ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

Keskusteluaiheita – Discussion papers

No. 1004

Elias Oikarinen*

PRICE LINKAGES BETWEEN STOCK, BOND AND HOUSING MARKETS – EVIDENCE FROM FINNISH DATA

* GS-fellow, Turku School of Economics and Business Administration & FDPE, Rehtorinpellonkatu 3, 20500 Turku, elias.oikarinen@tukkk.fi
Tel. +358 40 5871943

The author is grateful for comments received at the ACE research seminar in October 2005 and at the Finnish Society for Economic Research XXVII Annual Meeting. Financial support from the Finnish Foundation for Share Promotion, Yrjö Jahnsson Foundation and Kluuvi Foundation is gratefully acknowledged.

ISSN 0781-6847 15.02.2006

OIKARINEN, Elias, **PRICE LINKAGES BETWEEN STOCK, BOND AND HOUSING MARKETS – EVIDENCE FROM FINNISH DATA.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2006, 36 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; no. 1004).

ABSTRACT: There are a number of reasons to assume that significant interdependences exist between the financial asset markets and the housing market. Identifying the linkages between stock, bond and housing markets may improve return forecasts in different asset markets. Interdependence and predictability of different asset prices is 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 dynamic interdependences between stock, bond and housing markets using time series econometrics and utilizing a quarterly dataset from Finland over 1970-2005. In addition to short-term dynamics, there also appears to be long-run interrelations between the asset prices according to cointegration analysis. There is clearly a structural break in the long-run relationship between stock and housing prices in the early 1990s. Interaction between the markets seems to have diminished 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 cointegrating long-run relation. Co-movement of bond price changes with stock and housing appreciation is found to be weak, although bond prices belong to a long-run relation including also stock and housing prices.

Keywords: asset prices, housing, co-movement, cointegration

JEL codes: **G10 ja G11**

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. All these asset prices 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, a strong positive relation between stock and housing markets is likely to exist because both markets are significantly affected by current and expected income. 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 predict positive correlation between the price changes in different asset markets, whereas some other linkages suggest that there may be negative relations 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 price appreciation leads to increase in consumption and thus 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 for investment, 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 would lower bond prices and decrease demand for stocks and housing. 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., 2004).

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 (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 expected 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).

Also long-term interdependences between the asset markets are possible. There are actually theoretical reasons to believe that asset prices have long-term interdependence in the sense that they are cointegrated. According to Bossaerts (1988) 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[1] as the stock and bond markets and 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, in the short run the correlation 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 observation period. That is, the correlation coefficient may differ substantially in time and 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.[2] That is, psychological factors, such as the feeling of safety, may to some extent weaken the linkages between the financial assets and housing.

---

[1] The relatively weak efficiency of the housing market is caused especially 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.

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

It is of importance to know if there are, indeed, lead-lag relations and long-term equilibrium relationships between the price movements in different asset markets. This is because the existence of such linkages has got a number of important implications both to investors and 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 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. 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 important to understand the co-movements of 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, 1970Q1-2005Q2, 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.[3]

The paper proceeds as follows. The next section reviews past studies that have examined the interdependences between different asset classes. After this, the data used in the empirical part is described. The fourth part reports the empirical methodology used in the study. The findings

---

[3] 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 if housing is included in the analysis, the significance of the possible volatility linkages is likely to be negligible.

from the empirical analysis are presented in the fifth section. In the end, the paper is summarized and conclusions are derived.

2 LITERATURE REVIEW

While there exists a vast body of literature considering the linkages between different regional markets within a single asset category, there has been less attention towards the interdependences between different asset classes, especially between housing and financial assets.

In the earlier studies only contemporaneous correlations between asset returns were typically studied. 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.[4]

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. Nevertheless, empirical evidence implies that contemporaneous correlation between stock and bond returns is positive in average. It is notable that the findings according to which the correlation between the markets is greater with less frequent data is in line with the hypothesis that in the long term there exist tighter dynamic linkages between the markets.

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 and the stock market, but research on the linkages between the housing and the 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 the commercial real estate market and the financial markets are mixed, and it has been shown that the correlations vary substantially

---

[4] For example Wilson and Zurbruegg (2003) present a review of correlation instability especially between different real estate returns.

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 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 these 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 the stock market 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.[5] 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 coefficient 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 monthly 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 seems to be typically 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 series are usually constructed as averages during a period, whereas financial market return series typically use the values in the end (beginning) of each period. This may somewhat distort the reported correlation coefficients.

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

[5] 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.

market inefficiency causing dynamic interdependence between real estate and financial market returns. Nevertheless, research on the longer-term linkages between real estate prices and financial asset prices is still relatively 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)[6] 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 market and the stock market, 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. 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 around, is reported by Wilson et al. (1996) employing data from US, UK and Australia, Chen (2001) using data from Taiwan, and Takala and Pere (1991) and Kuosmanen (2002) regarding the Finnish asset markets. 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. 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 market appreciation has got a strong current and lagged effect on the growth of real housing prices. They estimated the full effect of a one percent increase in stock prices on housing price 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

[6] 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.

market excess returns in the housing market has got predictive power for stock market excess returns but not *vice versa*.

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 of 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 includes 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 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 1970Q1-2005Q2, whereas the bond data exists only from 1989Q1 onwards.

The control variables are added to the analysis, since 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, variables such as *C* and *T* 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* and *IR* cover a period from 1970Q1 to 2005Q2. *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. Both nominal and real values are employed in the study. Nominal values are deflated by the cost of living index (cli) to get real variables. Real variables are denoted by capital letters, while nominal values are indicated by lower case letters.

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.[7] It is reasonable to believe that the price movements displayed by the average sales prices from 1970 to 1986 do not differ significantly from the true price development. The housing price statistics are published by Statistics Finland and both indices are based on transactions of privately financed[8] flats in the secondary market.

The stock price index consists of the Unitas index until 1986Q4 and of the Hex index from 1987Q1 forward. Both indices describe the price movements of the publicly traded stocks in the Helsinki Stock Exchange (HEX). 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 included in the dataset.[9] 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 1994Q-2005Q2, 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) has been used. The pre 1994 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 this 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

---

[7] 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: correlation is .94 even between the differences of the two series.

[8] 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.

[9] Due to the regulations laid down by the European Central Bank the compilation of average lending interest rate statistics include also lending from other credit institutions starting from 2003. Because of this there is approximately a 0.3 percentage-point increase in the average rate since 2003. Therefore, 0.3 percentage-points are decreased from the figures starting from 2003Q1.

quarterly averages. Figure 1 exhibits the asset price indices together with some of the control variables.

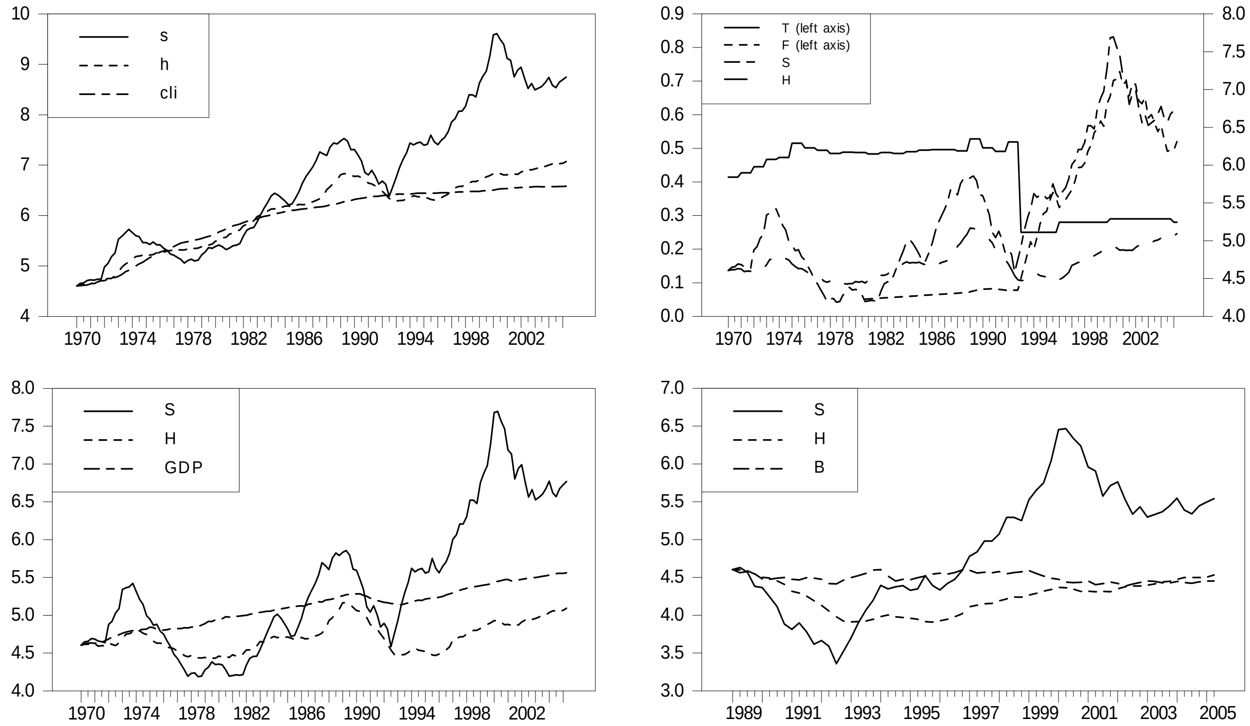

Figure 1 Asset price indices (in natural logarithms) and some control variables

The dramatic rise since 1986 in stock prices and, a little bit 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 IT industry. Expectations were overly optimistic and finally the bubble burst in 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 and the real housing price level is over 80% percent higher in 2005Q2 than in 1995Q4.

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 between housing and stocks, either, is hard to see after the early 1990s.

Descriptive statistics concerning the differenced real and nominal series in the asset prices are presented in Table 1. For the stock and housing series the statistics are presented also separately for pre-1989 period and from 1989 onwards. This is because the bond series starts at 1989Q1.

Table 1 Descriptive statistics of the differenced price series

Nominal series	**Geometric mean (annualised)**	**Standard deviation (annualised)**	**Jarque-Bera (p-value)**	**1st order[10] autocorrelation**
Housing	.072	.064	.000	.653**
Housing -1988	.117	.054	.000	.456**
Housing 1989-	.016	.063	.077	.722**
Stocks	.123	.230	.041	.355**
Stocks -1988	.159	.160	.167	.473**
Stocks 1989-	.080	.293	.987	.311*
Bonds	.011	.051	.055	.253*
Real series				
Housing	.014	.063	.010	.607**
Housing -1988	.026	.058	.001	.461**
Housing 1989-	-.004	.066	.085	.741**
Stocks	.063	.234	.184	.377**
Stocks -1988	.065	.169	.212	.518**
Stocks 1989-	.059	.294	.994	.325**
Bonds	-.009	.057	.047	.238

The descriptive statistics confirm what was already seen in Figure 1. 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 since 1989, even though housing prices were lower in real terms in 2005Q2 than in 1989. In the whole sample period housing prices have expectedly increased faster than the cost of living index.

