between different markets. Because of the relatively small number of observations, pairwise analyses are conducted at first. To start with, short- and long-term interdependences between the centre of the HMA and the OHMA are studied. Then the hypothesis that housing price movements in the HMA lead price changes in the other parts of Finland is evaluated. Thereafter, lead-lag relations between some regional centres and provinces surrounding them are investigated. Finally, based on the estimated models impulse response functions are plotted.

6.1 Dynamics between the centre and the other parts of the HMA

Johansen test including two lags in differences implies that there have been only short-run dynamics between ΔCentre and ΔOHMA. Based on Model 2 the small-sample corrected (SSC) Trace value is 12.2, which is significant only at the 79% level.

Visual inspection of the centre and OHMA indices (see Figure) suggests that the acceptance of the null of no cointegration might be due to a structural break in the early 1990s. That is the time when the economy gradually started to recover from the recession. With the recovery net migration to the HMA over doubled from 1992 to 1993, which might have caused a structural change especially in the trend term in the long-run relation. As demand for housing both in the centre and in the suburbs has increased substantially, it is logical that housing prices have risen more rapidly in the centre, where the supply is extremely inelastic. Therefore, the existence of a long-run relationship between the two areas is further examined by allowing for a structural change in the VECM. The test involves an inclusion of a dummy variable (D), which is 0 until 1992Q4 and has got a value of 1 in 1993Q1, 2 in 1993Q2 etc., in the long-run relationship and its first difference, i.e. 1, in the short-run model.[13] The p-value of the SSC Trace test statistics is .01 suggesting that the series exhibit cointegration if a structural break is allowed for. Hence, it is reasonable to believe that the centre and OHMA are cointegrated. This is expected, because housing in the suburbs of the HMA is likely to be a comparatively close substitute for housing in the centre and housing prices in different parts of the HMA are expected to have same driving forces.

In the full-sample model OHMA is restricted to be weakly exogenous even though the LR test suggests that the alfa does not equal zero. This is because the alfa of OHMA has got the wrong sign.[14] According to the full-sample VECM (presented in Table A2 in the Appendix) it is apparent that ΔCentre does not Granger cause ΔOHMA. In contrast, both ΔOHMA and EQE Granger cause ΔCentre.

Because of the possible change in the short-run dynamics during the sample period, VECMs are also estimated separately for 1987-1992 and 1993-2006. These models are summarized in Tables 7 and 8. The models indicate that the causalities have been similar in both sub-samples. Some of the statistics that are statistically significant in the latter sub-sample are not equally significant in the first part, though. The small number of degrees of freedom in the first part is likely to have a role in the smaller p-values.

The leading role of the OHMA since 1993 may have got much to do with the growth pattern of employment opportunities in the HMA. After 1993 the number of jobs located in the OHMA has grown substantially faster than the number of employment opportunities in the centre. Therefore, based on the logic concerning housing price movements inside a metropolitan area explained in section 2, the fact that ΔOHMA has lead ΔCentre is not totally unexpected. This logic, however, does not apply for the pre 1993 period. It is hard to explain why ΔOHMA has Granger caused ΔCentre during 1987-1992.

Notice that even though the employment opportunities have increased more rapidly in the suburbs, price level has grown much faster in the centre than in the OHMA. This is likely to be a consequence of the more inflexible supply in the centre even in the long run. Due to the growth of the area, demand for housing has grown notably also in the centre. The demand in the centre has been augmented e.g. by the increase in the number of jobs also in the centre and by a significant rise in the HMA in the number of young (often single) households that typically value the amenities of the centre highly.

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[13] This corresponds to the model $H_l(r)$ in Johansen et al. (2000).

[14] Because all characteristic root of the system are within the unit circle, the negative coefficient does not imply explosive behavior of the model.

Table 7 Summary of the VECM including the centre of the HMA and the other parts of the HMA (sub-sample: 1987-1992)[15]

	ΔCentre		ΔOHMA	
Constant	-.310	(1.6)	-.006	(.1)
ΔCentre(1)	.326	(.8)	.037	(.1)
ΔOHMA(1)	.309	(.6)	.727	(1.6)
β(1) [16]	.658	(1.6)		
Adj. R^2	.58		.58	
Residual analysis (p-values)				
Jarque-bera	.78		.79	
ARCH(2)	.63		.18	
LM(1) (system)	.88			
LM(4) (system)	.86			
Granger non-causality:				
ΔCentre	.96		.89	
ΔOHMA	.09		.08	
Equilibrium-error	.09		.74	

Table 8 Summary of the VECM including the centre of the HMA and the other parts of the HMA (sub-sample: 1993-2006)

	ΔCentre		ΔOHMA	
Constant	-.108*	(2.0)	.006	(.2)
ΔCentre(1)	-.158	(.8)	.014	(.1)
ΔOHMA(1)	.506*	(2.0)	.593*	(3.5)
Seasonal dummy 1	-.004	(.4)	-.004	(.6)
Seasonal dummy 2	-.010	(.8)	.000	(.0)
Seasonal dummy 3	.027*	(2.2)	.021*	(2.5)
β(1)	.328*	(2.2)		
Adj. R^2	.36		.43	
Residual analysis (p-values)				
Jarque-bera	.60		.80	
ARCH(2)	.80		.05	
LM(1) (system)	.82			
LM(4) (system)	.99			
Granger non-causality				
ΔCentre	.46		.87	
ΔOHMA	.08		.00	
Equilibrium-error	.02		.96	

[15] * denotes for five percent level of significance, and t-values are reported in the parenthesis.

[16] β = Centre - 1.098*OHMA + .0008t - .0017*D

The finding that there is no significant feedback effect from the centre to the OHMA may be accounted for by the size difference between the centre and the suburbs. The number of flats in the OHMA is about 15 times the number of flats in the centre. Due to the substitution effect, price change in the centre relative to the suburbs is likely to affect housing demand in the suburbs. However, the relative change in the demand in the suburbs is likely to be negligible because of the large size of the area. In contrast, the relative demand change in the centre induced by price change in the surroundings is likely to be much more significant.

Note that the Lagrange-multiplier test for no autoregressive conditional heteroscedasticity (ARCH) shows some evidence for heteroscedasticity in the latter model. Nevertheless, Rahbek et al. (2002) show that the Johansen test is robust to moderate ARCH effects, and ARCH effect does not usually cause serious problems for the properties of the estimates (see Gonzalo 1994).

6.2 Dynamics between the HMA and the other parts of Finland

Based on the theoretical considerations, it is expected that ΔHMA leads ΔSAT and that the HMA and SAT housing price indices are cointegrated. Cointegration is likely because a large number of people commute from the Satellites to the HMA, implying that dwellings in the Satellites work as a substitute for dwellings in the HMA. Expectedly, the Johansen test indicates the existence of a cointegrating relationship between the variables (SSC p-value is .03, maximum lag = 2). According to HQ, a break in the trend in the long-run relation does not bring significant information to the model. Price level in the Satellites appears to be the one that adjusts to deviation from the long-run relation. The LR test indicates that the HMA can be restricted to be weakly exogenous (p-value = .76). Also the Johansen test for the partial model indicates the existence of cointegration. The Trace test value is 24.4 with 15.2 being the 95 percent quantile in the Harbo et al. (1998) tables. In the full-sample VECM (see Table A3 in the Appendix) the speed of adjustment parameter of the Satellites is .40 suggesting that it takes several quarters for the housing prices in the Satellites to fully adjust to the long-run relation.

Again, separate models are estimated also for the early and late sub-samples (Tables 9 and 10).Contrary to the full-sample model, it seems that feedback from the Satellites to the HMA has existed after 1993. Moreover, after the early 1990s also housing prices in the HMA have adjusted towards the equilibrium. This indicates that housing appreciation in the HMA can be curbed to some extent by increasing housing supply in the surrounding towns. This finding is of importance, since housing prices have grown rapidly in the HMA and are currently considerably higher than in the other parts of Finland.

Table 9 Summary of the VECM including the HMA and the Satellites (sub-sample 1987-1992)

	ΔHMA		ΔSAT	
Constant	-.008	(.1)	-.069	(.8)
ΔHMA(1)	.327	(.6)	.417	(.7)
ΔSAT(1)	.430	(.9)	.265	(.5)
β(1) [17]			-.233	(.8)
Adj. R^2	.58		.67	
Residual analysis (p-values)				
Jarque-bera	.93		.96	
ARCH(3)	.30		.19	
LM(1) (system)	.32			
LM(4) (system)	.00			
Granger non-causality				
ΔHMA	.54		.77	
ΔSAT	.20		.06	
Equilibrium-error	.03		.01	

Table 10 Summary of the VECM including the HMA and the Satellites (sub-sample 1993-2006)

	ΔHMA		ΔSAT	
Constant	.100*	(2.0)	-.063	(1.3)
ΔHMA(1)	.845*	(5.3)	.692*	(4.6)
ΔHMA(2)	.296	(1.5)	-.174	(1.0)
ΔHMA(3)	-.731*	(3.5)	-.677*	(3.5)
ΔSAT(1)	-.396*	(2.0)	-.259	(1.4)
ΔSAT(2)	.218	(1.1)	.604*	(3.3)
ΔSAT(3)	.533*	(3.1)	.427*	(2.6)
Seasonal dummy 1	.025*	(4.0)	.012*	(2.0)
Seasonal dummy 2	-.002	(.3)	-.015*	(2.1)
Seasonal dummy 3	-.017*	(2.3)	-.025*	(3.7)
β(1)	-.360	(1.9)	-.240	(1.5)
Adj. R^2	.66		.62	
Residual analysis (p-values)				
Jarque-bera	.85		.32	
ARCH(4)	.14		.28	
LM(1) (system)	.88			
LM(4) (system)	.92			
Granger non-causality				
ΔHMA	.00		.00	
ΔSAT	.05		.00	
Equilibrium-error	.03		.26	

[17] β = HMA - .931*Satellites - .0028t

Cointegration between housing prices in two cities far away from each other is not as likely as cointegration between nearby areas (such as the HMA and the Satellites). This is because the substitution effect does not work between two regions that are located far away from each other. Nevertheless, cointegration may exist between the HMA and some of the distant areas. If it does, it is likely to be due to similarities in the economic bases and the same driving macroeconomic fundamentals behind housing prices in the distant regions. Then, however, the interpretation of the adjustment of the areas towards the cointegrating relation is problematic. With two markets located close to each other the adjustment is likely to take place due to the possibility of households to move between the markets without facing extremely large moving costs and because of the possibility of new migrants to the area to select between the markets. Between distant cities there is not likely to be such strong balancing process. It seems probable, instead, that cointegration between housing prices in different cities would be mainly due to the importance of common driving factors.[18]

Due to the complications in the economic interpretation of the adjustment towards the long-run relation, a VAR model, instead of VECM, is estimated to examine the dynamics between the HMA and the OGC, even though the data suggest that HMA and OGC indices are cointegrated.[19] Surprisingly, when employing the first sub-sample the estimated near VAR model shows some evidence of ΔOGC leading ΔHMA (see Table 11). In the latter sub-sample, instead, it seems evident that ΔHMA has lead ΔOGC (Table 12). The hypothesis of no feedback from the OGC to the HMA cannot be rejected at the conventional significance levels. The t-values of the coefficients of ΔHMA may be slightly distorted, since the residuals of ΔHMA appear to exhibit heteroscedasticity. It is interesting to observe that HMA leads the other growth centres, although the economic bases of the HMA and the OGC have notable similarities.

Even though it is clear that also in this case the dynamics have differed notably between the sub-samples, a full-sample model is reported in Table A4 in the Appendix.

In the Johansen test between the HMA and the ROF the hypothesis of no cointegration is clearly accepted by the SSC Trace statistics (p-value is .47, Model 2, maximum lag = 2). Reasonable long-run relation cannot be found if a structural break is allowed in the model, either. Thus, the causalities are studied based on VAR models. The relationship between the HMA and the ROF is in accordance with the theory: during the second sub-sample price

[18] Naturally the same economic driving forces play a role in the cointegrating relation between closeby submarkets as well.
[19] The results in the Johansen test are in accordance with the second empirical study of the thesis.

changes in the HMA have Granger caused changes in the ROF but not the other way around (see Table 14). During the first sub-sample the analysis does not present evidence for any lead-lag relations. However, the significant coefficients in the estimated near VAR model (Table 13) indicate that ΔHMA Granger caused ΔROF during the boom-bust cycle of 1987-1992 as well. Full-sample model is shown in the Appendix in Table A5.

Table 11 Summary of the VAR model including the HMA and the other growth centres (sample: 1987-1992)

	ΔHMA		ΔOGC	
Constant	-.013	(1.5)	-.004	(.6)
ΔHMA(1)	.090	(.4)		
ΔOGC(1)	.901*	(2.9)	.829*	(6.2)
Adj. R^2	.59		.62	
Residual analysis (p-values)				
Jarque-Bera	.66		.99	
LM(1)	.31		.28	
LM(4)	.13		.07	
ARCH(4)	.43		.93	
Granger non-causality based on the first-order VAR (p-values, explanatory variable in left)				
ΔHMA	.85		.99	
ΔOGC	.13		.09	

Table 12 Summary of the near VAR model including the HMA and the other growth centres (sample: 1993-2006)

	ΔHMA		ΔOGC	
Constant	.030*	(5.7)	.027*	(6.0)
ΔHMA(1)	.575*	(4.6)	.445*	(4.1)
ΔHMA(2)	.252	(1.7)	.234*	(1.9)
ΔHMA(3)	-.416*	(3.3)	-.420*	(3.9)
Seasonal dummy 1	-.027*	(3.6)	-.026*	(4.0)
Seasonal dummy 2	-.036*	(4.6)	-.028*	(4.2)
Seasonal dummy 3	-.022*	(3.1)	-.018*	(2.9)
Adj. R^2	.45		.42	
Residual analysis (p-values)				
Jarque-Bera	.98		.18	
LM(1)	.46		.18	
LM(4)	.43		.27	
ARCH(4)	.03		.63	
Granger non-causality based on the third-order VAR (p-values, explanatory variable in left)				
ΔHMA	.00		.07	
ΔOGC	.18		.24	

Table 13 Summary of the near VAR-model including the HMA and the rest of Finland (sample: 1987-1992)

	ΔHMA		ΔROF	
Constant	-.008	(.8)	-.001	(.2)
ΔHMA(1)	.759*	(5.4)	.373*	(2.2)
ΔHMA(2)			.176*	(2.4)
ΔROF(1)			.144	(.7)
Adj. R^2	.56		.66	
Residual analysis (p-values)				
Jarque-Bera	.82		.54	
LM(1)	.28		.52	
LM(4)	.25		.16	
ARCH(4)	.80		.18	
Granger non-causality based on the second-order VAR (p-values, explanatory variable in left)				
ΔHMA	.19		.21	
ΔROF	.81		.95	

Table 14 Summary of the near VAR-model including the HMA and the rest of Finland (sample: 1993-2006)

	ΔHMA		ΔROF	
Constant	.030*	(5.7)	.020*	(7.0)
ΔHMA(1)	.575*	(4.6)	.295*	(3.4)
ΔHMA(2)	.252	(1.7)	-.058	(.6)
ΔHMA(3)	-.416*	(3.3)	-.228*	(3.3)
ΔROF(1)			.145	(1.1)
ΔROF(2)			.337*	(2.8)
Seasonal dummy 1	-.027*	(3.6)	-.021*	(4.9)
Seasonal dummy 2	-.036*	(4.6)	-.024*	(5.5)
Seasonal dummy 3	-.022*	(3.1)	-.015*	(3.8)
R^2	.45		.54	
Residual analysis (p-values)				
Jarque-Bera	.98		.89	
LM(1)	.46		.13	
LM(4)	.43		.47	
ARCH(4)	.03		.91	
Granger non-causality based on the third-order VAR (p-values, explanatory variable in left)				
ΔHMA	.03		.01	
ΔROF	.47		.02	

Next, interdependences between the prices in different areas are studied by including four areas, the HMA, the Satellites, the OGC and the ROF, in the analysis simultaneously. The aim of is to examine if there exist other cointegrating relations between the regions than the ones between the HMA and the Satellites and between the HMA and the OGC. Not surprisingly, there do not appear to be other stationary long-run relations even if a structural break is allowed. Actually, at the conventional significance levels the test statistics imply the existence of only one cointegrating relation.[20] Nevertheless, taking account of the previous evidence and of the power problems of the Johansen test especially when the number of degrees of freedom is small, it seems reasonable to assume that there is also another cointegrating vector, which is the one between the HMA and the OGC.

A partial-system (r=1) model including all the four areas is used to further study the causalities between the regions (see Table 15). Causalities during the early sub-sample are not studied separately because it would entail significant degrees of freedom problems. Congruent with the pairwise tests, the four-variable model indicates that the HMA has Granger caused all the other areas and that there has been feedback from the Satellites to the HMA. Also in line with previous findings, the test results show some differences between the whole sample and the latter sub-period. In particular, it appears that the impact of the equilibrium-error has changed. In any case, if the model employing the whole sample was used alone to examine the dynamics, misleading conclusions were probably derived. Expectedly, the most peripheral areas (ROF) do not seem to Granger cause any of the regions.

Table 15 Granger non-causality test based on the four-variable model with three lags in differences

Dependent variable	Explanatory variable					
1994-2006						
	ΔHMA	ΔSAT	ΔOGC	ΔROF	eqe	Adj. R^2
Δ HMA	.00	.06	.19	.30	.05	.57
Δ SAT	.00	.04	.17	.68	.26	.54
Δ OGC	.01	.26	.68	.24		.45
Δ ROF	.00	.37	.37	.66		.53
1987-2006						
	ΔHMA	ΔSAT	ΔOGC	ΔROF	eqe	
Δ HMA	.00	.07	.41	.26	.97	.57
Δ SAT	.00	.13	.14	.37	.02	.66
Δ OGC	.00	.29	.28	.59		.62
Δ ROF	.02	.02	.13	.25		.69

[20] In a Model with seasonal dummies, maximum lag of four and a break in the trend in 1993Q1, the SSC Trace statistics are 83.0 (null hypothesis: r=0, p-value .05), 51.9 (r≤1, .15), 25.5 (r≤2, .43) and 5.4 (r≤3, .90).

6.3 Dynamics between provincial capitals and surrounding provinces

All of the four regional capitals appear to have a long-term relationship with the surrounding province.[21] Each of the cointegrating relations require a deterministic trend term. Table 16 reports the Trace test statistics and p-values for the hypothesis r=0 together with some other details concerning the models. The estimated VECMs are exhibited in Tables A6 through A13 in the Appendix.

As expected, housing price movements in all the regional centres Granger cause housing price changes in the surrounding provinces both directly and through the long-run relation. In general, the causality from the capitals to the periphery applies to both sub-samples. Furthermore, during the second sub-sample there appears to be some feedback from the surrounding provinces to the centres either directly or via the equilibrium relation. The relationship between Oulu and Oulu Region is an exception, however.

Although all the speed of adjustment parameters of the centres are not statistically significant at the 5% level, the coefficients are large enough to suggest that also the capitals adjust towards the long-run relation. This implies that housing appreciation in the centres may be restrained by increasing housing supply in the surrounding areas. Again Oulu is an exception, though.

The province surrounding Oulu is much larger in area than the other three provinces and relatively sparsely populated. Thus, it is not surprising that the relationship between Oulu and Oulu Region differs from the other capital-province relations. In any case, given the results concerning the other capitals and provinces, it is reasonable to assume that housing prices in Oulu do react to housing price development in the municipalities that are located close to Oulu.[22]

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[21] The small-sample corrected p-value in the test including Jyväskylä and the other parts of Central Finland is significant only at the 13% level. Nevertheless, given the potential power problems with the Johansen test and the significant speed of adjustment parameters, it is reasonable to assume that the regions are, indeed, cointegrated. Moreover, cointegration between Oulu and the rest of Oulu Region is supported also by Model 3.

[22] Unfortunately, quarterly data on housing prices in the smaller municipalities in Finland are not available.

Table 16 Johansen test statistics for cointegration between provincial capitals and surrounding provinces

	Turku - SWF	Tampere- TAR	Jyväskylä – JY	Oulu - OR
Small-sample corrected Trace (p-value)	23.9 (.08)	27.4 (.03)	22.1 (.13)	30.3 (.01)
Weak exogeneity of the centre (p-value)	.23	.05	.04	.69
Speed of adjustment, centre (t-value)	.152 (1.4)	.288 (2.1)	.229 (2.2)	-
Speed of adjustment, province (t-value)	.245 (2.8)	.254 (2.3)	.184 (2.1)	.459 (5.4)
Maximum lag	2	3	3	2
Seasonal dummies	No	Yes	Yes	Yes

6.4 Impulse response analysis

The analysis above shows that housing appreciation in the centre of the HMA can be better predicted by historical housing price changes in the suburbs than by changes in the centre itself, i.e. ΔOHMA leads Δcentre. Similarly, one can make more accurate predictions for capital returns in the Satellites, the OGC and the ROF by using historical capital returns in the HMA in the model instead of lagged price movements in the regions themselves. Furthermore, the results imply that housing price movements in the regional centres lead housing price changes in the surrounding provinces.

In order to evaluate the interrelations between the areas further, impulse response functions are plotted based on the estimated pairwise models. Since the first sub-sample was an extraordinary period and similar events are not likely to take place in the future, only the impulses from the models utilizing data from 1993Q1 onwards are examined. In the case of the HMA and the other Finnish regions, pairwise models are used instead of the model including all the four variables due to the relatively short sample period and thereby small number of degrees of freedom. It is assumed that the more parsimonious pairwise models give more accurate parameter estimates and are therefore better to use. In any case, the impulse responses based on the model including all the four areas do not differ notably from the impulses derived from the pairwise model.

The presented impulse responses should be treated with caution, since the models do not incorporate any of the fundamental variables driving housing prices. The impulse curves are derived because they might bring some additional information concerning the regional linkages. Note also that because Granger causality does not necessarily mean that true causal relations exist between different regions, I speak about predictions or expectations in this connection rather than say that a shock in one area causes or leads to the presented impulse responses.

The impulse response functions exhibited in Figures 3 and 4 can be interpreted as follows. Effects of a shock in Δ(O)HMA or in one of the provincial capitals show how much higher capital returns (than were predicted prior to the shock) are predicted by the relevant model due to a positive one %-point shock in capital returns in the (O)HMA or in the regional centres.[23]

Even though ΔOHMA Granger causes Δcentre and the HMA Granger causes the other three regions, Figure 3 does not show evidence for noteworthy lead-lag relations between the areas. Price movements in the OHMA and the centre seem to follow each other closely after a shock in ΔOHMA. This is expected, since prices in the two areas are cointegrated.

The fact that there does not appear to be notable lead-lag relation according to the graph, does not probably mean that there is no such relation. According to Granger (1969) "*in many economic situations an apparent instantaneous causality would disappear if the economic variables were recorded at more frequent time intervals*". If monthly or even weekly data could be used instead of quarterly data, clearer lead-lag relation between ΔOHMA and Δcentre might be perceived also from the impulse response graphs.

Figure 3 further shows that a positive shock in the HMA leads to higher expected capital returns in all the four regions, the HMA, the Satellites, the OGC and the ROF, for a few of quarters. The effect of a shock in capital returns decreases relatively fast in the HMA during the first two quarters after the shock. In the other regions the immediate responses to the shock are smaller but the responses do not shrink as fast as in the HMA. This may be explained either by different timing of business cycles or by a claim that the HMA housing market adjusts to the new information set (shock) somewhat faster than the other markets. The latter reasoning suggests that the found Granger causality from the HMA to the other regions is due to informational factors – due to the probable larger share of non-informed agents in the peripheral areas as well as because of the scale economies in information production and diffusion (see the discussion in section 2). It is also possible that impulse responses derived from more frequent data would bring stronger evidence concerning the lead-lag relation between the HMA housing markets and the other regions' housing markets.

The finding that the responses of the Satellites and the OGC diminish faster than those of ROF is expected. This is because the Satellites are located next

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[23] Shock refers here to a difference between the actual housing appreciation and the appreciation predicted by the estimated model.

to the HMA and the economic structure of the OGC reminds the economic structure of the HMA more than the structure of the ROF. Furthermore, the share of informed agents is likely to be greater in the OGC and the OGC are much more densely populated than the ROF – population density is likely to quicken the information diffusion.

Based on the impulse responses, the difference in the adjustment speed between the centres and the surrounding provinces is substantially more pronounced than between the HMA, the Satellites, OGC and ROF. In fact, the impulse response curves imply that in the Central Finland the reaction of housing prices takes place at a one quarter lag.

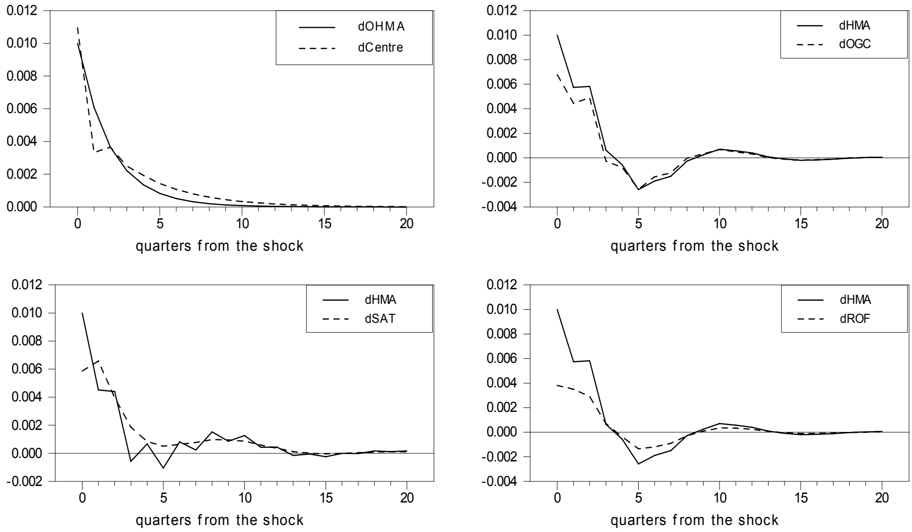

Figure 3 Impulse responses to a shock in ΔOHMA and in ΔHMA

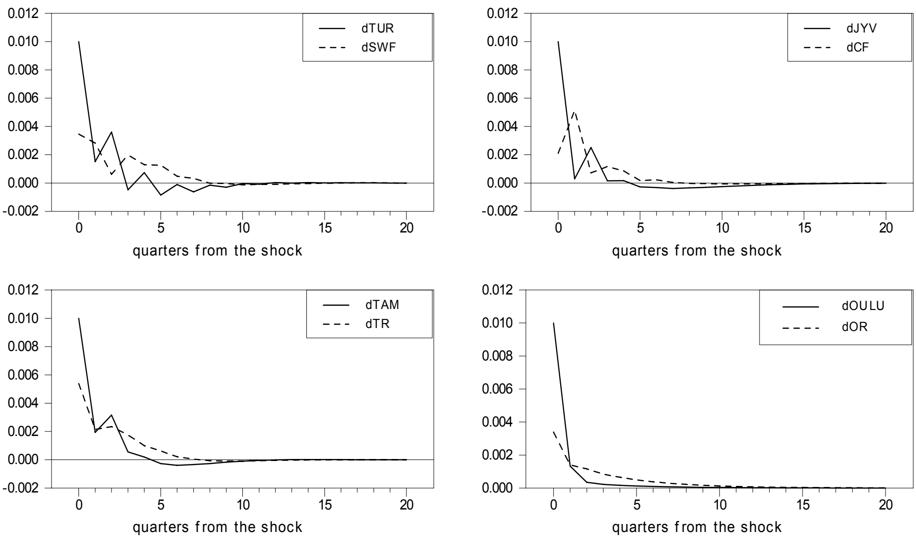

Figure 4 Impulse responses to a shock to housing appreciation in the provincial capitals

7 CONCLUSIONS

The aim of the study is to examine the diffusion of housing price movements in the Finnish regional housing markets. Of particular interest are the dynamics between central and surrounding areas. Using quarterly data from 1987 to 2006 cointegration tests are conducted and vector autoregressive and vector error-correction models are estimated to study the dynamic relations between regional housing markets.

Accordant with the prior expectations, the results show that housing price changes in the Helsinki Metropolitan Area (HMA), the main economic centre in Finland, Granger cause housing price movements in the other regions in Finland. In line with the theory is also the finding that housing appreciation in the regional centres appear to Granger cause housing price movements in the surrounding provinces. Inside the HMA, however, housing appreciation in the suburbs has Granger caused appreciation in the city centre. This is a good example of the fact that the dynamics between the centre and surroundings may be the other way around within a geographically small metropolitan area compared with the broader economy. Between relatively distant areas informational factors and timing of business cycles are likely to have a major influence on the leading role of the centre areas. Within the HMA, instead, employment growth pattern and migration have probably had a major role.

The empirical findings are of importance both to policy and investment decisions. The existence of strong positive interdependences between regional housing markets may strengthen cycles in the economy due to the wealth effect of housing. The fact that the co-movement between the markets appears to be extremely strong when the macroeconomy is especially volatile is particularly problematic. Moreover, the cointegrating relations between the HMA and the Satellites as well as between the provincial capitals and the surrounding provinces imply that housing appreciation in the growing centres can be restrained to some extent by increasing housing supply in the surrounding areas.

Furthermore, the dynamics between different markets are of relevance to portfolio allocation. Because of the long-run relations between different housing markets and of the differences in the adjustment speeds of the price levels, the use of quarterly correlations in housing portfolio analysis is misleading and may cause in misdirected investment strategies. In particular, quarterly correlations are likely to give too positive a picture about geographical diversification opportunities of a housing portfolio. It seems also evident that, in general, the use of unconditional investment opportunity sets in housing portfolio analysis is inefficient because even historical price data can be used to predict future returns. The Granger causalities reported in the empirical part actually suggest that better forecasts for regional housing price appreciation can be made by utilizing historical price data from the economic centre of a country or province than by using data from the more peripheral region itself. Whether one can take advantage of this predictability to make profit is another question, however, due to the high transaction costs and low liquidity of housing.

In addition to the empirical analysis, possible reasons for the lead-lag relations between central and surrounding regions are discussed theoretically in the paper. The empirical results are in line with the theory. The aim of the paper, however, is not to evaluate the driving factors behind the lead-lag relations in more detail. This task is left for future research. Furthermore, it has to be noted that the presented theoretical ideas and empirical results apply to a relatively small and coherent country, such as Finland. Links between regional housing markets in a country that is much more heterogeneous and larger in area and population, such as the US, may be different. However, within more homogenous subregions inside a large country, e.g. single provinces or states, the reasoning and results are likely to be applicable.

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APPENDIX 1 CONSTRUCTION OF INDICES

The methods of counting housing price changes in OHMA, OGC and ROF are explained below[24]. The housing price indices for these areas have been counted as follows:

$ind_{i,t} = (1 + \Delta ind_{i,t}) * ind_{i,t-1}$.

$ind_{i,t}$	= Value of the area i index in period t
$\Delta ind_{i,t}$	= Change in the area i index from period t-1 to period t

OHMA

In the hedonic HMA index the change in the index is approximately the weighted average of the change in the centre of the HMA and the change in the other parts of the HMA, where the changes have been weighted by the stock of flats. Therefore, the change in the OHMA index in each quarter has been estimated according to the following formula:

$\Delta ind_{ohma,t} = (nfla_{hma,t} * \Delta ind_{hma,t} – nfla_{c,t} * \Delta ind_{c,t}) / (nfla_{hma,t} – nfla_{c,t})$.