Normality of many of the differenced series is rejected. In most of the cases the rejection is due to excess kurtosis. The real series seem to be closer to normal distribution than the corresponding nominal series. Furthermore, all the asset price changes are highly autocorrelated. In all the series except for the real bond price changes the first-order autocorrelation is significant at the 5% level. Also the first-order autocorrelation of the real bond appreciation is significant at the 6% level. Real housing price movements are highly autocorrelated up to four lags. Autocorrelation in housing price changes has been even more pronounced after the financial deregulation than before it. For stock price appreciation, instead, the serial correlation was somewhat higher before 1989. Autocorrelation of the differenced bond series is notably smaller than that of the differenced stock and housing price series, and the second-order autocorrelation is already negative.

Both nominal and real bond price changes exhibit seasonal variation. Furthermore, stock and housing price movements had seasonal variation prior to 1989. Seasonal variation in stock and housing price appreciation seems to have vanished after the financial liberalization. None of the series is seasonally adjusted, however. Instead, seasonal dummies are included in the tests and models if necessary.

It is probable that there have been structural breaks in the asset price dynamics during the sample period. Firstly, the financial market liberalization may have caused a structural change

[10] * and ** denote for statistical significance at the 5% and 1% level, respectively.

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, there have been changes in the deductibility of interest payments on mortgages. Furthermore, from the beginning of 1993 foreigners were allowed to freely invest in Finnish securities.

Changes in the deductibility of mortgage interest payments may have influenced significantly the relative prices between housing and financial assets.[11] Hence, a deductibility variable (*T*) is also included in the analysis. 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 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%[12], has been substantially lower than the average marginal income tax rate increasing the after-tax interest rates on housing loans. Capital gains on owner-occupied dwellings have been practically tax-exempt during the whole sample period.

The abolition of foreign ownership restrictions increased foreign ownership considerably in the Finnish stock market (Booth et al. 1997). 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 factors naturally have an effect also on housing prices but to a substantially smaller extent. 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 different asset markets.

Indeed, since the beginning of 1993 stock price curve starts to diverge from the housing price index. This is probably 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 co-movement between *F* and *S* has been remarkable. Quarterly correlation between *F* and *S* is .93 and even correlation between the differenced series is .62.[13]

There may be 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 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 lower required returns on stocks.

---

[11] 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.

[12] For the first-time dwelling-buyers the deduction rate has been 30 percent.

[13] According to the Johansen test *F* and *S* are also cointegrated. Based on quarterly data ΔF does not seem to Granger cause ΔS, though. However, ΔF clearly Granger causes ΔS if monthly data is employed.

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 IT 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. This means that returns on stocks should exceed housing returns in the long run. 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.

4 METHODOLOGY

Empirical methodology in this paper includes correlation analysis as well as time series econometrics. Correlation analysis is conducted 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, 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. In some cases it is seen worthwhile to study the existence of a unit root further by employing the Phillips-Perron (PP) unit root test or the KPSS test in which stationarity is the null hypothesis.

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 and λ-max tests 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 other words, cointegration implies that there is at least one stationary long-run relation between the variables.

In the Johansen tests two possible CVAR models are considered:

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

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

where ΔX_t is $X_t - X_{t-1}$, X_t is a p-dimensional vector of the stochastic variables, $t = 1,\ldots,T$, μ is a vector of drift terms, Γ_i is p x p matrix of coefficients for the lagged differences of the endogenous variables at lag i, k is the maximum lag, i.e. the number of lags included in the corresponding vector autoregressive (VAR) model, α is a p x r (full rank) matrix of the speed of adjustment parameters, β' is a p x r (full rank) matrix, β_1 is a r-dimensional coefficient vector and ε is a vector of error terms. Furthermore, 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 (Johansen, 1996). Also some intervention dummies are often included in D. In this study, however, the inclusion of intervention dummies has not been seen necessary. Ψ is the coefficient vector for the dummy variables. Finally, r is the cointegration rank, i.e. the number of cointegrating vectors.

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 is not the same for all asset categories and the average price 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 been usually neglected in the previous literature, however.

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).[14] 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 in a particular model is done by comparing the Trace and λ-max statistics with the quantiles reported by Osterwald-Lenum (1992). The relatively small number of observations may cause size distortions in the Johansen tests. Hence, also small-sample corrected critical values are reported based on the finite-sample correction suggested by Reinsel and Ahn (1992). It must be noted, however, that the small-sample correction need not work well and often over-corrects (see e.g. Doornik et al., 1998). Furthermore, the Johansen test may also involve power problems that may be exacerbated by the small-sample correction. Therefore, the small-sample corrected values should be considered cautiously.

The LR test described in Johansen (1996) is employed 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. The LR test is also used to test the weak exogeneity of the variables.

[14] 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 does not actually have one. The cost of excluding the trend term when there should be one is markedly larger.

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 the case where one or more variables is 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. Then the number of cointegrating relations in the partial model, i.e. in a model including weakly exogenous variables, is tested based on the following CVAR model:

$$\text{Model 3: } \Delta X_t = \mu + \Gamma_1 \Delta X_{t-1} + \ldots + \Gamma_{k-1} \Delta X_{t-k+1} + \gamma_1 \Delta Z_{t-1} + \ldots + \gamma_{k-1} \Delta Z_{t-k+1} +$$

$$\alpha(\beta_X', \beta_1)(X'_{t-1}, t)' + \alpha\beta_Z{}' Z_{t-1} + \Psi D_t + \varepsilon_t, \quad (3)$$

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 equilibrium relationships.

The stability of the number of cointegrating relations and the stability of the cointegration space are checked employing the recursive analysis suggested in Hansen and Johansen (1992). Recursive estimation is implemented by the statistical program CATS in RATS.

If cointegration between the variables is found, CVAR model is estimated to study the dynamics between the variables. Equilibrium-error (EQE), i.e. 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.

It has to be noted that many of the parameter estimates in the models reported are not significant in the commonly used significance levels. The goal is to find the important interrelationships between the variables and 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 higher p-values.

Granger causality (GC) is tested[15] by a standard F-test to further study the linkages between different variables. With cointegrated variables GC can run also through the long-run equilibrium relation. Cointegration implies that the stationary EQE should Granger-cause at least one of the cointegrated variables (Engle and Granger, 1987). Hence, also EQE must be included in the GC test. In cointegrated data GC tests are done using the following model:

$$\Delta X_t = \mu + \sum_{j=1}^{n} \Delta X_{t-j} + \sum_{j=1}^{n} e_{t-j} + D_t + \varepsilon_t \quad (4)$$

If cointegration is not present, the lagged equilibrium-errors, e_{t-j}, are naturally not present in the GC test. Lagged EQEs are not included as explanatory factors for the variables that do not belong to the long-run relation.

Finally, innovation accounting, i.e. impulse response analysis and variance decomposition, is conducted employing the Choleski decomposition. Innovation accounting is based on vector

[15] Actually the test is Granger non-causality test, since the null hypothesis is that of no causality.

autoregressive (VAR) models including differenced series and an equal number of lags to the corresponding CVAR model.

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.

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. Nevertheless, correlation analysis can be helpful as a preliminary analysis 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 especially by studying cross-autocorrelations. Table 2 presents the correlations between the differenced price and Euribor series using quarterly, annual and biannual changes. To get a sufficient number of observations, annual and biannual figures have been calculated using overlapping observation windows.

Table 2 Correlations between stock, bond and housing price appreciation, and inflation and interest rate movements

	CORRELATIONS OF NOMINAL CHANGES							CORRELATIONS OF REAL CHANGES						
	Stock	Housing	Stock -88	Housing -88	Stock 89-	Housing 89-	Bond	Stock	Housing	Stock -88	Housing -88	Stock 89-	Housing 89-	Bond
Quarterly														
Housing	.345**							.392**						
Inflation	.130	.176*						.093	.049					
Housing -88			.253*							.403**				
Inflation -88			.039	.238*						-.019	.058			
Housing 89-					.394**							.398**		
Bond 89-					.058	-.079						.071	.076	
Euribor 89-					-.255*	-.056	-.669**					-.306*	-.028	.222
Inflation 89-					.252*	.089	-.347**					.233	.006	-.569**
Annual														
Housing	.470**							.558**						
Inflation	.232**	.326**						.210*	.290**					
Housing -88			.406**							.621**				
Inflation-88			.194	.387**						.161**	.310**			
Housing 89-					.530**							.553**		
Bond 89-					.010	-.123						.114	.077	
Euribor 89-					-.154	.088	-.866**					-.476**	-.269*	-.369**
Inflation 89-					.400**	.359**	-.411**					.399**	.349**	-.341**
Biannual														
Housing	.474**							.582**						
Inflation	.356**	.409**						.323**	.376**					
Housing -88			.543**							.806**				
Inflation-88			.350**	.493**						.294*	.386**			
Housing 89-					.501**							.529**		
Bond 89-					-.084	-.232						.093	.084	
Euribor 89-					-.082	.287*	-.848**					-.546**	-.242	-.439**
Inflation 89-					.568**	.495**	-.332*					.568**	.485**	-.198

Correlations, expectedly, vary between different periods and between data at different frequencies. Instead, with a few exceptions nominal and real figures differ only little from each other.

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 correlation figures imply that substantial diversification benefits can be gained by including stocks in a housing portfolio or *vice versa*. The real appreciation correlations are around 0.5 after the end of the 1980s, which is notably less than, for example, the housing appreciation correlations between regional housing markets in Finland.[16]

The longer the observation period is the larger is the correlation between stock and housing price movements, both in the nominal and in the real terms. This indicates that some kind of lead-lag relation exists between stock and housing markets. Correlation between stock and housing price movements grows fast when the observation period is lengthened from one to three quarters and keeps growing still, albeit slower, as the window is further extended. This can be seen from Figure 2. The Figure also clearly shows that stock and housing markets have been substantially less tightly linked since 1993.