$\Delta ind_{ohma,t}$	= change in the OHMA index from period t-1 to period t
$nfla_{hma,t}$	= number of flats in the HMA during period t
$\Delta ind_{hma,t}$	= change in the HMA index from period t-1 to period t
$nfla_{c,t}$	= number of flats in the centre during period t
$\Delta ind_{c,t}$	= change in the centre index from period t-1 to period t

OGC

The change in the OGC index has been counted as the weighted average of the change in each city, where the numbers of flats in each city have been used as the weights:

$\Delta ind_{ogc,t} = \Sigma(nfla_{i,t} * \Delta ind_{i,t}) / \Sigma(nfla_{i,t})$

$\Delta ind_{ogc,t}$	= change in the OGC index from period t-1 to period t

[24] All the data used in constructing the indices are from the Statistics Finland database. The data concerning the number of flats is annual. Linear interpolation has been used to estimate the number of flats in each quarter.

$nfla_{i,t}$	= number of flats in city i in period t
$\Delta ind_{i,t}$	= change in the city i index from period t-1 to period t
i	= Jyväskylä, Oulu, Tampere

ROF

In the index for the whole country the change in the index is approximately the weighted average of the change in different regions in Finland, where the changes have been weighted by the total floor area of flats in each subregion. The change in the ROF index in each quarter has been estimated employing the following formula:

$$\Delta ind_{rof,t} = [nfla_{country,t} * \Delta ind_{country,t} - \Sigma(nfla_{i,t} * \Delta ind_{i,t})] / (nfla_{country,t} - \Sigma\ nfla_{i,t}).$$

$\Delta ind_{rof,t}$	= change in the ROF index from period t-1 to period t
$nfla_{country,t}$	= number of flats in the whole country during period t
$\Delta ind_{country,t}$	= change in the index for the whole country from period t-1 to period t
i	= HMA, SAT, OGC

APPENDIX 2 ADDITIONAL TABLES

Table A1 Augmented Dickey-Fuller test results[25]

Index	Level (lags)	Difference (lags)
Centre of the HMA[s]	-1.32 (2)	-2.66** (3)
Other parts of the HMA[s]	-1.81 (4)	-2.99** (4)
Whole HMA[s]	-1.70 (4)	-3.45** (5)
Satellites	-1.98 (5)	-3.15** (4)
Other growth centres	-1.29 (5)	-3.49** (4)
Rest of Finland	-1.88 (5)	-3.23** (4)
Turku[s]	-1.93 (2)	-2.97** (1)
Rest of South West Finland	-1.72 (2)	-2.87** (1)
Tampere[s]	-1.39 (5)	-3.20** (4)
Rest of Tampere Region[s]	-1.90 (5)	-2.83** (4)
Jyväkylä[s]	-2.08 (2)	-3.12** (1)
Rest of Central Finland[s]	-1.95 (3)	-2.29* (3)
Oulu[s]	-1.15 (2)	-3.08** (1)
Rest of Oulu Region[s]	-1.58 (2)	-2.40* (2)

[25] * and ** denote for five and one percent level of significance, respectively, and [s] signifies that seasonal dummies were included in the test.

Table A2 Summary of the full-sample VECM including the centre of the HMA and the other parts of the HMA

	ΔCentre		ΔOHMA	
Constant	-.190*	(2.6)	-.008	(.1)
ΔCentre(1)	-.072	(.4)	-.028	(.2)
ΔOHMA(1)	.646*	(2.8)	.708*	(4.1)
ΔD	.070*	(3.1)	.012	(.7)
β(1)	.393*	(2.5)		
Adj. R^2	.43		.54	
Residual analysis (p-values)				
Jarque-bera	.51		.16	
ARCH(2)	.79		.01	
LM(1) (system)	.66			
LM(4) (system)	.15			
Granger non-causality				
ΔCentre	.91		.89	
ΔOHMA	.02		.00	
Equilibrium-error	.00		.14	

Table A3 Summary of the full-Sample VECM including the HMA and the Satellites

	ΔHMA		ΔSAT	
Constant	.002	(.1)	-.101	(2.9)
ΔHMA(1)	.547*	(2.6)	.495*	(2.7)
ΔSAT(1)	.174	(.9)	.054	(.3)
β(1)			.397*	(2.9)
Adj. R^2	.51		.62	
Residual analysis (p-values)				
Jarque-bera	.42		.18	
ARCH(2)	.08		.01	
LM(1) (system)	.77			
LM(4) (system)	.08			
Granger non-causality				
ΔHMA	.01		.01	
ΔSAT	.39		.77	
Equilibrium-error	.80		.00	

Table A4 Summary of the full-sample near VAR-model including the HMA and the other growth centres

	ΔHMA		ΔOGC	
Constant	.016*	(2.6)	.015*	(3.2)
ΔHMA(1)	.657*	(5.9)	.209*	(1.9)
ΔHMA(2)	.230	(1.8)	.292*	(3.0)
ΔHMA(3)	-.332*	(2.6)	-.203*	(2.0)
ΔHMA(4)	.185	(1.7)	.096	(1.2)
ΔOGC(1)			.268*	(2.5)
Seasonal dummy 1	-.023*	(2.6)	-.020*	(2.9)
Seasonal dummy 2	-.028*	(3.1)	-.022*	(3.2)
Seasonal dummy 3	-.015*	(1.6)	-.017*	(2.4)
Adj. R^2	.56		.57	
Residual analysis (p-values)				
Jarque-Bera	.03		.46	
LM(1)	.19		.21	
LM(4)	.17		.23	
ARCH(4)	.02		.42	
Granger non-causality based on the third-order VAR (p-values, explanatory variable in left)				
ΔHMA	.00		.07	
ΔOGC	.89		.62	

Table A5 Summary of the full-sample near VAR-model including the HMA and the rest of Finland

	ΔHMA		ΔROF	
Constant	.016*	(2.6)	.009*	(2.2)
ΔHMA(1)	.657*	(5.9)	.220*	(2.4)
ΔHMA(2)	.230	(1.8)	.186*	(2.3)
ΔHMA(3)	-.332*	(2.6)	-.128	(1.5)
ΔHMA(4)	.185	(1.7)	.131	(1.8)
ΔROF(1)			.301*	(2.8)
Seasonal dummy 1	-.023*	(2.6)	-.015*	(2.6)
Seasonal dummy 2	-.028*	(3.1)	-.014*	(2.5)
Seasonal dummy 3	-.015*	(1.6)	-.010	(1.7)
Adj. R^2	.56		.66	
Residual analysis (p-values)				
Jarque-Bera	.03		.33	
LM(1)	.19		.39	
LM(4)	.17		.30	
ARCH(4)	.02		.09	
Granger non-causality based on the second-order VAR (p-values, explanatory variable in left)				
ΔHMA	.01		.04	
ΔROF	.92		.34	

Table A6 Summary of the VECM including Turku and the rest of South West Finland (sample: 1987-1992)

	ΔTurku		ΔSWF	
Constant	-.002	(.0)	.155*	(2.2)
ΔTurku(1)	.583*	(1.9)	.297	(1.6)
ΔSWF(1)	.122	(.3)	.149	(1.0)
β(1)[26]	-.081	(.7)	.029	(.1)
Adj. R^2	.43		.59	
Residual analysis (p-values)				
Jarque-Bera	.19		.89	
LM(1)	.42			
LM(4)	.27			
ARCH(2)	.14		.72	
Granger non-causality				
ΔTurku	.12		.14	
ΔSWF	.63		.99	
Equilibrium-error	.44		.31	

Table A7 Summary of the VECM including Turku and the rest of South West Finland (sample: 1993-2004)

	ΔTurku		ΔSWF	
Constant	-.109	(1.5)	.156*	(2.9)
ΔTurku(1)	.205	(1.1)	.041	(.3)
ΔTurku(2)	.406*	(2.4)	-.098	(.8)
ΔSWF(1)	.231	(1.1)	.186	(1.2)
ΔSWF(2)	-.129	(.7)	-.092	(.7)
β(1)	-.219	(1.6)	-.328*	(2.8)
Adj. R^2	.23		.26	
Residual analysis (p-values)				
Jarque-Bera	.00		.96	
LM(1)	.32			
LM(4)	.73			
ARCH(4)	.85		.70	
Granger non-causality				
ΔTurku	.06		.63	
ΔSWF	.50		.07	
Equilibrium-error	.10		.01	

[26] β = Turku – 1.127*SWF – .001t

Table A8 Summary of the VECM including Tampere and the rest of Tampere Region (sample 1987-1992)

	ΔTampere		ΔTR	
Constant	-.417	(1.6)	.282	(1.5)
ΔTampere (1)	1.27*	(3.6)	.610*	(2.4)
ΔTampere (2)	.558	(1.5)	.490	(1.8)
ΔTR(1)	-.831*	(2.0)	-.583*	(2.0)
ΔTR(2)	.038	(.1)	-.297	(1.0)
β(1)[27]	-.696	(1.5)	-.561	(1.5)
Adj. R^2	.69		.75	
Residual analysis (p-values)				
Jarque-Bera	.57		.52	
Reset-test	.22		.65	
LM(1) (system)	.14			
LM(4) (system)	.31			
ARCH(3)	.42		.36	
Granger non-causality				
ΔTampere	.02		.01	
ΔTR	.34		.16	
Equilibrium-error	.26		.19	

Table A9 Summary of the VECM including Tampere and the rest of Tampere Region (sample 1993-2004)

	ΔTampere		ΔTR	
Constant	-.092	(1.8)	.098*	(2.4)
ΔTampere (1)	.525*	(2.9)	.257	(1.8)
ΔTampere (2)	.260	(1.5)	.068	(.5)
ΔTR(1)	-.389*	(2.0)	-.291	(1.8)
ΔTR(2)	.273	(1.4)	.142	(.9)
β(1)	-.294*	(2.0)	-.301*	(2.3)
Adj. R^2	.31		.49	
Residual analysis (p-values)				
Jarque-Bera	.01		.90	
Reset-test	.22		.65	
LM(1) (system)	.98			
LM(4) (system)	.72			
ARCH(3)	.77		.57	
Granger non-causality				
ΔTampere	.06		.03	
ΔTR	.15		.11	
Equilibrium-error	.08		.00	

[27] β = Tampere – 1.089*TR – .002t

Table A10 Summary of the VECM including Jyväskylä and the rest of Central Finland (sample 1987-1992)

	ΔJyväskylä		ΔCF	
Constant	-.127*	(2.4)	-.006	(.1)
ΔJyväskylä(1)	.357	(1.2)	.151	(.6)
ΔJyväskylä(2)	.556*	(1.9)	.125	(.5)
ΔCF(1)	.380	(1.0)	.156	(.5)
ΔCF(2)	.121	(.4)	.252	(1.0)
Seasonal dummy 1	-.052*	(2.1)	-.056*	(2.7)
Seasonal dummy 2	-.019	(.8)	-.032	(1.6)
Seasonal dummy 3	-.023	(.9)	-.027	(1.4)
β(1)[28]	-.523*	(2.3)		
Adj. R^2	.60		.51	
Residual analysis (p-values)				
Jarque-Bera	.51		.84	
LM(1) (system)	.40			
LM(4) (system)	.98			
ARCH(3)	.35		.41	
Granger non-causality				
ΔJyväskylä	.62		.81	
ΔCF	.63		.76	
Equilibrium-error	.09		.97	

Table A11 Summary of the VECM including Jyväskylä and the rest of Central Finland (sample 1993-2004)

	ΔJyväskylä		ΔCF	
Constant	-.035	(1.3)	.054*	(2.6)
ΔJyväskylä(1)	.161	(1.0)	.430*	(3.5)
ΔJyväskylä(2)	.254	(1.4)	.254	(1.8)
ΔCF(1)	.044	(.2)	-.444*	(3.2)
ΔCF(2)	.086	(.6)	-.133	(1.1)
Seasonal dummy 1	-.001	(.8)	-.018*	(2.1)
Seasonal dummy 2	-.020*	(1.9)	-.006	(.8)
Seasonal dummy 3	-.007	(.6)	-.017	(1.8)
β(1)	-.181	(1.6)	-.240*	(2.7)
Adj. R^2	.29		.58	
Residual analysis (p-values)				
Jarque-Bera	.55		.20	
LM(1) (system)	.34			
LM(4) (system)	.55			
ARCH(3)	.63		.57	
Granger non-causality				
ΔJyväskylä	.67		.00	
ΔCF	.84		.01	
Equilibrium-error	.15		.00	

[28] β = Jyväskylä – 1.051*CF – .003t

Table A12 Summary of the VECM including Oulu and the rest of Oulu Region (sample: 1987-1992)

	ΔOulu		ΔOR	
Constant	-.002	(.0)	.733*	(4.8)
ΔOulu(1)	.688*	(2.5))	-.261	(1.5)
ΔOR(1)	.122	(.5)	.048	(.3)
Seasonal dummy 1	.047*	(2.1)	-.013	(.9)
Seasonal dummy 2	.021	(.9)	-.001	(.1)
Seasonal dummy 3	.033	(1.5)	.030*	(2.2)
β(1)[29]			.649*	(4.8)
Adj. R^2	.50		.73	
Residual analysis (p-values)				
Jarque-Bera	.78		.94	
LM(1) (system)	.16			
LM(4) (system)	.24			
ARCH(2)	.81		.45	
Granger non-causality				
ΔOulu	.01		.10	
ΔOR	.67		.97	
Equilibrium-error	.92		.00	

Table A13 Summary of the VECM including Oulu and the rest of Oulu Region (sample: 1993-2004)

	ΔOulu		ΔOR	
Constant	.011	(.1)	.541*	(4.43)
ΔOulu(1)	.073	(.4)	.046	(.4)
ΔOR(1)	.175	(.9)	-.147	(1.0)
β(1)			.344*	(3.2)
Adj. R^2	.40		.58	
Residual analysis (p-values)				
Jarque-Bera	.46		.68	
LM(1) (system)	.53			
LM(4) (system)	.91			
ARCH(2)	.97		.70	
Granger non-causality				
ΔOulu	.50		.01	
ΔOR	.30		.29	
Equilibrium-error	.80		.01	

[29] $\beta = Oulu - 1.317*OR - .005t$

PRICE LINKAGES BETWEEN STOCK, BOND AND HOUSING MARKETS – EVIDENCE FROM FINNISH DATA

Abstract

There are a number of reasons to assume that significant interdependences exist between the financial asset markets and the housing market. In particular, the same economic fundamentals are anticipated to affect discount factors and expected cash flows of both housing and financial assets. Identifying the linkages between stock, bond and housing markets may improve return forecasts in different asset markets. Interdependence and predictability of different asset prices are of importance concerning portfolio diversification and allocation, especially from long-term investors' point of view. Furthermore, linkages between asset classes are likely to have significant policy implications. The purpose of this paper is to study the long- and short-term interdependences between stock, bond and housing markets using correlation analysis and time series econometrics utilizing a quarterly dataset from Finland over 1970-2006. In addition to short-term co-movement, there also appears to be long-run interrelation between the stock and housing prices according to cointegration analysis. There appears to be a structural break in the long-run relationship between stock and housing markets in the early 1990s. The break is most likely due to the abolishment of foreign ownership restrictions on Finnish stocks in 1993. Interaction between the markets appears to have diminished somewhat after the break. In line with the theory and previous research, it is found that stock appreciation Granger caused housing price changes prior to 1993. Since 1993, in turn, stock appreciation seems to have Granger caused housing only through a stationary long-run relation. Co-movement of bond price changes with stock and housing appreciation is found to be weak.

Keywords: asset prices, housing, co-movement, cointegration

1 INTRODUCTION

There are a number of reasons to assume that significant interdependences exist between the financial asset markets and the housing market. Despite the numerous important implications that the interrelations between the financial asset markets and the housing market may have on the economy, research examining these linkages has still been very limited.

It is evident that there are common macroeconomic factors driving the prices of stocks, bonds and housing. Like other asset prices, housing prices should equal the discounted stream of future cash flows, i.e. net rents. Rents and discount factors of housing are affected, to a large extent, by the same macroeconomic factors as are the discount factors and expected future cash flows of the financial assets. The discount factors are affected for example by movements in the real interest rate and in the inflation rate, and thereby by changes in the economic activity as a whole. In addition, notable positive co-variation between stock and housing prices is likely to exist because expected cash flows in both markets are significantly affected by business cycles. This linkage may have weakened during the last ten to fifteen years due to the growing influence of international investors on the national stock markets, however.

There are also a number of reasons why causal linkages between stock, bond and housing price movements may well exist. Some of the linkages are expected to strengthen correlation between the price changes in different asset markets, whereas some other linkages are likely to weaken the co-variation in the relatively short horizon.

Firstly, appreciation of an asset class has got wealth effects on consumption and investment. For example, greater wealth due to housing appreciation leads to increase in consumption and thereby to growth in the general economic activity. Economic activity is further enhanced by the positive relation between housing prices and construction activity. Growth in the economic activity, in turn, is likely to strengthen cash flow expectations in the stock market augmenting demand for equity. Furthermore, as the collateral value of housing increases, the credit constraints are eased. Therefore, many investors are able to borrow more, which may strengthen demand especially for stocks. On the other hand, due to the upturn in the economy real interest rates and the inflation rate may rise, which can increase the discount rates and thereby lower demand for the assets.[1] Similar process can naturally arise because of appreciation in stock prices, although recent research implies that the wealth effect of housing on consumption is greater than that of the stock market (see e.g. Case et al. 2001, Benjamin et al. 2004a and 2004b).

Secondly, appreciation in one asset class can raise demand for the other assets because of strategic portfolio allocation. That is, many investors want to hold a certain ratio of one asset to another asset in their portfolios. If the value of one asset relative to the other asset rises significantly, the investor has to reallocate his portfolio, i.e. the investor has to sell the asset that has appreciated relative to the other asset, and buy the other asset. Hence, price increase in one asset market can diffuse to the other asset markets.

Thirdly, “feedback” effect can cause negative short-term correlations between different asset price changes. The feedback effect is caused by typically backward-looking investors. High returns on an asset in the past augment the backward-looking investor’s expectations of future returns on the asset. This induces buying pressure on the asset that has performed better than the other assets in the past, while demand for the other assets may decline. For instance, the results of Chen et al. (2004) indicate the existence of this kind of phenomenon in the US markets. For housing demand the influence of the other assets’ returns can be thought to materialize through the user cost of housing – the user cost for housing ownership depends on the opportunity cost of the capital tied in housing. In general, higher expected returns on financial assets increase the opportunity cost thereby reducing housing demand. In the long-run, however, the speculative feedback effect must even out so that stock, bond and housing returns are likely to correlate positively in the longer horizon.

There are also other reasons why negative short-term relations between returns on different asset categories may arise. When the investors are scared, i.e. during highly uncertain times, they look for safety. Hence, they adjust their portfolios to include more safe assets (bonds) and less risky assets (stocks, housing). Due to this so-called “flight-to-quality” movement, bond prices and the prices of the riskier assets may move to opposite directions. Theoretical results in support of the flight-to-quality thought have been presented e.g. by Barsky (1989). Hartmann et al. (2004), in turn, report empirical evidence for flight-to-quality movement between stock and bond markets.

Also long-term interdependences between the asset markets are possible. Bossaerts (1988) presented theoretical reasons to believe that asset prices may have long-term interdependence in the sense that they are cointegrated.

[1] According to Andersen et al. (2005) in the stock market the discount rate effect dominates during economic expansion while “good” news on real activity raises stock prices during recessions.

According to Bossaerts, asset prices should be cointegrated if the economy moves close to, but does not attain, the separating equilibrium of the Capital Asset Pricing Model. Cointegration does not have to hold, for example, between two single stock price series, but it should hold between broad asset categories. Furthermore, common macroeconomic driving forces behind the price formation of different asset categories may create long-run linkages between different asset prices.

Many factors can disturb the expected cointegration, however. Changing risk premiums and subjective time preferences, long-lasting irrational expectations about future returns, changes in tax rules as well as market interventions of the public sector all may change the long-run relations between the asset prices. Moreover, innovations that increase productivity in some firms or industries but not in some others may induce structural breaks in the long-run relations between different asset prices. For example, an innovation that reduces the construction costs of housing significantly is likely to have a permanent negative effect on housing prices relative to stock prices.

Generally, given that housing market is not as efficient[2] as the stock and bond markets and that the price adjustment is likely to be more sluggish in the housing market, it is expected that causality, at least in the Granger sense, runs from the financial assets to the housing market. As the stock and bond markets are assumed to be more efficient, it is unlikely that such clear lead-lag relations can be found between these markets using quarterly data like in this study.

All in all, the correlations between price movements in different asset markets may be negative or positive, depending on the prevailing economic fundamentals, on the rationality of the investors and on the length of the assumed investment horizon. That is, the correlations may differ substantially in time and also depending on the frequency of the underlying data. Furthermore, the relationship between housing prices and financial asset prices may be slightly undermined by the consumption good nature of housing. As housing is a durable good producing utility to owner-occupiers, its pricing may differ somewhat from the assets that do not possess such consumption nature.[3] That is, psychological factors, such as the feeling of safety, may to some extent weaken the linkages between the financial assets and housing. Nevertheless, due to the central role of the macroeconomic forces on the

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[2] The relatively weak efficiency of the housing market is especially caused by the heterogeneity, low liquidity and high transaction costs of housing, and by the lack of centralized market place for housing. The absence of centralized market place, together with the heterogeneity of housing and the thinness of the housing markets, creates substantial lacks in the available information concerning the housing markets.

[3] See e.g. Henderson and Ioannides (1983) for a model of housing choice taking account of both consumption demand and investment demand.

discount factors and on the expected cash flows of both stocks and housing, it is likely that the correlation between housing and stock price movements is positive even in the relatively short horizon and especially in the long horizon.

It is of importance to know if there are, indeed, lead-lag relations and long-term equilibrium relationships between different asset markets. This is because the existence of such linkages has got a number of important implications both to investors and to policy makers.

First of all, a failure to understand and to take account of the linkages between different asset classes is likely to result in poorer portfolio performance and may lead to a significant mismeasurement of the portfolio risk especially in the longer horizon. Portfolio analysis based on high frequency data can give misleading picture concerning the diversification potentials. For a long-term buy-and-hold investor, such as direct real estate investors in general, even the use of quarterly correlations can be deceiving due to the potential lead-lag relations between different asset categories. If positive lead-lag relations between the asset prices exist, then longer-term correlations between price movements are larger than shorter-run correlations. This is further emphasized if asset prices are cointegrated. In the case of negative lead-lag relations, instead, longer-term diversification gains are likely to be better than implied by short-run correlations. In addition, investors neglect information that they could use to forecast future asset returns if they ignore the asset market linkages.

Second, interdependence between different asset markets is of significance for the fiscal and monetary policy because of its influences on macroeconomic cycles. Housing and equity form a major part of the household wealth. Hence, declines in stock and housing prices may have strong wealth effects, leading to significant reduction in consumption, investment and overall economic activity (see e.g. Case et al. 2001, Benjamin et al. 2004, Campbell and Cocco 2004). Therefore, positive linkages between stock and housing markets toughen economic cycles. This phenomenon is reinforced by the fact that simultaneous crash in both markets or even crash in one market followed by bust in the other market in the relatively close future may put into trouble even large banks that hold widely diversified portfolios. International diversification of stocks can reduce the risks to some extent. Due to the internalization of the financial markets different stock markets are likely to co-move strongly in the future, however. Besides, stock holdings are typically biased towards home markets. Thus, if for example housing price movements tend to follow stock price changes with lag, as suggested by a number of empirical studies, this should be anticipated and taken account of when doing policy decisions.

Consequently, it is of importance to examine the co-movements between different asset prices in order to be able to make better policy and investment decisions. Therefore, the price linkages between the Finnish financial markets and housing market are studied in this paper employing correlation analysis and time series econometrics. Quarterly data is used and the sample period (1970Q1-2006Q4) is substantially longer than typically used in the previous related studies. The long-run relations, including the selection of the deterministic variables, are rigorously identified. This is something that has usually been neglected in the cointegration analyses studying linkages between different asset classes. Based on the empirical findings the implications of the asset market interrelations are evaluated. The possible volatility linkages between the asset markets are out of scope of this article.[4]

The paper proceeds as follows. The next section reviews past studies that have examined the interdependences between different asset classes. After that, the data used in the empirical part is described. The fourth part reports the empirical methodology used in the study. The findings from the empirical analysis are presented in the fifth section. In the end, the paper is summarized and conclusions are derived.

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[4] Results of Antell (2004) indicate that the importance of volatility linkages is small in the Finnish markets even when using weekly data. As quarterly data has to be used when housing is included in the analysis, the significance of the possible volatility linkages is likely to be negligible.

2 LITERATURE REVIEW

While there exists a vast body of literature considering the linkages between different regional markets within a single asset category, less attention has been paid to the interdependences between different asset classes, especially between housing and financial assets.

In the earlier studies, typically, only contemporaneous correlations between asset returns were examined. More recent research, however, has more often acknowledged the importance of lead-lag relations between asset returns and even the possibility of cointegration between different asset prices. The use of contemporaneous return correlations may be misleading and lead to suboptimal portfolio allocation and policy decisions. This is because dynamic linkages between the asset prices may greatly strengthen the co-variation between the asset returns in the longer run. In addition, it is well known today that correlation coefficients between asset returns exhibit substantial instability over time.[5]

Although an extensive empirical literature has explored the relationship between stock and bond returns, little consensus has emerged. For example, while Shiller and Beltratti (1992) found a strong positive correlation between stock and bond price movements using annual US data, Campbell and Ammer (1993) document a relatively low average correlation employing more recent monthly data, and Andersen et al. (2005) report negative correlation with intraday data. Recently, many studies (e.g. Fleming et al. 1998, Scruggs and Glabadanidis 2003, Andersen et al. 2005) have shown that the correlation between stock and bond returns is far from constant. Furthermore, according to Hartmann et al. (2004) the flight-to-quality phenomenon is about as common as the co-crash of a bond and a stock market. Nevertheless, empirical evidence implies that contemporaneous correlation between stock and bond returns is positive on average. It is notable that the findings according to which the correlation between the markets is greater with less frequent data are in line with a hypothesis that, while the influence of macroeconomic factors on discount rates and expected cash flows dominates the co-movement between the markets in the long run, in the short horizon factors such as the flight-to-quality movement and feedback effect may have a significant role.

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[5] For example Wilson and Zurbruegg (2003) present a review of correlation instability especially between different real estate returns.

Linkages between Finnish stock and bond markets are studied by Antell (2004). Using weekly data over 1991-2003 Antell finds that the return correlation between stock and bond markets is approximately 0.1. Furthermore, Antell estimates a first-order VAR-EGARCH model, which shows no evidence of lagged dependence between the markets. Antell suggests that the fairly weak linkages between stock and bond markets may imply that the markets follow their own dynamics and are dominated by different clienteles.

There is a great deal of research examining the relationship between commercial property market and stock market, but research on the linkages between housing and stock markets has been limited. Furthermore, co-movement between bond prices and real estate prices has been studied only rarely.

The findings concerning the co-movement between commercial real estate markets and financial asset markets are mixed, and it has been shown that the correlations vary substantially between countries (see Quan and Titman 1997 and 1999). In most of the studies the real estate performance is based on property-related securities, such as the real estate investment trusts (REITs) and stocks of real estate investment companies. In general, papers using real estate securities have found strong positive correlations between real estate returns and financial asset returns. Among studies reporting strong contemporaneous relation between securitized real estate and stock and bond markets are e.g. Giliberto (1990), Gyourko and Kleim (1992), Eichholtz and Hartzell (1996) and Liu and Mei (1999). On the contrary, weak, sometimes even negative, contemporaneous correlations between commercial property markets and financial asset markets have been reported when data concerning direct real estate has been utilized (see e.g. Giliberto 1990, Gyourko and Kleim 1992, Ling and Naranjo 1999).

It should be noted that in the short run the performance of real estate securities may be a bad proxy for the performance of the actual real estate. There is substantial evidence suggesting that the performance of REITs reflects not only the underlying real estate assets, but also the advisory and ownership structure of those firms (see e.g. Bradley et al. 1998, Friday et al. 1999, Capozza and Seguin 2000). On the other hand, the low observed correlation between direct real estate and stocks in many studies may, at least partly, be an artifact of the data. This is because the real estate data often face the problem of appraisal smoothing due to the lack of actual transaction data.

The correlation between housing returns and stock returns has been systematically found to be positive.[6] Nevertheless, the reported correlations are sufficiently low to imply significant diversification opportunities. As an exception to the general rule, Hoesli and Hamelink (1997) report a negative (-.11) correlation between Geneva housing returns and the Swiss stock market returns based on annual data. Using annual hedonic housing price indices Hoesli and Hamelink further found the correlation between returns on housing in Zurich and on Swiss stock market to be .18. Gyourko and Kleim (1992), in turn, report a quarterly correlation of .26 between housing and stock returns in the US. According to Hutchinson (1994) the annual correlation in the UK markets has been small, only .08. Hutchinson used a short sample of appraisal based data, however. Relatively large correlation, .44, between excess returns on stocks and housing in Hong Kong is showed by Fu and Ng (2001). Moreover, in the Finnish market Kuosmanen (2002) found the correlation to be .37 based on quarterly transaction data.

Contrary to the findings between housing and stock returns, correlation between housing and bond returns typically seems to be negative. Gyourko and Kleim present monthly correlation of -.01 but Hoesli and Hamelink, and Hutchinson report substantially larger negative correlations, from -.26 to -.33 based on annual observations.

Housing price series are usually based on all the transaction prices during a particular period, whereas financial market return series typically use the values at the end (or beginning) of each period. This may distort the reported correlation coefficients slightly.

As noticed above, there are numerous papers where correlations between real estate, stock and bond returns are studied. However, contemporaneous correlations can give a wrong picture concerning the strength of the linkages between different markets. Fu and Ng (2001), for example, showed that real estate market inefficiency depresses the correlation between real estate and financial markets. Furthermore, there may also be reasons other than property market inefficiency causing dynamic interdependence between real estate and financial market returns. The estimates of Englund et al. (2002) suggest that investment horizon does, indeed, matter. According to Englund et al. quarterly correlation between stock and housing returns in Stockholm is .16, while the figure is .22 using ten quarter investment horizon and practically zero when an investment horizon of ten years is assumed. The corresponding figures

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[6] In general, volatility of housing returns is driven by capital returns. Hence, the correlation coefficients are similar whether total returns or only capital returns are used.

between housing and bonds are -.13, -.62 and -.47.[7] Englund et al. emphasize the portfolio implications of this kind of horizon effect. Nevertheless, research on the longer-term linkages between real estate prices and financial asset prices is still scarce.

Most of the studies examining dynamic interrelations between real estate and other asset categories have used securitized property as the real estate variable. Research by Okunev and Wilson (1997), Okunev et al. (2000 and 2002) and Glascock et al. (2000)[8] suggests that the securitized property markets and the stock markets are not linearly cointegrated. However, Okunev and Wilson (1997), and Okunev et al. (2000) found evidence of nonlinear cointegration. In addition, the results of Okunev et al. (2000 and 2002) based on a nonlinear Granger causality test indicate that stock market returns Granger cause securitized real estate returns. Between REITs and bonds the results of Glascock et al. (2000) imply that cointegration existed in 1980-1991 in the US but not after that.

Tuluca et al. (1998), in turn, detected two cointegrating vectors in a US dataset including price series of direct real estate, indirect real estate, T-bills, long-term bonds and stocks. Similarly, Chaudhry et al. (1999) found cointegration between direct commercial real estate, stock, bond and T-bill return indices. Surprisingly, the estimated long-run relation in Chaudhry et al. implied that stock index has got a negative long-run relationship with the real estate index. The long-run relation was not identified any further to test if real estate or some other variables could actually be extracted from the long-run relation.