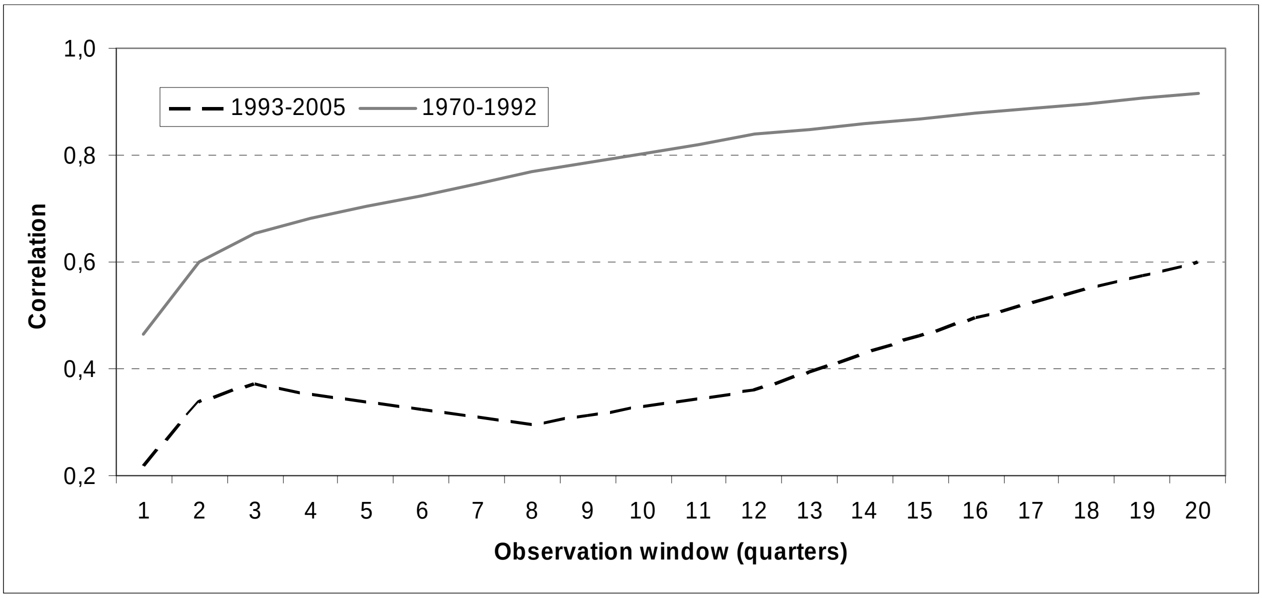

Figure 2 Correlation between stock and housing appreciation

The linkages between the bond markets and the other two asset markets are weak according to the reported contemporaneous correlations. There seems to be a slight positive interrelation between the real price movements but all the correlations are statistically insignificant.

Correlations between movements in the inflation rate and stock and housing appreciation are surprisingly large. The figures, except for one, are positive and usually statistically significant. A major reason for this is that the nominal interest rate seems to respond only faintly to

[16] Annual correlations between regional housing markets in Finland have been typically around 0.9 (see Oikarinen and Asposalo, 2004; Oikarinen, 2005a).

changes in the inflation rate. Rise in the inflation rate probably signifies upturn in the economic activity which, in turn, raises demand for stock and housing. The correlations between inflation rate movements and stock and housing appreciation get larger as the horizon is lengthened. Bond prices, instead, are expectedly adversely affected by a rise in the inflation rate. Furthermore, the figures imply that after the financial deregulation stock appreciation correlates more strongly and housing appreciation more weakly with changes in inflation.

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. This is in line with the recent findings by Oikarinen (2005b) based on a CVAR model.

It has often been noticed that interaction between the asset categories are greater during crisis periods. For example Andersen et al. (2005), employing intraday data, found that during expansion the stock-bond correlations are positive albeit small, whereas they are strong and negative during recession. Similarly, the quarterly data used in this study suggests that the correlations between bonds and the other assets were somewhat greater during the deep recession in Finland in the early 1990s. This is probably due to large swings in the interest rates during the period.

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 figure .467 top left shows the correlation between current housing price appreciation and last periods' stock price growth.

Table 3 Cross-autocorrelations of quarterly changes in 1989Q1-2005Q2[17]

	1	2	3	4		1	2	3	4
NOMINAL VARIABLES									
s – h	.467***	.220*	.167	.137	h – s	.194	.154	.159	-.034
s – b	-.120	-.138	-.093	-.166	b – s	.161	-.008	.123	.100
h – b	-.272	-.177	-.220*	-.262*	b – h	.116	.230*	.064	.164
s – ir	.080	.246**	.132	.130	ir – s	-.177	-.065	-.250**	-.223*
s – p	-.020	-.036	.062	.167	p – s	.026	-.090	.050	.172
h – ir	.293**	.413***	.319***	.306***	ir – h	-.237*	-.139	-.129	-.256**
h – p	.058	-.042	.174	.008	p – h	.186	-.107	.011	.106
b – ir	-.306**	-.073	-.024	.111	ir – b	-.240*	.002	.093	.245**
b – p	.301**	.115	-.154	-.187	p – b	-.164	.028	.240*	.049
REAL VARIABLES									
S – H	.469***	.248**	.181	.122	H – S	.249**	.212*	.183	.009
S – B	-.090	-.104	-.076	-.171	B – S	.217*	.060	.152	.149
H – B	-.187	-.124	-.192	-.201*	B – H	.192	.300**	.158	272**
S – IR	.027	.097	-.020	-.115	IR – S	-.076	.080	-.124	-.209*
S – p	.004	-.029	.055	.162	p – S	.022	-.081	.060	.160
H – IR	-.078	.115	-.041	.112	IR – H	-.228*	.023	-.080	-.124
H – p	.162	.011	.136	-.012	p – H	.156	-.060	.056	.052
B – IR	-.472***	-.161	.168	.228**	IR – B	.084	-.067	-.211*	.065
B – p	.395***	.137	-.172	-.191	p – B	-.171	.072	.269**	-.013

[17] Unlike in the other tables, *, ** and *** denote for statistical significance at the 10%, 5% and 1% level, respectively.

It is evident from Tables 2 and 3 and Figure 2 that the contemporaneous quarterly correlations give inadequate picture concerning the linkages between different asset prices. Particularly the links between housing price growth and stock appreciation seem to be tight. In fact, the correlation between current housing price change and one quarter lagged stock price growth is larger than the contemporaneous quarterly correlation between housing and stock appreciation.

There are significant cross-autocorrelations also between bond and stock price movements and especially between the bond and housing price changes. 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 is 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. In contrast, stock and housing price movements have got positive coefficients on 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.

In addition, there are a number of large and significant cross-autocorrelations between the assets and the interest rate. Notable part of the cross-autocorrelations between the asset prices are likely to be caused by the linkages between the interest rate and the asset prices. In contrast, between stock and housing appreciation and movements in the inflation rate there are no significant cross-autocorrelations. The significant positive first-lag reaction of the inflation rate on bond price change is in line with the theory. Drop in the real interest rate increases bond value and stimulates the economy thereby increasing inflationary pressures.

It is important to understand that significant cross-autocorrelations do not necessarily imply the existence of causality (other than GC) 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.

In any case, the analysis above shows that the use of quarterly correlations in analyzing portfolio that includes stocks and housing is misleading. As housing investments are long-run in nature, quarterly figures give too optimistic picture about diversification benefits between stocks and housing.

5.2 Econometric analysis

Linkages between the asset prices are further studied by time series econometrics. Real variables are used in the analysis. First, the order of integration of the variables is checked. Then the existence of cointegrating relationships is tested and compositions of the cointegrating relations are analyzed. Finally, Granger causalities and impulse response functions are examined based on the estimated CVAR models.

The ADF test indicates that all the real variables as well as the inflation rate and the deductibility of mortgages interest payments are I(1).[18] The unit root test results are reported in Table A1 in the Appendix. Concerning the order of integration of *p* the evidence is contradictory. Based on the ADF and KPSS tests the existence of a unit root in the series seems

---

[18] Unit root in *T* cannot be rejected even when allowing for a structural break in 1993Q1.

probable. The PP test, on the other hand, implies that inflation is stationary. In any case, *p* is treated as a non-stationary variable since the Johansen test clearly implies that *p* is not stationary.

The results by Barot and Takala (1998) suggest that real housing prices in Finland are stationary. Hence, the existence of a unit root in the real housing price series is studied also by the PP test and the KPSS test. The evidence is mixed, because PP clearly accepts the null of a unit root whereas KPSS indicates that *H* is stationary. As with *p*, Johansen test results show that *H* should be treated as an I(1) variable in the cointegration analysis.

5.2.1 Sample from 1970Q1 to 2005Q2

Using the whole sample period, the Johansen 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 seven variables, *S*, *H*, *L*, *GDP*, *p*, *C* and *T* were also examined. This analysis confirmed 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, *S* and *H* seem to exhibit cointegration before foreign investors were allowed to freely invest in Finnish securities and before the tax deductibility rules of mortgage interest payments were altered, i.e. in 1970-1992.[19] According to the Johansen test results using Model 2, *S* and *H* are probably pairwise cointegrated during 1970-1992. This finding is in line with the results by Takala and Pere (1991) concerning the period over 1970Q1-1990Q2. Note that only housing prices adjust to the equilibrium relation. Test on Model 3 confirms the inference that there seems to be one cointegrating relation between *S* and *H*. 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.

Evidence of the existence of a stationary long-run relation between stock and housing prices from 1993 onwards is dubious. Cointegration test including only *H* and *S* implies that there may be a cointegrating vector between the variables. The statistical significance of the vector is not very strong, though. If also *IR* is included in the tested model, there is clearly at least one long-run equilibrium relation, possibly even two. The most stationary relation is not an equilibrium relation between *S* and *H*, however, since *H* can be excluded from it. Moreover, only *IR* adjusts to this relation.[20]

The second possible long-run relation seems to be the one between *H* and *S* that was already found in the test excluding *IR*. Again the test statistics are not too conclusive concerning the stationarity of this relation. Nevertheless, cointegration between *H* and *S* during 1993-2005 is supported by the significant alfas of both variables. Furthermore, stability of the potential long-run relation cannot be rejected and visual inspection does not indicate non-stationarity of the

---

[19] If *F* is included in the analysis, Johansen test statistics suggest that there might be a cointegrating relation including both *S* and *H* from 1980Q4 onwards. The potential relation, however, seems to be highly unstable even if additional control variables are included in the model.

[20] This is theoretically problematic since the effect of the Finnish economy on Euribor is negligible. The finding might be due to the interaction between stock prices and inflation – inflation rate affects also the real interest rate. Adding *p* in the test does not change the results notably, though. Note that even the inclusion of *F* in the model does not make the analysis any more conclusive.

equilibrium-error, even though there seems to be relatively large volatility and deviation from the equilibrium during 1993-96.

Table 4 Johansen test results in a system including real housing and stock price indices

H_0(rank)	Trace test	Crit. value (5%)	Crit. Value (10%) ssc		H_0(rank)	H_1(rank)	λ-max test	Crit. value (5%)	Crit. value (10%) ssc
Sample: 1970Q1 – 2005Q2 (variables= *H*, *S*; model 2, ml=5, seasonal dummies)									
r = 0	17.6	25.3	25.6		r = 0	r = 1	11.3	19.0	18.9
r ≤ 1	6.30	12.3	11.7		r = 1	r = 2	6.30	12.3	11.7
Sample: 1970Q1 – 1992Q4 (variables= *H*, *S*; model 2, ml=5, seasonal dummies, p-value in the test for weak exogeneity of *S* = .75)									
r = 0	24.7	25.3	27.9		r = 0	r = 1	19.4	19.0	20.6
r ≤ 1	5.30	12.25	12.9		r = 1	r = 2	5.30	12.25	12.9
Sample: 1970Q1 – 1992Q4 (variables = *H*, *S*; model 3, ml=5, seasonal dummies)									
r = 0	19.3	15.2	16.2						
Sample: 1992Q3 – 2005Q2 (variables= *H*, *S*; model 2, ml=2, seasonal dummies)									
r = 0	24.8	25.3	27.7		r = 0	r = 1	18.7	19.0	20.6
r ≤ 1	6.15	12.3	12.8		r = 1	r = 2	6.15	12.3	12.8
Sample: 1992Q3 – 2005Q2 (variables= *H*, *S*, *IR*; model 2, ml=2, seasonal dummies)									
r = 0	72.1	42.4	50.0		r = 0	r = 1	46.3	25.5	29.6
r ≤ 1	25.9	25.3	29.1		r = 1	r = 2	19.2	19.0	21.6
r ≤ 2	6.63	12.3	13.4		r = 2	r = 3	6.63	12.3	13.4

The structural break in 1993 can be seen well from 3. 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 1993Q1-2005Q2 long-run equilibrium (assuming there is such a relation) based on the model including only *S* and *H*. The mean of the equilibrium-error has been removed from both of the exhibited series. The considerable deviations from the equilibrium in the late 1980s and early 1990s in the upper graph are due to the extremely large volatility in the asset prices caused by the asset price boom in the late 1980s and the extraordinarily deep recession in the beginning of the 1990s. The graphs clearly show that the housing price level relative to stock price level has decreased since the early 1990s.

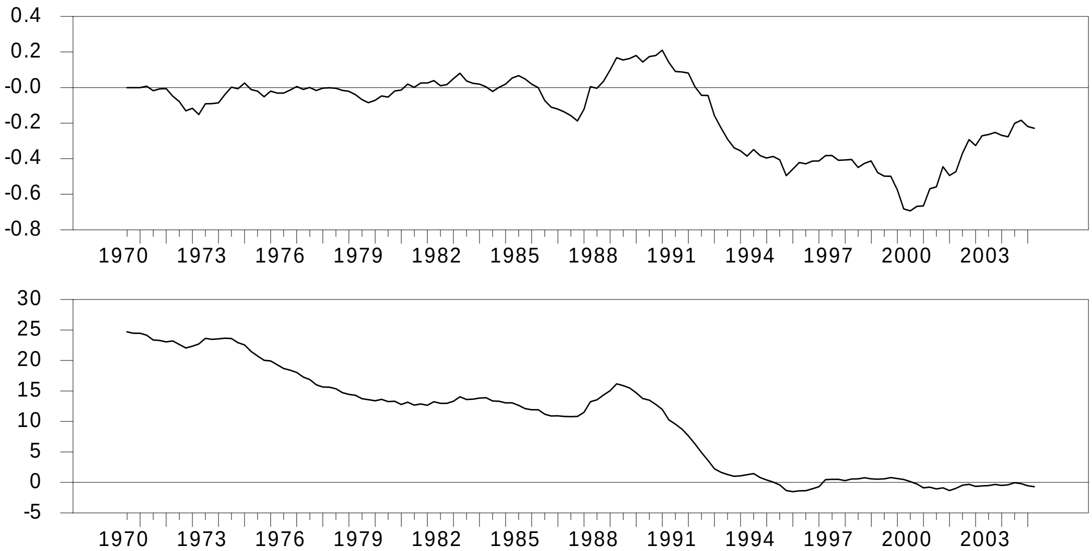

Figure 3 Deviation of real housing price level from the long-run relations

Granger causality during 1971Q4-1992Q4 is studied by a third-order CVAR model including Δ*H*, Δ*S*, Δ*L*, Δ*l*, Δ*INF* and three seasonal dummies. Based on the model the adjustment speed of housing prices towards the long-run relation has been 14.8% per quarter. The estimated speed of adjustment parameter is twice the size of 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 Δ*S* Granger causing itself, though, especially if stock prices are set weakly exogenous (we). Housing price movements, instead, were caused by the deviation from the equilibrium relation but not directly by previous housing price changes. Furthermore, Δ*H* caused both the real lending rate and the inflation rate. Hence, both Δ*L* and Δ*INF* must be Granger caused also by Δ*S* during the first part of the sample.

Table 5 shows that there have been notable changes in the causalities after 1992.[21] Δ*S* still causes Δ*H* but evidently not itself. Instead, there is some evidence of Δ*H* causing itself in the latter period. Stock prices clearly seem to be more predictable by the interest and inflation rate movements since 1993 than before. Somewhat surprising is the finding that Δ*H* is not Granger caused by the inflation or interest rate movements in either of the periods. The alfa of housing prices in the later period is equal to the pre 1993 alfa. The CVAR model including also control variables suggests that stock prices do not adjust towards the long-run relation in the post 1992 period either. The adjusted R^2 figures of the CVAR models are also reported in Table 5.

[21] This estimated model is similar to the model of pre 1993 period with the exception that real and nominal Euribors are included in stead of real and nominal lending rate and that there is one lag less incorporated.

Table 5 P-values in the Granger causality tests

Dependent variable	Explanatory variable						
1971Q4-1992Q4							
	ΔS	ΔH	ΔL	Δl	Δp	eqe	Adj. R^2
Δ Stock	.107	.553	.945	.913	.947	.893	.276
Δ Housing	.001	.346	.975	.930	.979	.038	.644
Δ Real lending rate	.082	.014	.412	.233	.391		.585
Δ Nominal lending rate	.122	.645	.256	.328	.290		.061
Δ Inflation rate	.047	.016	.479	.233	.417		.540
Δ Stock (we)	.003	.538	.872	.745	.867		.286
1993Q1-2005Q2							
	ΔS	ΔH	ΔIR	Δir	Δp	eqe	Adj. R^2
Δ Stock	.686	.890	.102	.114	.098	.335	.229
Δ Housing	.042	.148	.669	.580	.669	.006	.533
Δ Real euribor	.259	.266	.010	.024	.010		.723
Δ Nominal euribor	.821	.022	.432	.459	.431		.495
Δ Inflation rate	.225	.066	.032	.050	.030		.682
Δ Stock (we)	.121	.095	.085	.090	.081		.183

Figures A1 and A2 in the Appendix graph the impulse responses derived from the CVAR models. The impulse responses indicate that the effect of a shock to ΔS on ΔH is notably smaller in the latter period. Also the variance decomposition (see Table A3 in the Appendix) based on a VAR model suggests that housing price changes are today driven to a much lesser extent by stock appreciation than in the 1970s and 80s. Before 1993 innovations in ΔS accounted for half of the long-term forecast error of ΔH, while the corresponding figure is only 3% after 1992.

Permanent effect of a shock to ΔH on S, instead, seems to be surprisingly large according to the CVAR model from 1993 onwards. The effect implied by the model that may be implausibly strong – the permanent response of S to a one percentage positive shock to ΔH is approximately 4% – is mainly caused by the estimated long-run relation. As the Granger causality test suggests that the stock price index may actually be weakly exogenous, also a model where stock prices do not adjust to the long-run relation is estimated.[22] Impulses from this model are displayed in Figure A3 in the Appendix. Figure A3 indicates that the permanent response of S to a one percentage positive shock to ΔH is negligible. In any case, the variance decomposition implies that the effect of housing price movements on stock price appreciation is slightly larger today than before 1993. The effect, however, is still only small.

Impulse responses and variance decomposition as well as GC tests imply that the effect of the stock market on the housing market has diminished since the 1970s and 80s. Weaker linkages after the financial deregulation were suggested also by the real appreciation correlations reported in Table 2. Hence, the data proposes that the tight financial regulation in the 1970s and 80s increased co-variation between stock and housing prices especially in the longer horizon.

[22] The impulse responses of stock prices may also imply that some important variable is missing from the model. Nevertheless, inclusion of any of the variables in this study does not change the perceived phenomenon.

5.2.2 Sample from 1989Q1 to 2005Q2 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 1989Q1-2005Q2, the Johansen test gives only slight support on cointegrating relation between stock, bond and housing prices. Closer inspection of the potential long-run relationship shows that the relation is not a cointegrating vector between the indices. The relatively large test values just show that *B* is close to trend stationary. P-value of excluding *S* and *H* from the cointegration space is .33.

It is hard to find a sensible long-run relation which includes at least two of the asset price series and to which at least one of the asset prices adjusts. An evident cointegrating relation is found if *IR* is included in the analysis. The relation seems to include at least *S* and *B*, but the LR test cannot reject the hypothesis that none of the asset series responds to deviations from the long-run relation.

Nevertheless, inclusion of GDP in the analysis helps to find a reasonable long-run relation from 1993Q1 onwards. Assuming one cointegrating vector, none of the variables can be excluded from the relation but *S* and *GDP* can be set weakly exogenous. The second possible long-run relation seems to be the one between *S* and *H* found earlier. As mentioned above, the results concerning stationarity of this relation is somewhat inconclusive. Therefore, only the first relation is employed in the forthcoming analysis. Model 3 confirms the existence of one cointegrating relationship, and the stability of the long-run relation cannot be rejected.

The existence of one cointegrating relationship is assumed even though this is suspected according to the small-sample corrected values. This is because, in addition to the possible over-correction, the Johansen test is known for power problems when the number of observations is small. Moreover, the relation seems sensible and the speed of adjustment parameter of both housing and bond prices are statistically significant.