There are also some studies on the lead-lag relations between housing and stock markets, but research analyzing the existence of long-horizon interdependence between housing and stock prices is still extremely limited. In the Finnish market the existence of a long-term relationship has been studied by Takala and Pere (1991). Using quarterly data from 1970 to 1990 Takala and Pere found evidence of cointegration between housing and stock prices. Their results further showed that housing prices adjust by less than 10% per quarter towards the long-run equilibrium relation. According to Barot and Takala (1998), in turn, stock prices could be most properly used as a weakly exogenous variable in a trivariate cointegrated system including also housing prices and private consumption deflator using both Finnish and Swedish data.

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[7] The correlation coefficients are estimated based on a VAR model. If two or more returns series are actually cointegrated, the reported figures may underestimate the actual correlations, especially in the long horizon.

[8] Glascock et al. (2000) claim that the results imply cointegration between REIT return index and S&P 500 index at the 10% significance level. However, wrong critical values are used in the analysis.

Furthermore, Barot and Takala note that stock prices seem to have a rather minimal effect on the long-run equilibrium relation.

Consistent with the theory, the results typically imply that stock returns lead housing market returns. Granger causality from the stock market to the housing market, but not the other way round, is reported by Chen (2001) using data from Taiwan, and Takala and Pere (1991) and Kuosmanen (2002) regarding the Finnish asset markets. Moreover, Englund at al. (2002) show evidence of stock returns Granger causing housing returns, but not *vice versa*, in Stockholm. The VAR model estimated in the study suggests that higher stock returns anticipate lower housing returns. Leading role of the stock market with respect to the housing market is also implied by Borio and McGuire (2004). They show that there is a tendency for peaks in the equity prices to precede peaks in the housing prices. The lag is typically several quarters. Furthermore, employing annual panel data including 130 metropolitan areas across the US, Jud and Winkler (2002) found that real stock appreciation has got a strong current and lagged effect on the growth of real housing prices. They estimated the full effect of one percent increase in stock prices on housing appreciation to be .17%. In contrast with the other results are the findings of Fu and Ng (2001), which indicate that in the Hong Kong market excess returns in the housing market have got predictive power for stock market excess returns but not the other way round.

To summarize, there are numerous papers where correlations or dynamic interdependences between returns on real estate, stocks and bonds are studied. However, research on the linkages, especially on long-term interrelations, between housing market and financial asset markets is still very limited. Furthermore, in all the papers mentioned above that have studied the existence of cointegration between different asset markets, the possibility of a need for a deterministic trend term in the long-run equilibrium relation has been neglected. Thus, there may actually exist substantially stronger dynamic interdependences between different asset markets than implied by the previous literature. Because of the importance of the deterministic variables in the cointegration tests, the model specification is considered more rigorously in this paper.

3 DATA

The data used to study the linkages between the stock, bond and housing markets include quarterly time series of several different variables. The asset price series are as follows:

- Housing prices index (*H*)
- Stock price index (*S*)
- Government bond price index (*B*)

In addition, there are a number of control variables incorporated in the empirical analysis:

- Inflation rate (*p*)
- Twelve month Euribor (*IR*)
- Commercial bank lending rate (*L*)
- Deductibility of interest payments on housing loans in taxation (*T*)
- Construction cost index (*C*)
- Gross domestic product (*GDP*)
- Share of foreign ownership of the total market value of the Helsinki Stock Exchange (*F*)

It is only price indices of housing, stocks and bonds that are incorporated in the empirical analysis, since it is the linkages between different asset prices, not between total returns, that are of interest in the study. The stock and housing price indices cover 1970Q1-2006Q4, whereas the bond data exists only from 1989Q1 onwards.

The control variables are added to the analysis because they may affect the possible long-run relations between the asset prices. Hence, some of these variables might be needed in the tested models in order to find a cointegrating relation that includes the asset prices. In particular, variation in variables such as *C*, *T* and *F* may "disturb" the relation between housing prices and the other asset prices and therefore may have to be controlled for. Moreover, even if the control variables do not influence the detection of the long-run relations they may exhibit important information concerning short-run dynamics of the asset prices. All the control variables except for *L*, *IR* and *F* cover a period from 1970Q1 to 2006Q4. *L* and *IR* series start from 1971Q4 and 1987Q1, respectively.

When analyzing the interdependence between stocks and housing, the series included in the analysis are indexed with the value being 100 in 1970Q1. Similarly, when bonds are included in the analysis, all the series have the value of 100 in 1989Q1. *T*, *L*, *IR* and *F* are not indexed, however. Furthermore, natural logarithms are taken from all the indexed series. Only real values are employed in the study, except for the inflation rate. Nominal values are deflated by the cost of living index to get real variables.

The housing price index represents housing price development in the whole country. Ideally, a quality adjusted housing price index should be used. Unfortunately, such index exists starting only from 1987. Therefore, an average sales price (per square meter) index and a hedonic price index are joined to have a substantially longer sample period, i.e. series starting from 1970Q1.[9] It is reasonable to believe that the price movements displayed by the average sales prices from 1970 to 1986 do not significantly differ from the true price development. The housing price statistics are published by Statistics Finland and both indices are based on transactions of privately financed[10] flats in the secondary market.

The OMX Helsinki CAP index (OMXHCAP) is employed to depict the price development of the publicly traded stocks in the Helsinki Stock Exchange (HEX).[11] In OMXHCAP the weight of one company is restricted to be 10% at the most. OMXHCAP is used because of the significant role of Nokia in HEX since the mid 1990s. At the maximum the market value of Nokia accounted for 70% of the total market value of HEX in 2000Q4. That is, in the OMX Helsinki index (OMXH, formerly HEX index), where the weight of Nokia is not restricted, changes in the share price of Nokia dominate the movements in the index. Hence, it is reasonable to employ OMXHCAP, which represents the general development of the Finnish stock market better than OMXH. The bond price series, in turn, is the total all lives Finnish government bond price index from Datastream.

The market interest rate variable, *IR*, is the twelve month Helibor until 1998Q4 and the corresponding Euribor after that. Because the *IR* variable exists only starting from the late 1980s, also the average lending interest rate of deposit banks in Finland concerning the whole outstanding loan stock (*L*) is

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[9] Another option would have been to use the average sales price index throughout the sample period. It is better to use quality-adjusted index for part of the sample period than not to use it at all, however. In any case, there is no significant difference between the average sales price series and the hedonic index series. Moreover, none of the results presented in this paper would change notably if the average price index was used for the whole sample period.

[10] In Finland the housing market is divided into two sectors. Privately financed housing can be bought and sold at market prices without any restrictions. This sector covers approximately 80 percent of the market. In the publicly regulated sector, instead, selling prices and rental prices are controlled.

[11] OMXHCAP was formerly called HEX-portfolio index. Prior to 1990 OMXHCAP corresponds to the Unitas index.

included in the dataset. The *GDP* data is readily deflated and seasonally adjusted. *GDP* series is based on the OECD Economic Outlook data provided by Datastream. The national construction cost index, in turn, is reported by Statistics Finland. Finally, quarterly values of the share of foreign ownership of the total market value of HEX, covering 1994Q1-2006Q4, have been received from the Finnish Central Securities Depository. For the 1980Q4-1993Q4 period the foreign ownership data derived by Ali-Yrkkö and Ylä-Anttila (2003) is used. The foreign ownership data is transformed to correspond to the OMXHCAP index, i.e. the influence of Nokia on the foreign ownership rate is restricted. The pre 1994 foreign ownership data is annual. Quarterly values have been estimated by linear interpolation.

Note that quarterly values of the asset price series represent the arithmetic average of all the perceived values during the quarter. *H* is like that by construction. For *S* and *B* series, in turn, the quarterly figures are counted as arithmetic averages of the perceived daily values. This has been done in order to get more comparable series. Also the interest rate series represent quarterly averages. Figure 1 exhibits the asset price indices together with some of the control variables.

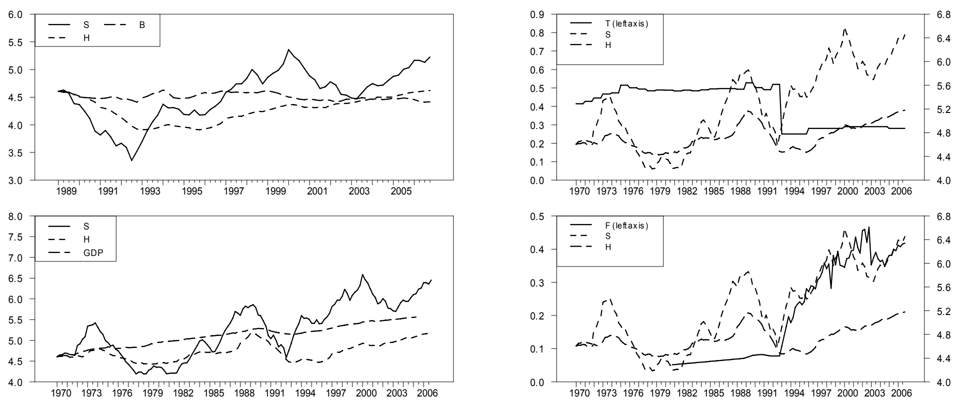

Figure 1 Asset price indices (in natural logarithms) and some control variables

The dramatic rise since 1986 in stock prices and somewhat later in housing prices was largely a consequence of the financial market liberalization in the late 1980s that was followed by a boom in bank lending. Both housing and stock prices started to fall during 1989 and both markets finally collapsed at the beginning of the 1990s. Real stock prices dropped by over 70% from 1989Q2 to 1992Q3 and real housing prices by 50% from 1989Q1 to 1993Q1.

Another stock market bubble took place in the late 1990s. Stock price index climbed rapidly mainly due to a boom in the ICT industry. Expectations were overly optimistic, and finally the bubble burst at the beginning of the 21st century. That time the boom-bust cycle in the stock market was not joined by the housing market. Since 1996 housing prices have increased relatively steadily. The real housing price level has over doubled between 1995Q4-2006Q4.

Expectedly, there are no large swings in the bond price index. Contrary to housing and stock prices, visual inspection does not show evident co-movement between bond prices and the other price series. Co-movement also between housing and stocks is hard to see after the early 1990s.

Descriptive statistics concerning the differenced real asset price series are presented in Table 1. Housing and stock statistics using also the data from 1970 to 1992 and from 1994Q1 onwards are reported separately, since it is argued later that there is a structural break in the data in 1993.

Table 1 Descriptive statistics of the differenced real price series

Asset	**Geometric mean (annualised)**	**Standard deviation (annualised)**	**Jarque-Bera (p-value)**	**1st order[12] autocorrelation**
Housing 1970-2006	.016	.062	.003	.610**
Housing 1970-1992	-.005	.070	.200	.616**
Housing 1994-2006	.053	.041	.000	.479**
Stocks 1970-2006	.051	.197	.756	.412**
Stocks 1970-1992	.006	.190	.935	.423**
Stocks 1994-2006	.083	.197	.774	.234
Bonds 1989-2006	-.011	.051	.047	.238*
Bonds 1994-2006	-.013	.048	.010	.281*

The descriptive statistics confirm what was already seen in Figure . Stock prices have been much more volatile and have risen substantially faster than housing prices. Housing prices, in turn, have been more volatile and risen more than the bond prices.

Normality of many of the differenced series is rejected. In most of the cases the rejection is due to excess kurtosis. Furthermore, the asset price changes are highly autocorrelated, in general. In all the series except for the real stock price changes in 1994-2006 the first-order autocorrelation is significant at the 5% level. Also the first-order autocorrelation of real stock appreciation in the latter sub-sample is significant at the 8% level. Real housing price movements are highly autocorrelated up to four lags. Instead, autocorrelation of the differenced bond series is notably smaller and the second-order autocorrelation is already negative. Finally, there are some signs of seasonal

[12] * and ** denote for statistical significance at the 5% and 1% level, respectively.

variation in the data, especially in the housing appreciation series during the latter sub-sample. None of the series is seasonally adjusted, however. Instead, seasonal dummies are included in the tests and models if necessary.

There may well have been structural breaks in the asset price dynamics during the sample period. Firstly, the financial market liberalization may have caused a structural change in the relationship between the perceived stock and housing series. Secondly, the rental market was regulated in Finland for a long period. Rent regulation was finally released in several stages during 1992-95. Thirdly, a tax reform took place in Finland in 1993. Furthermore, from the beginning of 1993 foreigners were allowed to invest freely in Finnish securities.

Capital gains were taxed in income taxation, i.e. capital tax rate was determined by an investor's marginal income tax rate, before 1993. In 1993 a separate capital tax rate was enforced. The capital income tax rate, which has varied between 25% and 29%, has been substantially lower than the average marginal income tax rate. This shift in taxation may have altered the relationship between different asset prices especially since capital gains on owner-occupied dwellings have been practically tax-exempt for the owner-occupants during the whole sample period.[13]

Furthermore, due to the tax reform there was a substantial change in the deductibility of interest payments on mortgages in taxation. Until 1992 the interest payments were deductible in income taxation. Thus, the after-tax interest rate was determined by marginal income tax rate. Since the tax reform, instead, a taxpayer has in practice been able to deduct the interest expenditure multiplied by the capital income tax rate from her taxes. This has resulted in a decrease in the average level of deductibility of mortgage interest payments, which, in turn, may have lowered housing price level relative to the other asset prices permanently.[14] Hence, a deductibility variable (T) is included in the analysis.

The abolition of foreign ownership restrictions considerably increased foreign ownership in the Finnish stock market. Kallunki and Martikainen (1997) point out the tremendous effect of the liberalization during the early 1990s on the behavior of the Finnish stock market. Also according to Antell (2004) the effect of global forces on stock prices in HEX has been greater after the deregulation in 1993. One might actually state that HEX and Finnish government bonds are nowadays part of the global financial markets. Global

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[13] Concerning owner-occupants who have not resided in the dwelling for at least two years on end the possible capital gains have been taxed upon selling of the dwelling.

[14] Findings of Koskela et al. (1992) indicate that rising marginal tax rate increased housing prices by raising the deductibility of mortgage interest payments and thereby increasing the rate of return on housing in the 1970s and 80s.

factors naturally have an effect also on housing prices but to a substantially smaller extent, at least in the relatively short horizon. This is because of the local nature of housing markets. Therefore, the effect of foreign investors on asset prices may have transformed the links between housing and financial assets.

Indeed, since the beginning of 1993 stock price curve starts to diverge from the housing price index. This may be a consequence of both the decrease in the deductibility of interest payments on mortgages and of the activity of foreign investors in the stock market. Figure 1 shows that since 1993 the co-movement between *F* and *S* has been strong. Quarterly correlation between *F* and *S* is .62.[15]

There are a number of reasons why the abolition of foreign ownership restrictions may have caused the parting of the paths of *H* and *S*. Compared to Finnish investors, foreign investors' required returns may have been lower (e.g. due to diversification benefits) or expectations concerning future dividends higher, or both. Especially after the sharp drop in stock prices during 1989-1992, Finnish investors were extremely cautious and Finnish stocks may have been undervalued. Moreover, the number of active market participants increased leading to a rise in the number of trades in the market, which enhanced stock market liquidity. Better liquidity, in turn, is likely to lead to lower required return on stocks.

In addition to changes in *T* and *F*, the rise of the Finnish economy from the extremely severe recession may have strengthened the separation of the stock and housing series. More recently, the divergence between stock and housing prices was augmented by the rise of the ICT stocks.

After all, it is natural that stock appreciation is faster than housing price growth. Stock market returns, in general, are more volatile than returns on housing. Thus, it is expected that returns on stocks should exceed housing returns in the long run. Furthermore, as stock market dividend yield is typically smaller than housing market "dividend" (rental income minus maintenance costs) yield, stock prices must grow faster than housing prices.

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[15] According to the Johansen test *F* and *S* are cointegrated in 1993-2006.