Table 6 Johansen test results in a system including real housing, stock and bond price indices

H_0(rank)	Trace test	Crit. value (5%)	Crit. value (10%) ssc		H_0(rank)	H_1(rank)	λ-max test	Crit. value (5%)	Crit. value (10%) ssc
Sample: 1989Q1 – 2005Q2 (variables= *H*, *S*, *B*; model 2, ml=2, seasonal dummies)									
r = 0	41.6	42.4	46.9		r = 0	r = 1	22.5	25.5	27.7
r ≤ 1	19.2	25.3	27.3		r = 1	r = 2	11.7	19.0	20.2
r ≤ 2	7.43	12.3	12.6		r = 2	r = 3	7.43	12.3	12.6
Sample: 1989Q1 – 2005Q4 (variables = *H*, *S*, *B*, *IR*; model 2, ml=2, seasonal dummies, p-value in the test for weak exogeneity of *H*, *S* and *B* = .17)									
r = 0	102.5	63.0	73.9		r = 0	r = 1	61.2	31.5	36.4
r ≤ 1	41.4	42.4	48.8		r = 1	r = 2	20.6	25.5	28.9
r ≤ 2	20.8	25.3	28.5		r = 2	r = 3	13.8	19.0	21.1
r ≤ 3	7.09	12.3	13.1		r = 3	r = 4	7.09	12.3	13.1
Sample: 1992Q2 – 2005Q4 (variables = *H*, *S*, *B*, *GDP*; model 2, ml=3, seasonal dummies, p-value in the test for weak exogeneity of *S* and *GDP* = .34)									
r = 0	76.0	63.0	88.7		r = 0	r = 1	32.5	31.5	43.7
r ≤ 1	43.4	42.4	58.6		r = 1	r = 2	22.4	25.5	34.7
r ≤ 2	21.1	25.3	34.1		r = 2	r = 3	14.1	19.0	25.3
r ≤ 3	6.99	12.3	15.7		r = 3	r = 4	6.99	12.3	15.7
Sample: 1992Q2 – 2005Q4 (variables = *H*, *B*, *S*, *GDP*; model 3, ml=3, seasonal dummies)									
r = 0	42.4	35.5	48.7						
r ≤ 1	12.0	17.9	23.5						

Granger-causalities during the period of 1993Q1-2005Q2 are studied by a model containing two lags in differences and including ΔS, ΔH, ΔB, and ΔGDP. Contrary to the model excluding *B* reported in Table 5, this model does not show that ΔS causes ΔH (see Table 7). The model suggests that housing prices have not been Granger caused directly by any of the other variables and even the evidence of ΔH causing itself is unclear. The R^2 figure for ΔH is as large as .5, however, and ΔH is likely to be caused by ΔS, ΔB, ΔH and ΔGDP through the equilibrium-relation. Housing price movements, on the other hand, have significant explanatory power at least on the bond price changes. This linkage probably materializes through the effect of ΔH on the inflation and interest rates.[23] In addition, there is also evidence suggesting that ΔH Granger causes stock appreciation and especially GDP growth. The effect on GDP comes up when GDP is restricted to be weakly exogenous.

Stock appreciation is caused also by ΔB according to the GC test including lagged equilibrium-errors. The results for ΔS, however, change notably if stock prices are assumed to be weakly exogenous. Note also that the adjusted coefficients of determination indicate that quarterly housing and bond price movements are substantially more predictable than stock price appreciation.

[23] Because Euribor rates are nowadays determined by the whole EMU area, it is highly unlikely that housing price appreciation in Finland affects the Euribor rates significantly. Hence, it is probable that the effect of housing price movements on bond prices is mainly caused by the inflationary influences of housing price appreciation.

Table 7 P-values in the Granger causality tests including bond price series

Dependent variable		Explanatory variable					
		ΔS	ΔH	ΔB	ΔGDP	eqe	Adj. R^2
	Δ Stock	.151	.104	.031	.213	.082	.014
	Δ Housing	.237	.127	.654	.618	.077	.503
	Δ Bond	.801	.000	.512	.489	.000	.631
	Δ GDP	.175	.241	.581	.275	.639	.164
	Δ Stock (we)	.138	.346	.314	.420		.027
	Δ GDP (we)	.176	.001	.889	.381		.268

According the impulse response curves derived from a CVAR model where both stock prices and GDP are weakly exogenous (see Figure A4 in the Appendix) the response of housing prices to a shock to ΔS is similar to that indicated by the model excluding bond prices. The responses of *S* and *H* to a shock to ΔH are somewhat different from the earlier model. Based on the model incorporating bonds and GDP, shock to ΔH has got a permanent positive effect on *S* and *H* and a permanent negative influence on *B*. The responses of stocks and housing to a shock to ΔB are, in turn, likely to be largely a consequence of the interaction between bond prices, inflation rate and real interest rate. Note that both housing and bond prices adjust sluggishly towards the long-run equilibrium – the speed of adjustment is 15% per quarter for housing and 20% per quarter for bonds.

In line with the previous findings, the results in Table 7 and variance decomposition (see Table A4 in the Appendix) suggest that the interaction between stock and housing prices has weakened substantially after the deregulation of the Finnish financial markets. All the asset price movements are mainly driven by themselves. Furthermore, changes in the *GDP* growth seem to account only for a tiny portion of the short- and long-term forecast errors of the asset price movements.[24] It should be noted, nevertheless, that the effect of ΔGDP through the long-run equilibrium relation is likely to increase the actual influence of the *GDP* growth on housing and bond price changes.

6 SUMMARY AND CONCLUSIONS

There are many reasons to believe that significant interdependences exist between the financial asset markets and the housing market. Despite the numerous important implications the interrelations between different asset categories may have on the economy, research examining these linkages has still been very limited.

In this paper the possible reasons for dynamic interrelations between housing prices and financial asset prices are discussed first. The main aim, however, 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. Even though there clearly is interaction also between bond price changes and

[24] Changing the ordering of the variables in the Choleski decomposition does not alter the results notably.

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.

Cointegration analysis indicates that there are also long-run dynamic interrelations between the asset prices. Only housing and bond prices seem to respond to deviations from the long-run relationships, however. It seems that there was a structural break in the long-run relationship between stock and housing prices at the beginning of 1993. The break was probably 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 most likely had some importance. It is found that the interaction between the stock and housing markets has diminished after the liberalization of the financial market. The weakening of the co-movement between stock and housing prices is likely to be permanent, since the housing market necessarily is and will be local to a great extent whereas the stock market is driven by global forces.

The empirical findings are of importance both to policy and investment decisions. Although price movements in different asset markets are clearly interdependent, the results suggest that relatively large diversification gains are obtainable by diversifying the portfolio between the asset categories. The weakened interaction between stock and housing markets has further improved the diversification opportunities. In any case, the dynamics between different asset markets are of relevance to asset allocation. Because of the lead-lag relations, the use of quarterly correlations in portfolio analysis is misleading at least from a long-term investor's point of view and may cause in misdirected investment strategies. In particular, quarterly correlations are likely to give a too positive picture about diversification opportunities between the asset classes. The results also show that housing and bond price movements are highly predictable so that unconditional portfolio analysis is likely to be fallacious. Whether one can take advantage of the predictability to make profit is another question, however.

The abatement of the linkages between stock and housing prices is likely to have positive consequences for the macroeconomy. Up until the early 1990s 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. This may have a major impact on the macroeconomic volatility, if the conclusion is, indeed, correct. 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 probable that the foreign investors' influence on the stock market has decreased the simultaneity of stock and housing market cycles.

Previous literature has in general neglected the possible need for a deterministic trend term in the long-run relation between different asset prices. This is problematic, since in many cases where cointegration has not been found it might actually be detected if a trend term was included in the long-run relation. There are theoretical reasons to assume that trend term may need to be included in the long-run relation when testing for cointegration between stock and housing prices. In this study the deterministic trend could not be excluded from any of the estimated long-run relationships.

REFERENCES

Ali-Yrkkö, Jyrki – Ylä-Anttila, Pekka (2003). Globalization of Business in a Small Country – Does Ownership Matter?. In Hyytinen, Ari – Pajarinen, Mika (eds): *Financial Systems and Firm Performance: Theoretical and Empirical Perspectives*. The Research Institute of the Finnish Economy, B:199, Taloustieto Oy: Helsinki.

Andersen, Torben G. – Bollerslev, Tim – Diebold, Francis X. – Vega, Clara (2005) *Real Time Price Discovery in Stock, Bond and Foreign Exchange Markets*. National Bureau of Economic Research, Working Paper 11312.

Antell, Jan (2004) *Essays on the Linkages between Financial Markets, and Risk Asymmetries*. Publications of the Swedish School of Economics and Business Administration Nr 131. Helsinki.

Barot, Bharat – Takala, Kari (1998) *House Prices and Inflation: A Cointegration Analysis for Finland and Sweden*. Bank of Finland Discussion Papers 12/98.

Barsky, Robert B. (1989) Why Don't the Prices of Stocks and Bonds Move Together? *American Economic Review*, 79 (5): 1132-1145.

Benjamin, John D. – Chinloy, Peter – Jud, G. Donald (2004) Why Do Households Concentrate Their Wealth in Housing? *Journal of Real Estate Research*, 26 (4): 329-343.

Booth, Geoffrey G. – Martikainen, Teppo – Tse, Yiuman (1997) Price and volatility spillovers in Scandinavian stock markets. *Journal of Banking and Finance*, 21 (6): 811-823.

Borio, Claudio – McGuire, Patrick (2004) Twin peaks in equity and housing prices? *BIS Quarterly Review*, March 2004: 79-93.

Bossaerts, Peter (1988) Common Nonstationary Components of Asset Prices. *Journal of Economic Dynamics and Control*, 12 (2-3): 347-364.

Bradley, Michael – Capozza, Dennis R. – Seguin, Paul J. (1998) Dividend policy and Cash-Flow Uncertainty. *Real Estate Economics*, 26 (4): 555-580.

Campbell, John Y. – Ammer, John (1993) What Moves the Stock and Bond Markets? A Variance Decomposition for Long-Term Asset Returns. *Journal of Finance*, 48 (1): 3-37.

Campbell, John Y. – Cocco, Joao F. (2004) *How Do House Prices Affect Consumption? Evidence from Micro Data*. Harvard Institute of Economic Research. Discussion Paper Number 2045.

Campbell, John Y. – Hamao, Yasushi (1992) Predictable Stock Returns in the United States and Japan: A Study of Long-Term Capital Market Integration. *Journal of Finance*, 47 (1): 43-69.

Capozza, Dennis R. (2000) Debt, Agency, and Management Contracts in REITs: The External Advisor Puzzle. *Journal of Real Estate Finance and Economics*, 20 (2): 91-116.