4 METHODOLOGY

Empirical methodology in this paper includes correlation analysis as well as time series econometrics. Correlation analysis is performed at the beginning of the empirical section. Its purpose is to give a preliminary view concerning interdependences between the asset prices. Correlation coefficients employing different observation windows are calculated. In addition, cross-autocorrelations between the variables are analyzed.

More rigorous examination of the linkages between different asset categories is conducted by employing cointegration tests and by estimating cointegrated vector autoregressive (CVAR) models. First, the augmented Dickey-Fuller (ADF) test is used to study the order of integration of the variables. The number of lags included in the ADF tests is decided based on the general-to-specific method. A constant term is included in the ADF test if the series clearly seems to be trending or if the ADF test without the constant term suggests that the series is exploding. In addition, three seasonal dummies are added to the test if Akaike Information Criteria (AIC) recommend it.

The existence of cointegration between variables which are integrated of order one [I(1)], i.e. whose levels are non-stationary but first differences are stationary, is tested employing the Johansen Trace test for cointegration. The lack of cointegration implies that dynamics between the series are only short-run in nature. The existence of one or more cointegrating vectors between the variables, instead, indicates that also long-run interdependence exists.

In the Johansen tests two possible CVAR models are considered[16]:

Model 1:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha\beta' X_{t-1} + \Psi D_t + \varepsilon_t \qquad (1)$$

Model 2:

$$\Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \alpha(\beta', \beta_1)(X'_{t-1}, t)' + \Psi D_t + \varepsilon_t, \qquad (2)$$

Three centered seasonal dummies are included in D if recommended by the Hannan-Quinn information criteria (HQ). The inclusion of centered seasonal dummies does not influence the critical values (see Johansen 1996). Also some intervention dummies are often included in D. In this study, however, intervention dummies are not included.

[16] The models correspond to equations (19) and (23) presented in section 6.1 in the Introductory Chapter of the thesis.

The difference between the models is that in Model 2 a deterministic time trend (t) is included in the cointegration space, i.e. in the long-run equilibrium relationship. If one of the variables included in the test grows faster than another, time trend might be needed in the long-run relation. Differences in the growth rates may occur, for instance, if the risk premium or dividend rate is not the same for all asset categories and the average asset appreciation in the long run is consequently larger in one market than in another market. If the growth rates differ but the trend term is not included in the tested model, it is possible that cointegration is not found even if it actually exists. This fact has usually been neglected in the previous literature.

It is only the models with unrestricted constant that are considered, because *a priori* assumption is that at least one variable in each of the tests exhibits a growing trend. If both models seem to be valid options, Model 2 is used as suggested by Doornik et al. (1998). If, however, the trend term can clearly be excluded from the cointegration space according to Likelihood Ratio (LR) test (see Johansen 1996), the number of cointegrating relations is tested based on Model 1.

The maximum lag is selected so that HQ is as small as possible and the residuals in the CVAR model do not exhibit significant serial correlation based on the LM(1) and LM(4) tests. The LM tests are conducted on residuals in the unrestricted model, i.e. in the model where r is set to equal p, as recommended by Hansen and Juselius (1995).

The selection of the number of cointegrating vectors (r) is done by comparing the estimated Trace statistics with the quantiles approximated by the Γ-distribution (see Doornik 1998). Because asymptotic distributions can be rather bad approximations to the finite sample distributions, the Bartlett small sample corrected values, suggested by Johansen (2002), are employed. The LR test described in Johansen (1996) is used to test for the weak exogeneity of the variables as well as to identify the cointegrating relations. Identification is conducted by testing if one or more variables can be excluded from the long-run relation, i.e. by testing if one or more of the coefficients in the β-vector can be set to equal zero. In these LR tests Bartlett small-sample correction by Johansen (2000) is used.[17] Furthermore, the stability of each estimated long-run relation is examined employing a recursive estimation analysis (see Dennis 2006, pp. 95-112).

If "control variables" that are assumed not to enter the possible long-run relations are included in the cointegration test, the testing of the number of cointegrating vectors is done as proposed by Rahbek and Mosconi (1999). In

[17] According to a Monte Carlo analysis conducted by Canepa (2006), the Bartlett corrected LR test provides, with some caution, a reliable inference when testing linear restrictions of the cointegrating vectors.

the case where one or more variables are restricted to be weakly exogenous so that they do not adjust to the long-run equilibrium, the methodology and asymptotic tables presented in Harbo et al. (1998) are applied (in the text below, this model is called Model 3).[18] see p. 69 in the Intoductory chapter for details).

If cointegration between the variables is found, CVAR model is estimated to study the dynamics between the variables. Equilibrium-error (EQE), i.e. the deviation from the long-run relation, is included in the model due to the fact that important information concerning long-run dynamics is lost if only differenced variables are used in the analysis. The number of lags (n) as well as the additional control variables included in the CVAR models are decided based on the LR test using Sim's correction for small samples.

Granger non-causality (GNC) is tested by a standard F-test to further study the linkages between different variables. With cointegrated variables Granger causality can run also through the long-run equilibrium relation. As Engle and Granger (1987) show, cointegration implies that the stationary EQE should Granger cause at least one of the cointegrated variables. Hence, also EQE must be included in the GNC test on cointegrated variables:

$$\Delta X_t = \mu + \sum_{j=1}^{n} \Gamma_j \Delta X_{t-j} + e_{t-1} + D_t + \varepsilon_t. \tag{3}$$

If cointegration is not present, the lagged equilibrium-error, e_{t-1}, is naturally not present in the GNC test. Furthermore, lagged EQE is not included as explanatory factor for the variables that do not belong to the long-run relation.

Note that a finding that x Granger-causes y does not necessarily imply that x causes y. It merely means that current and historical observations of x are statistically significant in predicting future value of y. From now on, when causality is mentioned in the text it refers to Granger causality.

Finally, innovation accounting, i.e. impulse response analysis and variance decomposition, is performed based on the estimated models employing the Choleski decomposition.

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[18] See page 69 in the Intoductory chapter for details about the Harbo et al. model.

5 EMPIRICAL FINDINGS

5.1 Correlation analysis

As mentioned earlier, correlation coefficients between asset returns often exhibit temporal instability and are dependent on the length of the observation window (investment horizon). Nevertheless, correlation analysis can be helpful when studying interrelations and diversification potentials between different assets. One can get useful insight into the linkages between the asset markets by comparing correlations in different time periods and correlations calculated using different observation windows and by studying cross-autocorrelations. Table 2 presents the correlations between the asset price series using real quarterly and annual changes of the variables. Correlations are reported separately for the early (1970Q1-1992Q4) and late (1994Q1-2006Q4) sub-samples, since it is argued below that a structural break took place in 1993.[19]

Correlations, expectedly, vary between data at different frequencies. Instead, correlation between housing and stock appreciation does not appear to have decreased after 1993. This does not support the hypothesis that the impact of foreign investors on HEX has diminished co-variation between housing and stock markets. Anyhow, all the coefficients between housing and stocks are statistically significant. Furthermore, the exhibited correlations between stock and housing appreciation are somewhat greater than typically reported in the previous literature. Nevertheless, the correlations imply that notable diversification benefits can be gained by including stocks in a housing portfolio or *vice versa*. The annual real appreciation correlation is approximately .7 after 1993, which is somewhat smaller than, for example, the correlations between regional housing markets in Finland.

The longer the observation period is, the larger is the correlation between stock and housing price movements. This indicates that tighter linkages exist between stock and housing prices than suggested by the relatively short-run correlation figures. Correlation between stock and housing price movements grows fast when the investment period is lengthened from one to three quarters and keeps growing still, albeit slower, as the investment horizon is

[19] Because it seem possible that the adjustment of the stock market to the abolishment of the foreign ownership restrictions might have taken a couple of quarters and the adjustment of the housing market to the tax regime shift might have been sluggish, the latter sub-sample starts at 1994Q1 instead of 1993Q1.

further extended. This can be seen in Figure 2, which shows the reliance of the correlation figure upon the employed observation window. Note that the long-run correlations in the figure are based on overlapping observation windows.

Table 2 Correlations between real stock, bond and housing appreciation and inflation and real interest rate movements

	Stock	Housing	Stock -92	Housing -92	Stock 94-	Housing 94-	Bond 94-
Quarterly							
Housing	.457**						
Inflation	-.197*	-.177					
Housing -92			.465**				
Inflation -92			-.178	-.034			
Housing 94-					.527**		
Bond 94-					.057	.073	
Euribor 94-					-.193*	-.081	.118
Inflation 94-					-.075	-.169	-.596**
Annual							
Housing	.605**						
Inflation	-.317*	-.152					
Housing -92			.636**				
Inflation -92			-.288	.057			
Housing 94-					.692**		
Bond 94-					-.299	-.074	
Euribor 94-					-.329	-.469	-.344
Inflation 94--					-.148	-.191	-.597*

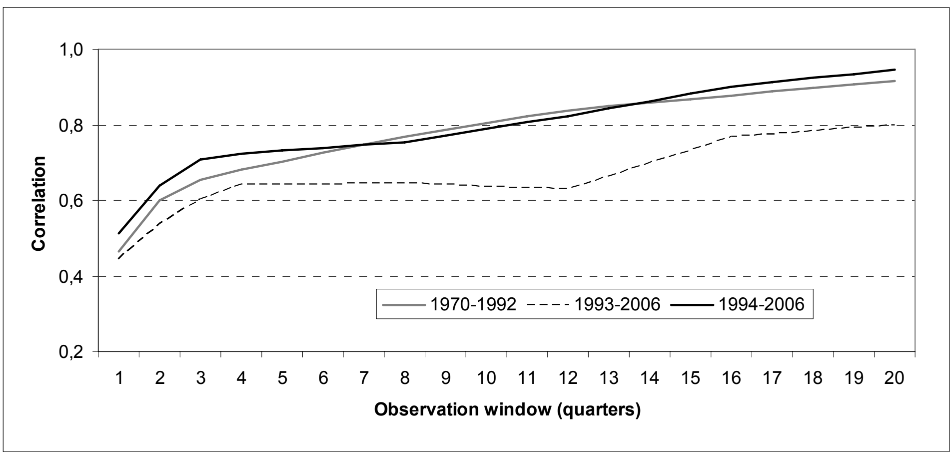

Figure 2 Correlation between real stock and housing appreciation

Figure 2 indicates that, contrary to the prior thoughts, the influence of foreign investors on Finnish stock market has not altered the diversification opportunities between Finnish stock and housing markets either in the short run or in the long horizon. The fact that correlation gets close to one as the horizon is lengthened shows that there is a tight long-run connection between the two series, i.e. *H* and *S* may well be cointegrated. Anyhow, the hypothesis that a structural break took place in 1993 is supported by the 1993-2006 curve, which significantly differs from the other two curves.

It is not unexpected that the correlations between *S* and *H* are notably smaller in the short horizon than in the longer run. The short-term co-movement between the assets is diminished by the role of speculative volatility in stock prices and by the sluggish adjustment of the housing market to various shocks. In the longer horizon stock prices have to converge towards their fundamental values, i.e. the influence of speculative traders diminishes, and the housing market is able to adjust. Therefore, as the fundamental values (discount factors and expected cash flows) of these assets are determined to a great extent by the same underlying economic factors, the long-run co-movements between the assets is strong.

Note that some part of the relatively small short-run correlations may be accounted for by the "noise" in housing price data, i.e. the fact that the housing price data do not perfectly cater for the differences in the average quality of dwellings sold in different periods. It seems reasonable to assume that the influence of "noise" is only slight, however, since the number of observations (housing transactions) in each quarter is substantial.

The co-movement between bond markets and the other two asset markets seems to be weak. There appears to be a slight positive interrelation between the real price movements but all the correlations are statistically insignificant. Furthermore, there is no similar horizon effect between bonds and the other assets as between stocks and housing.

The correlations between inflation rate movements and asset price changes are negative, with the exception of annual correlation with housing appreciation in the latter sub-sample. Expectedly, bonds seem to offer the worst and housing the best protection against movements in the inflation rate. Finally, real housing prices seem to react to the changes in the real interest rate sluggishly – the correlation gets notably larger in absolute value as the observation window is lengthened from one quarter.

Cross-autocorrelations up to four lags are reported in Table 3. The variable mentioned on the left side is the lagged variable. For example the value .396 top left shows the correlation between current housing appreciation and last periods' stock price growth. Because of the possible break in 1993, only a period from 1994Q1 onwards is utilized in calculating the autocorrelations.

Table 3 Cross-autocorrelations of quarterly changes in 1994Q1-2006Q4[20]

	1	2	3	4		1	2	3	4
S – H	.396***	.104*	-.087	-.114	H – S	.276***	.218**	.102	.059
S – B	-.311**	-.195	-.074	-.060	B – S	.073*	.211	.216	.254**
H – B	-.319**	-.221**	-.085	-.181*	B – H	.299	.268	.300*	.472**
S – IR	-.169	.256	-.028	.002	IR – S	.007	.208*	-.278**	-.120
S – p	.250**	.006	.109*	.124**	p – S	-.339	-.314	.005	-.299
H – IR	-.251*	.283	-.027	.017	IR – H	-.154*	.200	-.160	-.094
H – p	.274***	-.015**	.115***	.144***	p – H	-.259	-.379	-.048**	-.182**
B – IR	-.456***	-.080	.247	-.081	IR – B	.213	-.077	-.062*	.158
B – p	-.064	.013	-.316**	-.158	p – B	-.223**	.138	-.040	-.119

It is evident according to Tables 2 and 3 and according to Figure 2 that the contemporaneous quarterly correlations give an inadequate picture concerning the linkages between different asset prices. Particularly the links between housing and stock markets seem to be tight. There are significant cross-autocorrelations also between bond and stock price movements and between bond and housing appreciation. In many cases the cross-autocorrelations are bigger than the corresponding contemporaneous correlations. The negative coefficients of the bond market on lagged price changes in the stock and housing markets are probably due to the positive effect of stock and housing appreciation on the inflation and interest rates. Also the feedback effect may decrease demand for bonds as the returns in the other asset markets rise. By contrast, stock and housing price movements have positive coefficients on lagged bond price changes. This is because bond prices go up as interest rate drops. Decrease in the interest rate also affects the stock and housing market demand positively, often with lag.

In addition, there are a number of large and significant cross-autocorrelations between the assets and the interest and inflation rates. The significant positive correlation between current inflation and lagged stock and housing appreciation is expected, since rapid housing and stock price growth typically anticipates swift growth in the overall economy and thereby, in general, relatively rapid inflation.

It is important to understand that significant cross-autocorrelations do not necessarily imply the existence of causality between the variables. Nevertheless, large cross-autocorrelations do indicate predictability of the variables and show that there are interdependences between the asset prices beyond the level signified by the contemporaneous correlations alone. Moreover, the use of quarterly correlations in analyzing a portfolio that includes stocks and housing is misleading. As housing investments are long-run in nature, quarterly figures give too optimistic a picture about diversification benefits between stocks and housing.

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[20] Unlike in the other tables, *, ** and *** denote for statistical significance at the 10%, 5% and 1% level, respectively.

5.2 Econometric analysis

Linkages between the asset prices are further studied by time series econometrics. First, the order of integration of the variables is checked. Then the existence of cointegrating relationships is tested and the compositions of the cointegrating relations are analyzed. Finally, Granger causalities, impulse response functions and variance decompositions are examined based on the estimated CVAR and VAR models.

The ADF test indicates that all the variables, except for *L*, are I(1).[21] Also *L* is treated as an I(1) variable in the cointegration analysis, though. This is because the Johansen test results indicate that none of the variables can separately form a stationary vector. The unit root test results are reported in Table A1 in the Appendix.

5.2.1 Sample from 1970Q1 to 2006Q4

Using the whole sample period, the small-sample corrected (SSC) Trace test results reported in Table 4 do not support the existence of a cointegrating relation between *S* and *H*. Inclusion of any of the control variables does not change this result. Cointegrating relationships in a system including six variables (*S*, *H*, *L*, *GDP*, *C* and *T*) were also examined. This analysis supports the inference that there is no cointegrating relationship including both *S* and *H* using the whole sample period (see Table A2 in the Appendix).

Nevertheless, the Johansen test (using Model 1) suggests that *S* and *H* were pairwise cointegrated during 1970-1992, i.e. before foreign investors were allowed to freely invest in Finnish securities and before the tax deductibility rules of mortgage interest payments were altered. This finding is in line with the results by Takala and Pere (1991) concerning the period over 1970Q1-1990Q2. Only housing prices adjust to the long-term relation. Test on Model 3 confirms the inference that there appears to be a cointegrating relation between *S* and *H* (p-value is .02). Stability of the long-run relation cannot be rejected, even though there is notable deviation from the equilibrium in the late 1980s and early 1990s.

Note that the Trace statistics actually suggest that there are two cointegrating vectors when the sample from 1970 to 1992 is employed. If this was the case, both *S* and *H* would be stationary. This unexpected result is not supported by the other statistics, however. In particular, neither of the variables can be excluded from the estimated cointegrating relation (the p-

[21] Unit root in *T* cannot be rejected even when allowing for a structural break in 1993Q1.

values in the LR test are smaller than 1%). This indicates that the series cannot be stationary and there cannot be more than one stationary relation in a system including *S* and *H*.

The analysis suggests that there may be long-run dynamics between stock and housing prices since 1994 as well. Trace test including only *H* and *S* does not support the existence of cointegration. Nevertheless, the alfa of housing appears to be relatively large and statistically highly significant whereas the alfa of *S* is clearly not significant. Hence, Model 3, where *S* is restricted to be weakly exogenous (we), is employed to get a more powerful test. Then the hypothesis of no cointegration can be rejected at the 15% level of significance. Based on the recursive analysis the stability of the potential long-run relation cannot be rejected. Furthermore, visual inspection does not indicate non-stationarity of the equilibrium-error, even though there is relatively large volatility and deviation from the equilibrium during 1994-96. If *IR* and *GDP* are included in the test as weakly exogenous variables, the p-value is further decreased to 3%. It appears that both *IR* and *GDP* can be excluded from the long-run relation, which indicates that *S* and *H* are pairwise cointegrated. The existence of strong long-run linkages between *S* and *H* also during the latter sub-sample is in line with the correlation analysis.

Table 4 Johansen test results in a system including real housing and stock price indices

H_0: r = 0		H_1: r ≤ 1		H_2: r ≤ 2	
Trace statistics	p-values	Trace statistics	p-values	Trace statistics	p-values
Sample: 1970Q1 – 2006Q4 (variables= *H*, *S*; model 2, ml=5, seasonal dummies)					
13.9	.67	6.7	.39		
Sample: 1970Q1 – 1992Q4 (variables= *H*, *S*; model 1, ml=5, seasonal dummies, p-value in the test for weak exogeneity of *S* = .96)					
17.7	.02	4.6	.03		
Sample: 1994Q1 – 2006Q4 (variables= *H*, *S*; model 2, ml=2, seasonal dummies)					
14.8	.60	3.9	.76		
Sample: 1994Q1 – 2006Q4 (variables= *H*, *S* (we); model 3, ml=2, seasonal dummies)					
12.1	.15				
Sample: 1994Q1 – 2006Q4 (variables= *H*, *S* (we), *IR* (we), *GDP* (we); model 3, ml=3, seasonal dummies, p-value in the test for exclusion of *IR* and *GDP* = .37)					
22.6	.03				
Sample: 1980Q4 – 2006Q4 (variables= *H*, *S*; model 2, ml=5, seasonal dummies)					
15.1	.57	6.3	.43		
Sample: 1980Q4 – 2006Q4 (variables= *H*, *S*, *L*, *F*, *T*; model 1, ml=2, seasonal dummies, p-value in the joint test for exclusion of *T* and for weak exogeneity of *F* = .19)					
76.0	.01	39.0	.27	16.6	.68
Sample: 1980Q4 – 2006Q4 (variables= *H*, *S*, *L*, *F* (we); model 3, ml=2, seasonal dummies, p-value in the test for exclusion of trend = .20)					
56.0	.01	20.6	.45	5.0	.81

The lowest part of Table 4 shows test statistics for models including also *L*, *F* and *T*. The sample starts in 1980Q4 because data on *F* are not available earlier. The five variables appear to form one cointegrating vector. The model gives support to the hypothesis that the structural shift in the long-run relation between *S* and *H* was to a large extent due to the abolishment of the restrictions on foreign ownership of Finnish securities, since *T*, which caters for the change in the tax code, can be excluded from the long-run relation. On the contrary, stationarity of the long-run relation necessitates the inclusion of *F*. A model where *F* is set weakly exogenous and that does not include *T* confirms the finding. Trend term can be extracted from the long-run relation and signs for the variables are as expected. Increase in *F* raises stock prices relative to housing prices. Also this long-run relation appears to be relatively stable.

The structural break in 1993 can be seen well in Figure 3.[22] The upper graph shows the equilibrium error from the 1971Q2-1992Q4 long-run relation both during the first part of the sample and after the structural break. The lower part, in turn, pictures the equilibrium-error from the 1994Q1-2006Q4 long-run relation based on the model including only *S* (we) and *H*. The considerable deviation from the equilibrium in the late 1980s in the upper graph is due to the extremely large volatility in the asset prices caused by the asset price boom in the late 1980s.

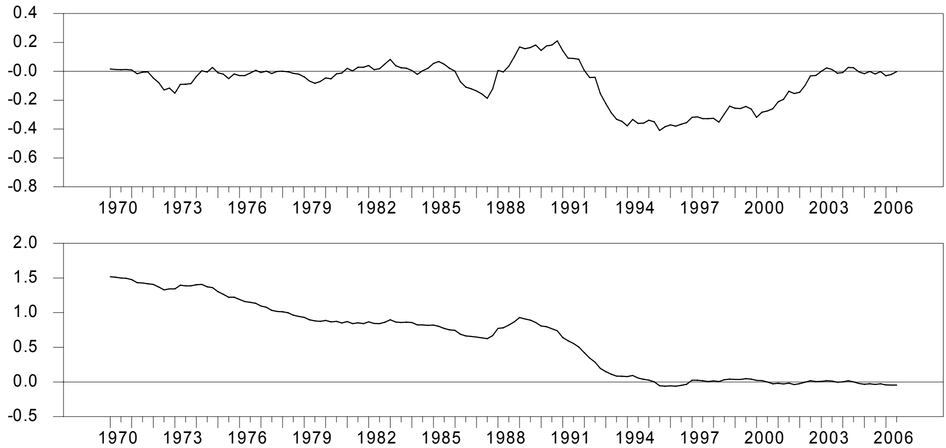

Figure 3 Deviation of real housing price level from the long-run relations

The lower graph clearly implies that the housing price level relative to stock price level has decreased since the early 1990s. However, the upper graph may have a different message: the notable deviation from the early sub-sample's cointegrating relation during the 1990s and the early 21st century (probably caused by the change in the foreign ownership rules) may have been temporary. This might be due to the fact that over the long horizon also local housing demand is likely to be strongly affected by global forces. Possibly, because of the sluggishness of the housing market, it took several years before the increasing influence of the global forces on local markets was fully reflected in housing prices. The stock market, instead, with a significant number of foreign participants responded to the changing environment much

[22] The existence of cointegration between *S* and *H* allowing for a one time break in the trend in the long-run relation can be formally tested by the test proposed by Johansen et al. (2000). This test does not give evidence for cointegration with one time break in 1993Q1. This is likely to be due to the facts that the test implicitly assumes that the short-run dynamics as well as the other long-term dynamics do not differ between the sub-samples and that there might have been a "transition period" in 1993 during which the asset prices have gradually adjusted to the changed environment.

more rapidly. In any case, later on with longer data in hand this question can be studied in more detail.

Since the short-run dynamics between stock and housing markets may have changed after 1992, the GNC tests and innovation accounting are conducted based on both the pre 1993 and post 1993 models. Granger causalities during 1971Q4-1992Q4 are studied by a third-order CVAR model including ΔH, ΔS, ΔGDP, ΔL and three seasonal dummies. The estimated adjustment speed of housing prices towards the long-run relation is 10% per quarter, which is close to the figure 7.4% reported by Takala and Pere (1991). Generally, given that housing market is not as liquid as the stock market and the price adjustment is likely to be more sluggish in the housing market, one would expect that the causality runs from the stock market to the housing market. Indeed, in line with the previous empirical evidence from the Finnish market reported by Takala and Pere and with the theory, stock price movements caused housing price changes prior to 1993 but not *vice versa*. Stock price movements were not Granger caused by any of the other variables. There is evidence of ΔS Granger causing itself, though. Housing appreciation, in turn, was caused also by its own previous values as well as by the deviation from the equilibrium relation.

Table 5 suggests that there have been some notable changes in the causalities after 1992.[23] It appears that nowadays ΔS causes ΔH only through the long-run relation. This is not totally unexpected, since today both short- and long-run movements in stock prices are greatly influenced by international investors, whereas local factors dominate housing appreciation in the short horizon. In the longer run, instead, also local housing markets are expected to be influenced substantially by global forces. Therefore, it is in line with the prior expectations that (only) housing prices adjust towards the long-run relation between the two assets. Expectedly, ΔH seems to cause itself in the latter period as well. The alfa of housing prices in the latter period is somewhat greater than the pre 1993 alfa, namely some 20% per quarter.

Note that the asset price movements appear to Granger cause GDP growth. This is probably due to the positive effect of the asset price growth on economic activity together with forward-looking features in the asset price movements. That is, today both stock and housing appreciation seem to be pre-cyclical.

The adjusted R^2 figures of the models are also reported in Table 5. The informational efficiency of the stock market appears to have improved after the financial deregulation (including the abolishment of the restrictions on

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[23] This estimated model is similar to the model of pre 1993 period with the exception that Euribor is included instead of the lending rate and that there is one lag less incorporated.

foreign ownership). That is, at present it appears to be hard to predict stock price movements based on historical information, at least at the quarterly level, whereas before the 1990s current and previous stock appreciation had significant predictive power with respect to future stock price changes. Housing appreciation, instead, has been highly predictable also after the 1980s. This is not surprising, since the special features of the housing market are expected to cause notable autocorrelation in housing price movements.

Table 5 P-values in the Granger non-causality tests[24]

Dependent variable	Explanatory variable					
1971Q4-1992Q4						
	ΔS	ΔH	ΔGDP	ΔL	eqe	Adj. R^2
Δ Stock	**.00**	.53	.90	.69	.68	.26
Δ Housing	**.00**	**.00**	.64	.04	**.02**	.66
Δ GDP	.16	.49	.34	.82		.27
Δ Lending rate	**.03**	**.07**	**.05**	**.00**		.71
Δ Stock (we)	**.00**	.55	.91	.71		.27
1994Q1-2006Q4						
	ΔS	ΔH	ΔGDP	ΔIR	eqe	Adj. R^2
Δ Stock	.42	.24	.66	.44	.77	.08
Δ Housing	.35	**.00**	.52	.93	**.00**	.50
Δ GDP	.11	**.08**	.35	.35		.19
Δ Euribor	.85	**.08**	.99	**.00**		.68
Δ Stock (we)	.37	.20	.53	.53		.15

The ordering of the variables in the innovation accounting is the following: *GDP*, *S*, *H*, *L*/*IR*. It is therefore assumed that aggregate income does not contemporaneously respond to innovations in any of the other variables, but may affect all the other variables within the quarter. Real interest rate, in turn, is allowed to respond within a quarter to shocks in any of the other variables. The ordering reflects the common assumption that interest rate changes are transmitted to the economy with lag.

The variance decompositions derived from the estimated CVAR models (shown in Table A3 in the Appendix) imply that shocks in the asset prices themselves explain major part of the forecast errors of the asset price movements.[25] Nevertheless, the variance decompositions do not necessarily

[24] The models are not reported in detail, since the interpretation of individual coefficients is problematic. The GNC tests together with innovation accounting summarize the dynamic interrelations proposed by the model.

[25] The forecast error variance decomposition shows the proportion of the movements in a series that are due to its "own" shocks versus shocks to the other variables in the model (Enders 2004, p. 280).

mean that the impact of the fundamental variables on the asset prices is small – forward-looking components in the asset prices are one potential explanation for the finding.

To further study the relation between stock and housing markets impulse responses are derived based on the estimated CVAR models (see Figure A1 in the Appendix). The impulse curves on the left hand side show the expected impact of one percent positive shock to stock prices on housing prices in the former sub-sample. The right hand side curves, in turn, show what the model predicts the impact to be today. The graphs include the response of the stock prices themselves. Responses of stock prices to a shock in housing prices are not graphed, since the responses appear to be negligible.

The curves imply that the effect of a stock market shock on housing prices is substantially smaller today than it was prior to 1993. In fact, the response of housing prices to a stock market shock appears to be negligible after 1994. This further illustrates the differences between the two sub-samples. It is reasonable to assume that in the 1970s and 80s a shock in stock prices was often due to changes in the Finnish macroeconomic fundamentals (and in expectations concerning those fundamentals) that also influenced the national housing market. Currently, by contrast, the influence of global factors (including the possible short-term speculation of the international investors) that do not have a straightforward impact on the local housing markets, at least not in the relatively short run, often cause stock market volatility. This could explain the discrepancy between the presented impulse response curves.

Nevertheless, the large long-term correlation and the possible cointegration between stock and housing prices indicate that in the long run the same factors still drive stock and housing prices. As mentioned, the increase of the correlation with the horizon may be due to the sluggish adjustment of the housing market together with the fact that the impact of short-run speculation on the stock market dampens in the long run.

The impulse curves further suggest that, while there was a strong momentum effect in stock appreciation prior to the financial liberalization, such momentum does not exist anymore. This is in line with the earlier claim according to which the informational efficiency of the stock market seems to have improved. The role of the international investors in this development may have been significant. Note, however, that the impulse responses should be examined with some caution, since the standard errors of many of the estimated parameters are relatively large.

The ordering of the variables often influences variance decomposition notably. Nevertheless, with the estimated models the importance of the ordering of the variables is relatively small.

5.2.2 Sample from 1989Q1 to 2006Q4 including bond prices

Next, bond price index is added to the analysis. The Johansen test results are summarized in Table 6. Employing the whole sample including bond data, i.e. the period over 1989Q1-2006Q4, the Johansen test suggests that the three asset price series form a stationary vector. Closer look at the potential stationary vector, however, reveals that the small p-value is due to the close to trend stationary bond price series.[26] It is hard to find a sensible and stable long-run relation which includes at least two of the asset price series and to which at least one of the asset prices adjusts. Even the inclusion of *F* in the test does not help, although it was found above that there is a long-run relation starting from 1980Q4 including *S*, *H* and *F*. If *IR* is included in the analysis, none of the asset prices seem to respond to deviations from the potential long-run relation.

Anyhow, because of the probable structural break in 1993, it is probably better to estimate a model using only the latter part of the sample in any case. Eventually, the most sensible and stable long-run relationship from 1994Q1 onwards appears to be the one between *S* and *H* that was already estimated above. The relation seems to be more stable when *B*, *GDP* and *IR* are included in the short-run model. Model 3 confirms the cointegration test results. As earlier, only housing prices seem to respond to deviation from the long-run relation. The estimated speed of adjustment is surprisingly large, almost 30% per quarter.