Case, Bradford – Goetzmann, William N. – Rouwenhorst, K. Geert (2000) *Global Real Estate Markets – Cycles and Fundamentals*. National Bureau of Economic Research, Working Paper 7566.

Case, Karl E. – Quigley, John M. – Shiller, Robert J. (2001) *Comparing wealth effects: the stock market versus the housing market*. National Bureau of Economic Research, Working Paper 8606.

Chaudhry, Mukesh K. – Myer, F.C. Neil – Webb, James R. (1999) Stationarity and Cointegration in Systems with Real Estate and Financial Assets. *Journal of Real Estate Finance and Economics*, 18 (3): 339-349.

Chen, Jun – Hudson-Wilson, Susan – Nordby, Hans (2004) Real Estate Pricing: Spreads & Sensibilities: Why Real Estate Pricing Is Rational. *Journal of Real Estate Portfolio Management*, 10 (1): 1-21.

Chen, Nan-Kuang (2001) asset price fluctuations in Taiwan: Evidence from stock and real estate prices 1973 to 1992. *Journal of Asian Economics*, 12 (2): 215-232.

Doornik, Jurgen A. – Hendry, David F. – Nielsen, Bent (1998) Inference in Cointegrated Models: UK M1 Revisited. *Journal of Economic Surveys*, 12 (5): 533-572.

Eichholtz, Piet M.A. – Hartzell, David J. (1996) Property Shares, Appraisals and the Stock Market: An International Perspective. *Journal of Real Estate Finance and Economics*, 12 (2): 163-178.

Engle, Robert R. – Granger, Clive W. J. (1987) Co-Integration and Error-Correction: Representation, Estimation and Testing. *Econometrica*, 55 (2): 251-276.

Fleming, Jeff – Kirby, Chris – Ostdiek, Barbara (1998) Information and volatility linkages in the stock, bond and money markets. *Journal of Financial Economics*, 49 (1): 111-137.

Friday, H. Swint – Sirmans, G. Stacy – Conover, C. Mitchell (1999) Ownership Structure and the Value of the Firm: The Case of REITs. *Journal of Real Estate Research*, 17 (1-2): 71-90.

Fu, Yuming – Ng, Lilian K. (2001) Market Efficiency and Return Statistics: Evidence from Real Estate and Stock Markets Using a Present-Value Approach. *Real Estate Economics*, 29 (2): 227-250.

Giliberto, S. Michael (1990) Equity Real Estate Investment Trusts and Real Estate Returns. *Journal of Real Estate Research*, 5 (2): 259-263.

Glascock, John L. – Lu, Chiuling – So, Raymond W. (2000) Further Evidence in the Integration of REIT, Bond, and Stock Returns. *Journal of Real Estate Finance and Economics*, 20 (2): 177-94.

Gyourko, Joseph – Kleim, Donald B. (1992) What Does the Stock Market Tell Us About Real Estate Returns? *Journal of the American Real Estate and Urban Economics Association*, 20 (3): 457-485.

Hansen, Henrik – Johansen, Soren (1992) *Recursive Estimation in Cointegrated VAR-Models*. Discussion Paper 92-13, Institute of Economics, University of Copenhagen.

Hansen, Henrik – Juselius, Katarina (1995) *CATS in RATS, Cointegration Analysis of Time Series*. Estima: Illinois, USA.

Harbo, Ingrid – Johansen, Soren – Nielsen, Bent – Rahbek, Anders (1998) Asymptotic Inference on Cointegration Rank in Partial Systems. *Journal of Business and Economic Statistics*, 16 (4): 388-399.

Henderson, J.V. – Ioannides, Y.M. (1983) A Model of Housing Tenure Choice. *American Economic Review*, 73 (1): 98-113.

Hoesli, Martin – Hamelink, Foort (1997) An examination of the role of Geneva and Zurich housing in Swiss institutional portfolios. *Journal of Property Valuation and Investment*, 15 (4): 354-371.

Hutchison, Norman E. (1994) Housing as an Investment? A Comparison of Returns from Housing with Other Types of Investment. *Journal of Property Finance*, 5 (2): 47-61.

Johansen, Soren (1996) *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press: Oxford.

Jud, G. Donald – Winkler, Daniel T. (2002) The Dynamics of Metropolitan Housing Prices. *Journal of Real Estate Research*, 23 (1-2): 29-45.

Kallunki, Juha-Pekka – Martikainen, Teppo (1997) Financial Market and the Relationship Between Stock Returns and Financial Leverage in Finland. *Applied Economics Letters*, 4 (1): 19-21.

Koskela, Erkki – Loikkanen, Heikki A. – Virén, Matti (1992) House prices, household savings and financial market liberalization in Finland. *European Economic Review*, 36 (2-3): 549-558.

Kuosmanen, Petri (2002) *Riski ja tuotto asuntomarkkinoilla*. Acta Wasaensis No 107: Vaasa. (In Finnish)

Ling, David C. – Naranjo, Andy (1999) The Integration of Commercial Real Estate Markets and Stock Markets. *Real Estate Economics*, 27 (3): 483-515.

Liu, Crocker H. – Mei, Jianping (1998) The Predictability of International Real Estate Markets, Exchange Rate Risks and Diversification Consequences. *Real Estate Economics*, 26 (1): 3-39.

Miles, Mike – Cole, Rebel – Guilkey, David (1990) A Different Look at the Commercial Real Estate Returns. *Journal of the American Real Estate and Urban Economics Association*, 18 (4): 403-430.

Mosconi, Rocco – Giannini, Carlo (1992) Non-Causality in Cointegrated Systems: Representation, Estimation and Testing. *Oxford Bulletin of Economics and Statistics*, 54 (3): 399-417.

Myer, F.C. Neill – Chaudhry, Mukesh K. – Webb, James R. (1997) Stationarity and Co-Integration in System with Three National Real Estate Indices. *Journal of Real Estate Research*, 13 (3): 369-381.

Oikarinen, Elias – Asposalo, Henri (2004) *Housing Portfolio Diversification Potentials in the Helsinki Metropolitan Area in the Short and Long Horizon*. Turku School of Economics and Business Administration, Series Discussion and Working Papers 11:2004.

Oikarinen, Elias (2005a) *The Diffusion of Housing Price Movements from Centre to Surrounding Areas*. The Research Institute of the Finnish Economy, Discussion Papers No. 979.

Oikarinen, Elias (2005b) *Is Housing Overvalued in the Helsinki Metropolitan Area*. The Research Institute of the Finnish Economy, Discussion Papers No. 992.

Okunev, John – Wilson, Patrick (1997) Using Nonlinear Tests to Examine Integration Between Real Estate and Stock Markets. *Real Estate Economics*, 25 (3), 487-503.

Okunev, John – Wilson, Patrick – Zurbruegg, Ralf (2000) The Causal Relationship Between Real Estate and Stock Markets. *Journal of Real Estate Finance and Economics*, 21 (3): 251-261.

Okunev, John – Wilson, Patrick – Zurbruegg, Ralf (2002) Relationship between Australian Real Estate and Stock Market Prices – a Case of Market Inefficiency. *Journal of Forecasting*, 21 (3): 181-192.

Osterwald-Lenum, Michael (1992) A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics. *Oxford Bulletin of Economics and Statistics*, 54 (3): 461-472.

Quan, Daniel C. – Titman, Sheridan (1997) Commercial Real Estate Prices and Stock Market Returns: An International Analysis. *Financial Analysts Journal*, 53 (3): 21-34.

Quan, Daniel – Titman, Sheridan (1999) Do Real Estate Prices and Stock Prices Move Together? An International Analysis. *Real Estate Economics*, 27 (2): 183-207.

Rahbek, Anders – Mosconi, Rocco (1999) Cointegration rank inference with stationary regressors in VAR-models. *Econometrics Journal*, 2 (1): 76-91.

Reinsel, G. C. – Ahn, S. K. (1992) Vector autoregressive models with unit roots and reduced rank structure, estimation, likelihood ratio tests, and forecasting. *Journal of Time Series Analysis*, 13: 353-375.

Scruggs, John T. – Glabadanidis, Paskalis (2003) Risk Premia and the Dynamic Covariance Between Stock and Bond Returns. *Journal of Financial and Quantitative Analysis*, 38 (2): 295-316.

Shiller, Robert J. - Beltratti, Andrea E. (1992) Stock Prices and Bond Yields. *Journal of Monetary Economics*, 30 (1): 25-46.

Takala, Kari – Pere, Pekka (1991) Testing the cointegration of house and stock prices in Finland. *Finnish Economic Papers*, 4 (1): 33-51.

Tuluca, Sorin A. – Seiler, Michael J. – Myer, F.C. Neill – Webb, James R. (1998) Cointegration in Return Series and Its Effects on Short-Term Prediction. *Managerial Finance*, 24 (8): 48-63.

Wilson, Patric J. – Okunev, John (1996) Evidence of Segmentation in Domestic and International Property Markets. *Journal of Property Finance*, 7 (4): 78-97.

Wilson, Patric J. - Zurbruegg, Ralf (2003) International Diversification of Real Estate Assets: Is It Worth It? Evidence from the Literature. *Journal of Real Estate Literature*, 11 (3): 259-277.