Table 6 Johansen test results in a system including real housing, stock and bond price indices

H_0: r = 0		H_1: r ≤ 1		H_2: r ≤ 2	
Trace statistics	p-values	Trace statistics	p-values	Trace statistics	p-values
Sample: 1989Q1 – 2006Q4 (variables= *H*, *S*, *B*; model 2, ml=2)					
49.8	.01	23.9	.10	10.4	.12
Sample: 1994Q1 – 2006Q4 (variables = *H*, *S*, *B*, *GDP* (we), *IR* (we); model 3, ml=3, seasonal dummies, p-value in the joint test for exclusion of *B*, *GDP* and *IR* and for weak exogeneity of *S* and *B* = .10)					
55.0	.08	31.1	.15	13.7	.20
Sample: 1994Q1 – 2006Q4 (variables = *H*, *S* (we), *B* (we), *GDP* (we), *IR* (we); model 3, ml=3, seasonal dummies, p-value in the test for exclusion of *B*, *GDP* and *IR* = .11)					
25.0	.03				

[26] In addition to the ADF test, the Phillips-Perron unit root test and the KPSS test (in which stationarity is the null hypothesis) imply that *B* is actually not stationary.

Granger causalities during the period of 1994Q1-2006Q4 are studied by a CVAR model containing three lags in differences and including ΔS, ΔH, ΔB, ΔGDP and ΔIR (see Table 7). The causalities between ΔH and ΔS are congruent with those reported in Table 5. Thus, also this model indicates that the predictive power of ΔS with respect to ΔH has diminished after the 1980s. Similarly to stock appreciation, bond price changes do not seem to be predictable by using historical data of the other asset price series.

Table 7 P-values in the Granger causality tests including bond price series

Dependent variable	Explanatory variable: ΔS	ΔH	ΔB	ΔGDP	ΔIR	eqe	Adj. R^2
Δ Stock	.43	.64	.32	.24	.63	.93	.10
Δ Housing	.71	**.00**	.64	.97	.94	**.04**	.48
Δ Bond	.51	.88	**.08**	.24	.53		.11
Δ GDP	**.09**	.36	.44	**.10**	.54		.25
Δ Euribor	.76	.75	**.02**	**.00**	.82		.71
Δ Stock (we)	.39	.64	.24	.22	.56		.19

Figure A2 in the Appendix presents the impulse responses to shocks in the asset prices derived from the estimated five variable CVAR model. Because the evidence for a stable long-run relation between stocks and housing is not totally confirmative, it is reasonable to examine also a third-order VAR model, i.e. a model that excludes the potential tight long-run relation between S and H. The impulses derived from the VAR model can be seen in Figure A3. Some of the impulse responses derived from the VAR model are notably different from the ones derived from the CVAR model.

Although the presented impulse response curves should be interpreted with some caution, the curves appear to have some interesting implications. First of all, a shock to stock prices should be substantial in order to anticipate notable future movements in any of the asset prices. This suggests that, in general, speculation in the stock market is not transmitted to the housing and bond markets. Secondly, a positive shock to ΔB appears to anticipate higher real stock and housing appreciation. This is expected, since a positive shock to ΔB takes place due to lower than expected inflation or interest rate. On the other hand, shock to S or H does not seem to affect B notably. Note that without the long-run restriction a positive bond price shock appears to anticipate higher stock and housing appreciation than based on the CVAR model. In addition, the impulse responses of S and H to a housing market shock differ notably between the CVAR and VAR models. In particular, based on the VAR model, shock to housing prices is more permanent in nature. Thus, the VAR model suggests that none of the variables exhibit notable mean-reversion.

The results from the variance decomposition (see Table A4 in the Appendix) are in line with those based on the model without the bond series.[27] The influence of *IR* on stock and housing prices appears to be somewhat greater based on the five-variable model, though. Furthermore, the analysis implies that the importance of bond price movements on the other two asset prices is negligible. Finally, the fact that the driving nature of the other variables with respect to bond prices is only faint is probably due to the importance of the inflation rate to real bond price movements.

[27] Again, the decompositions do not appear to greatly depend on the ordering of the variables. Furthermore, the variance decompositions between the CVAR and VAR model do not differ notably.

6 SUMMARY AND CONCLUSIONS

There are many reasons to believe that significant interdependences exist between the financial asset markets and the housing market. In particular, the same economic fundamentals are expected to affect the discount factors and expected cash flows of both housing and financial assets. Despite the numerous important implications that the interrelations between different asset categories may have on the economy, research examining these linkages has still been limited.

The main aim of this paper is to empirically analyse linkages between the stock, bond and housing prices. Data from Finland is used in the empirical analysis. The results imply that significant co-movement exits between the stock and housing prices. Correlation between stock and housing appreciation is the greater, the longer the investment horizon is – while in the long-horizon the diversification gains between well diversified stock and housing portfolios appear to be close to negligible in Finland, in a relatively short horizon notable diversification gains are obtainable. Hence, from a long-term institutional investor's point of view the use of quarterly correlations in portfolio analysis is misleading and may cause in misdirected investment strategies. Note, however, that for households that do not hold a well diversified portfolio (of housing at least) the diversification benefits are likely to be substantially greater, since the unsystematic risk involved with a single dwelling is typically remarkable.

Even though there appear to be some interaction also between bond price changes and stock and housing appreciation, the co-movement between bond prices and the other asset prices has been substantially weaker than between stock and housing prices. This indicates that the inclusion of bonds in a portfolio including stocks or housing may create substantial diversification benefits.

Cointegration analysis implies that there was a structural break in the long-run relationship between stock and housing markets in 1993. The analysis suggests that the break was mainly due to the abolition of foreign ownership restrictions in the Finnish capital markets. Also the substantial decrease in the deductibility of mortgage interest payments in taxation in 1993 may have been of some importance. It is argued that the growing importance of international investors in the Finnish stock market may have diminished co-movement between stock and housing markets permanently, since the housing market necessarily is and will be local to a great extent whereas the stock market is today driven by global forces. It is found, however, that neither short-run nor long-run correlation between the stock and housing appreciation has changed after the abolishment of the restrictions concerning foreign ownership of Finnish stocks.

The results also show that housing price movements are highly predictable. Therefore, the unconditional portfolio analysis may be fallacious. Whether one can take advantage of the predictability of the asset price movements to make profit is another question, however.

Up until the early 1990s the Finnish housing market followed the booms and busts in the stock market. It seems that this seemingly inevitable phenomenon of the almost simultaneous cycles has vanished, despite the finding that correlation between stock and housing appreciation has not changed. That is, higher than average stock appreciation tends to be accompanied by higher than average housing price growth, but the volatility of housing prices relative to stock prices has been substantially smaller since the mid 1990s than earlier. Furthermore, it appears that, in general, speculation in the stock market does not have notable impact on the housing market. This may have a positive impact on the macroeconomic stability.

The interest rate movements are likely to have a role in the absence of the boom-bust linkage between stock and housing markets after the early 1990s. In the 1970s and 80s stock market bust was typically accompanied with a rise in the real interest rates. The interest rates did not rise notably during or after the last steep drop in the stock prices, however. In addition, it is possible that the foreign investors' influence on the stock market has undermined the earlier strong linkage between booms and busts in the stock and housing markets. It is possible, however, that during future crisis periods stock and housing price co-movement strengthens especially if the real interest rates increase substantially.

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APPENDIX ADDITIONAL TABLES AND FIGURES

Table A1 Augmented Dickey-Fuller test results[28]

Variable	**Level (lags)**	**Difference (lags)**
Stock prices	-.95 (5)[c,s]	-4.92** (4)
Housing prices	-2.26 (4)[c,s]	-3.82** (4)
Bond prices 1989-	-2.56 (1)[c]	-5.95** (0)
Lending rate	-1.99* (4)[s]	-6.70** (3)[s]
Euribor 1989-	-1.88 (2)[s]	-19.9** (1)[s]
GDP	-.61 (3)[c]	-2.79** (2)
Construction costs	-2.49 (2)[c]	-5.91** (1)
Inflation rate	-1.28 (4)[s]	-6.94** (3)[s]
Deductibility	-1.26 (0)	-8.43** (0)

Table A2 Johansen test results in a system including *S*, *H*, *L*, *GDP*, *C* and *T*

H_0(rank)	Trace value	p-value
Sample: 1971Q4 – 2006Q4 (model 2, ml=3, seasonal dummies)		
r = 0	94.4	.56
r ≤ 1	62.8	.76
r ≤ 2	40.3	.83
r ≤ 3	25.9	.74
r ≤ 4	13.2	.72
r ≤ 5	4.4	.68

Table A3 Decomposition of variance of Δ*S* and Δ*H* based on the CVAR models

Step (quarters	1971Q4-1992Q4							
	Stock appreciation				Housing appreciation			
	ΔGDP	*ΔS*	*ΔH*	*ΔL*	*ΔGDP*	*ΔS*	*ΔH*	*ΔL*
1	.002	.997	.000	.000	.001	.031	.968	.000
2	.002	.977	.000	.021	.009	.332	.646	.013
5	.030	.949	.001	.020	.025	.453	.507	.015
10	.035	.944	.001	.020	.025	.488	.466	.021
20	.036	.943	.001	.020	.024	.476	.476	.024
	1994Q1-2006Q4							
	ΔGDP	*ΔS*	*ΔH*	*ΔIR*	*ΔGDP*	*ΔS*	*ΔH*	*ΔIR*
1	.028	.972	.000	.000	.008	.199	.792	.000
2	.032	.910	.048	.009	.021	.348	.630	.004
5	.040	.870	.065	.025	.032	.379	.587	.001
10	.048	.827	.096	.029	.077	.304	.616	.003
20	.049	.822	.100	.029	.081	.298	.617	.003

[28] * and ** denote for statistical significance at the 5% and 1% level of significance, respectively, [c] indicates that constant was included in the test and [s] means that three seasonal dummies were included in the test.

Table A4 Decomposition of variance of ΔS, ΔH and ΔB based on the CVAR model

Step (quarters)	Stock appreciation					Housing appreciation					Bond appreciation				
	ΔGDP	ΔS	ΔH	ΔIR	ΔB	ΔGDP	ΔS	ΔH	ΔIR	ΔB	ΔGDP	ΔS	ΔH	ΔIR	ΔB
1	.035	.965	.000	.000	.000	.000	.160	.840	.000	.000	.003	.008	.015	.069	.905
2	.042	.853	.031	.065	.008	.009	.290	.677	.024	.000	.025	.101	.046	.054	.773
5	.038	.767	.057	.103	.035	.019	.293	.604	.078	.006	.032	.111	.059	.085	.713
10	.039	.747	.068	.112	.034	.032	.260	.630	.072	.006	.035	.118	.073	.087	.686
20	.039	.745	.069	.112	.034	.033	.260	.630	.072	.006	.035	.118	.075	.087	.684

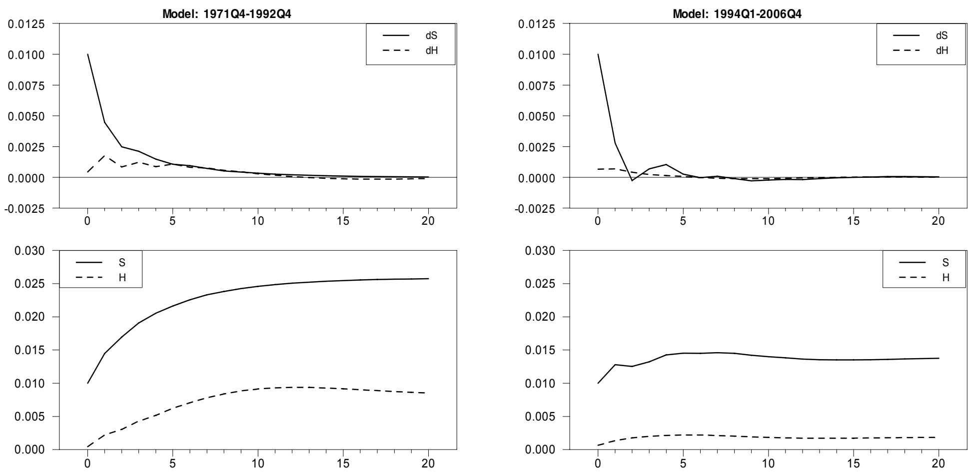

Figure A1 Impulse responses to a shock in stock prices based on the estimated CVAR models that do not include bonds

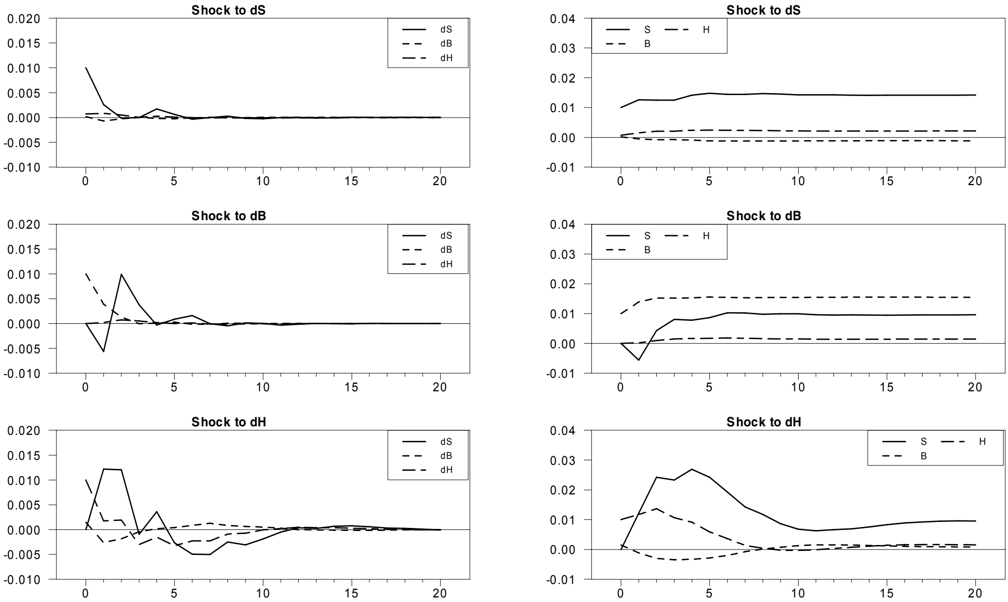

Figure A2 Impulse responses to a shock in the asset prices based on the CVAR model including bonds

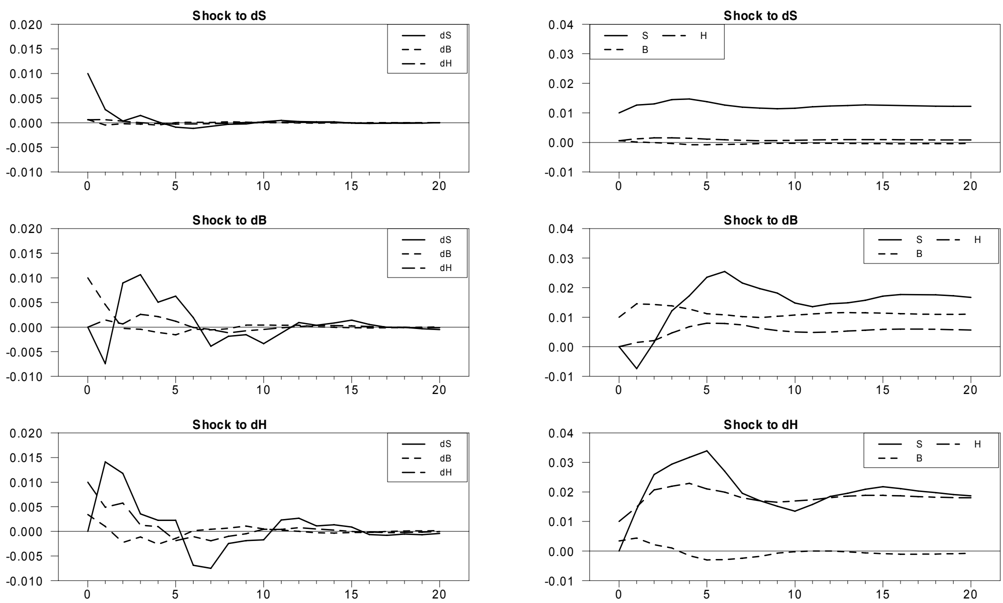

Figure A3 Impulse responses to a shock in the asset prices based on the VAR model including bonds

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