APPENDIX

Table A1 Augmented Dickey-Fuller test results[25]

Variable	**Level (lags)**	**Difference (lags)**
NOMINAL		
Stock prices	-.29 (10)^{c}	-3.94** (9)
Housing prices	-1.91 (9)$^{c, s}$	-3.02** (4)
Bond prices 1989-	-2.01 (8)^{c}	-2.51* (7)
Inflation rate	-1.18 (4)^{s}	-6.80** (3)^{s}
Deductibility	-.72 (0)	-11.8** (0)
Lending rate	-.81 (1)	-7.70** (0)^{s}
Euribor 1989-	-2.80** (4)	
REAL		
Stock prices	-.29 (10)^{c}	-4.18** (9)
Housing prices	-2.49 (4)$^{c, s}$	-3.74** (4)
Bond prices 1989-	-2.58 (1)$^{c, s}$	-5.75** (0)^{s}
Lending rate	-1.95 (4)^{s}	-6.52** (3)^{s}
Euribor 1989-	-1.30 (4)	-4.41** (3)
GDP	-.98 (3)^{c}	-2.79** (2)
Construction costs	-2.64 (2)^{c}	-4.87** (5)

[25] * 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 A2 Johansen test results in a system including *S*, *H*, *L*, *GDP*, *p*, *C* and *T*

H_0(rank)	Trace test	Crit. value (5%)	Crit. value (10%) ssc		H_0(rank)	H_1(rank)	λ-max test	Crit. value (5%)	Crit. value (10%) ssc
Sample: 1971Q4 – 2005Q2 (model 2, ml=4)									
r = 0	185	147	183		r = 0	r = 1	59.8	49.4	60.2
r ≤ 1	125	115	144		r = 1	r = 2	45.2	44.0	53.2
r ≤ 2	79.9	87.3	108		r = 2	r = 3	28.9	37.5	45.2
r ≤ 3	51.0	63.0	76.9		r = 3	r = 4	20.6	31.5	37.9
r ≤ 4	30.4	42.4	50.8		r = 4	r = 5	14.4	25.5	30.0
r ≤ 5	16.0	25.3	29.6		r = 5	r = 6	8.84	19.0	21.9
r ≤ 6	7.15	12.3	13.6		r = 6	r = 7	7.15	12.3	13.6
LR tests on the long-run relations assuming two cointegrating vectors:									
p-value for excluding *S* and *T* from one cointegrating relation = .46									
p-value for excluding *H* and *C* from one cointegrating relation = .30									
p-value in the joint test for excluding *S* and *T* from one cointegrating relation and *H* and *C* from the other cointegrating relation = .27									

Table A3 Decomposition of variance of Δ*S* and Δ*H* based on VAR models

Step (quarters)	1972Q3-1992Q4									
	Stock price appreciation					Housing price appreciation				
	ΔS	*ΔH*	*ΔL*	*Δl*	*Δp*	*ΔS*	*ΔH*	*ΔL*	*Δl*	*Δp*
1	1.00	.000	.000	.000	.000	.022	.978	.000	.000	.000
2	.967	.017	.009	.000	.006	.282	.710	.000	.004	.003
5	.923	.014	.007	.049	.007	.381	.594	.018	.004	.003
10	.898	.020	.010	.058	.013	.502	.455	.015	.023	.005
15	.896	.022	.010	.058	.014	.507	.444	.015	.029	.006
20	.896	.022	.010	.058	.014	.507	.443	.015	.029	.006
	1993Q1-2005Q2									
	ΔS	*ΔH*	*ΔIR*	*Δir*	*Δp*	*ΔS*	*ΔH*	*ΔIR*	*Δir*	*Δp*
1	1.00	.000	.000	.000	.000	.001	.990	.000	.000	.000
2	.864	.010	.049	.017	.061	.028	.906	.000	.061	.004
5	.728	.049	.047	.121	.055	.026	.782	.004	.182	.006
10	.708	.054	.049	.135	.053	.030	.770	.004	.190	.006
15	.706	.055	.049	.136	.053	.030	.768	.004	.192	.006
20	.706	.055	.049	.136	.053	.030	.768	.004	.192	.006

Table A4 Decomposition of variance of ΔS, ΔH and ΔB based on VAR model

Step (quarters)	1993Q1-2005Q2											
	Stock price appreciation				Housing price appreciation				Bond price appreciation			
	ΔS	ΔH	ΔB	ΔGDP	ΔS	ΔH	ΔB	ΔGDP	ΔS	ΔH	ΔB	ΔGDP
1	1.00	.000	.000	.000	.008	.992	.000	.000	.002	.010	.988	.000
2	.944	.015	.039	.001	.031	.946	.021	.002	.010	.093	.895	.002
5	.858	.060	.055	.027	.028	.817	.144	.012	.031	.152	.811	.007
10	.818	.089	.060	.033	.053	.786	.148	.012	.034	.182	.744	.009
15	.813	.091	.062	.031	.055	.782	.150	.012	.035	.186	.769	.009
20	.813	.091	.063	.030	.056	.781	.151	.012	.036	.187	.768	.009

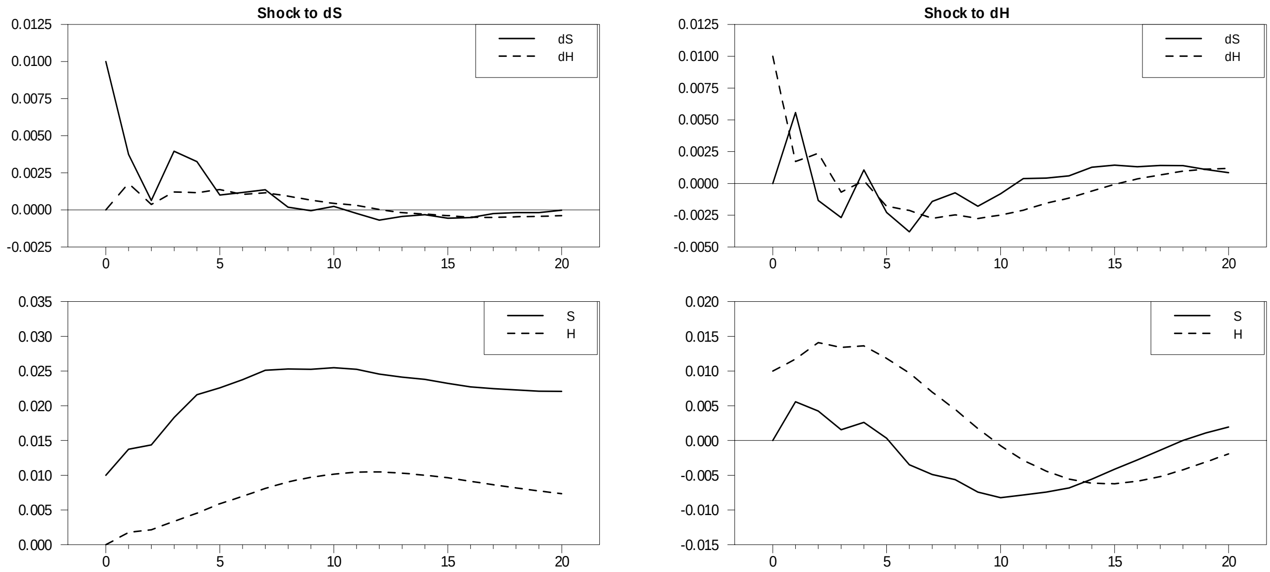

Figure A1 Impulse responses based on the 1972Q3-1992Q4 model

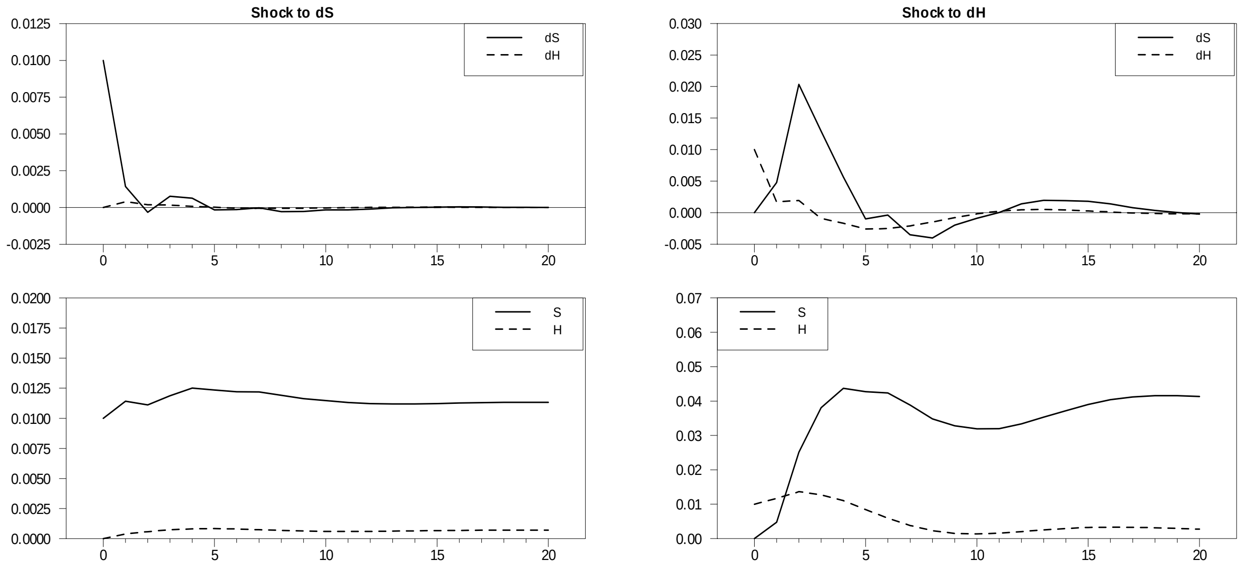

Figure A2 Impulse responses based on the 1993Q1-2005Q2 model

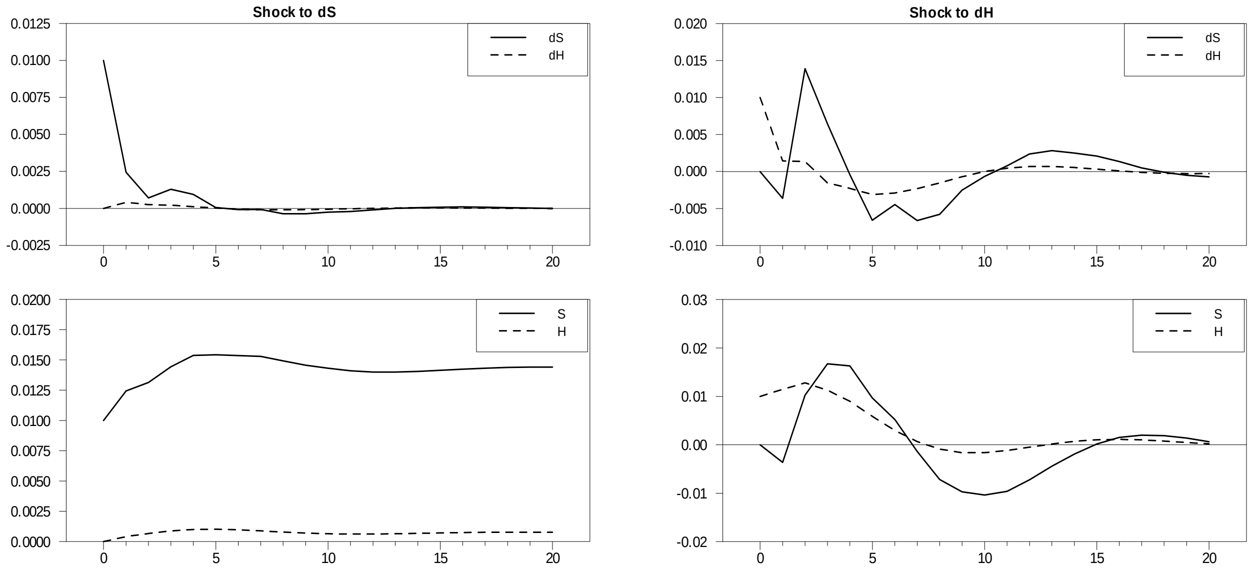

Figure A3 Impulse responses based on the 1993Q1-2005Q2 model where *S* is weakly exogenous

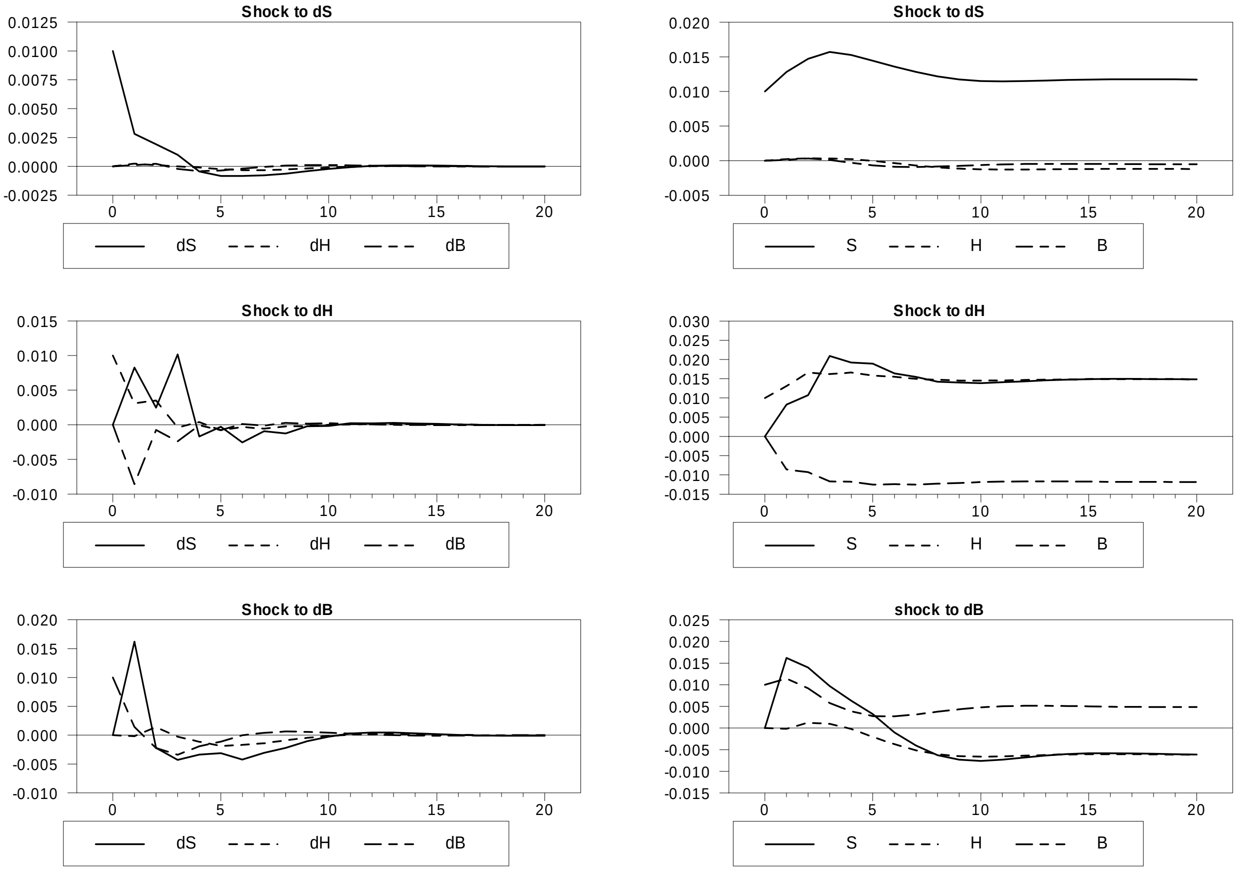

Figure A4 Impulse responses based on the 1993Q1-2005Q2 model including bond price series

E L I N K E I N O E L Ä M Ä N   T U T K I M U S L A I T O S   (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, FIN-00120 HELSINKI

Puh./Tel. (09) 609 900
Int. 358-9-609 900
http://www.etla.fi

Telefax (09) 601753
Int. 358-9-601 753

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

Julkaisut ovat saatavissa elektronisessa muodossa internet-osoitteessa:
http://www.etla.fi/finnish/research/publications/searchengine

No 972 HANNU PIEKKOLA, Knowledge Capital as the Source of Growth. First version17.03.2005. 35 p. New version 10.02.2006. 30 p.

No 973 PEKKA YLÄ-ANTTILA – CHRISTOPHER PALMBERG, The Specificities of Finnish Industrial Policy – Challenges and Initiatives at the Turn of the Century. 29.03.2005. 25 p.

No 974 TUOMAS MÖTTÖNEN, Talouspoliittisen päätöksenteon tietoperustat. Esimerkkinä yritys- ja pääomaverouudistus. 29.03.2005. 90 s.

No 975 JYRKI LESSIG, Suhdannevaihteluiden symmetriaa kultakannan aikana. Ruotsin modernisoituminen, ulkomaankauppa ja taloudellinen integraatio 1800-luvun eurooppalaisten valuuttaliittojen aikana. 31.03.2005. 56 s.

No 976 SAMI NAPARI, Occupational Segregation during the 1980s and 1990s – The Case of Finnish Manufacturing. 18.04.2005. 54 p.

No 977 JYRKI ALI-YRKKÖ – ANTHONY DE CARVALHO – PAAVO SUNI, Intia maailmantaloudessa. 03.06.2005. 31 s.

No 978 RAINE HERMANS – MARTTI KULVIK – ANTTI-JUSSI TAHVANAINEN, ETLA 2004 Survey on the Finnish Biotechnology Industries – Background and Descriptive Statistics. 22.04.2005. 40 p.

No 979 ELIAS OIKARINEN, The Diffusion of Housing Price Movements from Centre to Surrounding Areas. 25.04.2005. 36 p.

No 980 JYRKI ALI-YRKKÖ, Impact of Public R&D Financing on Employment. 06.05.2005. 24 p.

No 981 MAARIT LINDSTRÖM, Onko luovilla aloilla taloudellista merkitystä? Luovat alat, kulttuurialat ja taidekoulutetut eri toimialoilla. 19.05.2005. 26 s.

No 982 MARTTI NYBERG – MAARIT LINDSTRÖM, Muotoilun taloudelliset vaikutukset. 20.05.2005. 25 s.

No 983 NIKU MÄÄTTÄNEN, Vapaaehtoiset eläkevakuutukset, verotus ja säästäminen. 24.05.2005. 31 s.

No 984 TUOMO NIKULAINEN – MIKA PAJARINEN – CHRISTOPHER PALMBERG, Patents and Technological Change – A Review with Focus on the Fepoci Database. 25.05.2005. 26 p.

No 985 PEKKA SULAMAA – MIKA WIDGRÉN, Asian Regionalism versus Global Free Trade: A Simulation Study on Economic Effects. 27.05.2005. 12 p.

No 986 EDVARD JOHANSSON – PETRI BÖCKERMAN – RITVA PRÄTTÄLÄ – ANTTI UUTELA, Alcohol Mortality, Drinking Behaviour, and Business Cycles: Are Slumps Really Dry Seasons? 16.06.2005. 10 p.

No 987 ARI HYYTINEN – MIKA PAJARINEN, Why Are All New Entrrepreneurs Better than Average? Evidence from Subjective Failure Rate Expectations. 23.06.2005. 34 p.

No 988 RAINE HERMANS – MARTTI KULVIK, Initiatives on a Sustainable Development Strategy for Finnish Biotechnology. 22.06.2005. 25 p.

No 989 MIKA WIDGRÉN, Revealed Comparative Advantage in the Internal Market. 01.08.2005. 20 p.

No 990 ARI HYYTINEN – MIKA PAJARINEN, Yrittäjäksi ryhtyminen ja yrittäjyysasenteet Suomessa: Havaintoja kyselytutkimuksista. 10.08.2005. 19 s.

No 991 CHRISTOPHER PALMBERG – MIKA PAJARINEN, Alliance Capitalism and the Internationalisation of Finnish Firms. 01.11.2005. 39 p.

No 992 ELIAS OIKARINEN, Is Housing Overvalued in the Helsinki Metropolitan Area? 29.09.2005. 33 p.

No 993 MIKA MALIRANTA – PEKKA ILMAKUNNAS, Decomposing Productivity and Wage Effects of Intra-Establishment Labor Restructuring. 02.11.2005. 26 p.

No 994 VILLE KAITILA – MAARIT LINDSTRÖM – EWA BALCEROWICZ, Puolan liiketoimintaympäristö ja suomalaisten yritysten kokemukset. 10.11.2005. 72 s.

No 995 SERGEY SUTYRIN – VLADIMIR SHEROV, Russian Regions and Their Foreign Trade. 25.11.2005. 26 p.

No 996 HANNU PIEKKOLA, Public Funding of R&D and Growth: Firm-Level Evidence from Finland. 20.12.2005. 30 p.

No 997 AIJA LEIPONEN, Clubs and Standards: The Role of Industry Consortia in Standardization of Wireless Telecommunications. 08.12.2005. 44 p.

No 998 EWA BALCEROWICZ, Poland's Enterprise Environment – A Polish View. 10.01.2006. 19 p.

No 999 STEFAN NAPEL – MIKA WIDGRÉN, The European Commission – Appointment, Preferences, and Institutional Relations. 17.01.2006. 20 p.

No 1000 JUKKA LASSILA – TARMO VALKONEN, The Finnish Pension Reform of 2005. 20.01.2006. 20 p.

No 1001 OLLI-PEKKA OKSANEN, Are Foreign Investments Replacing Domestic Investments? – Evidence from Finnish Manufacturing. 19.01.2006. 59 p.

No 1002 ARTO SEPPÄ, Open Source in Finnish Software Companies. 25.01.2006. 36 p.

No 1003

No 1004 ELIAS OIKARINEN, Price Linkages Between Stock, Bond and Housing Markets – Evidence from Finnish Data. 15.02.2006. 36 p.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on mahdollista ostaa Taloustieto Oy:stä kopiointi- ja toimituskuluja vastaavaan hintaan.

Papers in this series are reports on preliminary research results and on studies in progress. They are sold by Taloustieto Oy for a nominal fee covering copying and postage costs.