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Dynamic linkages of real estate and stock markets in Finland

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Abstract

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Traditionally real estate has been seen as a good diversification tool for a stock portfolio due to the lower return and volatility characteristics of real estate investments. However, the diversification benefits of a multi-asset portfolio depend on how the different asset classes co-move in the short- and long-run. As the asset classes are affected by the same macroeconomic factors, interrelationships limiting the diversification benefits could exist. This master's thesis aims to identify such dynamic linkages in the Finnish real estate and stock markets. The results are beneficial for portfolio optimization tasks as well as for policy-making.

The real estate industry can be divided into direct and securitized markets. In this thesis the direct market is depicted by the Finnish housing market index. The securitized market is proxied by the Finnish all-sectors securitized real estate index and by a European residential Real Estate Investment Trust index. The stock market is depicted by OMX Helsinki Cap index. Several macroeconomic variables are incorporated as well. The methodology of this thesis is based on the Vector Autoregressive (VAR) models. The long-run dynamic linkages are studied with Johansen's cointegration tests and the short-run interrelationships are examined with Granger-causality tests. In addition, impulse response functions and forecast error variance decomposition analyses are used for robustness checks.

The results show that long-run co-movement, or cointegration, did not exist between the housing and stock markets during the sample period. This indicates diversification benefits in the long-run. However, cointegration between the stock and securitized real estate markets was identified. This indicates limited diversification benefits and shows that the listed real estate market in Finland is not matured enough to be considered a separate market from the general stock market. Moreover, while securitized real estate was shown to cointegrate with the housing market in the long-run, the two markets are still too different in their characteristics to be used as substitutes in a multi-asset portfolio. This implies that the capital intensiveness of housing investments cannot be circumvented by investing in securitized real estate.

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Kiinteistöjä on perinteisesti pidetty hyvänä osakeportfolion hajautustyökaluna niiden maltillisempien tuotto- ja riskiominaisuuksien vuoksi. Hajautushyödyt riippuvat kuitenkin omaisuusluokkien välisistä riippuvuussuhteista eri aikaväleillä. Makroekonomisten muuttujien vaikuttaessa molempiin omaisuusluokkiin, hajautushyötyä rajoittavia dynaamisia yhteyksiä saattaa syntyä omaisuusluokkien välille. Tässä Pro gradu-tutkielmassa pyritään tunnistamaan näitä dynaamisia yhteyksiä Suomen kiinteistö- ja osakemarkkinoilla. Tuloksilla on käyttöä portfolion optimointitehtävissä sekä poliittisen päätöksenteon tukena.

Kiinteistösijoitukset voidaan jakaa suoriin ja arvopaperistettuihin sijoituksiin. Tässä tutkielmassa suoria sijoituksia kuvaa asuntomarkkinaindeksi. Arvopaperistettuja sijoituksia kuvaa suomalainen kiinteistösijoitusyhtiöindeksi ja eurooppalainen asuntosijoitusyhtiöndeksi. Osakemarkkinaindeksinä toimii OMX Helsinki Cap. Myös

makroekonomisia muuttujia käytetään. Metodologia perustuu vektoriautoregressio-malleihin. Johansenin cointegraatiotestillä tarkastellaan pitkän aikavälin yhteyksiä, ja Granger-kausaliteettitesteillä lyhyen aikavälin yhteyksiä. Impulse response -funktioita ja variance decomposition -analyysia käytetään vahvistamaan tuloksia.

Tulokset osoittavat, että asunto- ja osakemarkkinoiden välillä ei vallitse pitkän aikavälin dynaamista yhteyttä, joten hajautushyödyt ovat mahdollisia. Sen sijaan osake- ja arvopaperistettujen kiinteistömarkkinoiden välillä on pitkän aikavälin riippuvuussuhde, joten hajautushyödyt ovat rajalliset. Tulos myös osoittaa, ettei arvopaperistettuja kiinteistömarkkinoita voi Suomessa pitää yleisestä osakemarkkinasta erillisenä sijoitusluokkana. Lisäksi, asunto- ja arvopaperistettujen kiinteistömarkkinoiden osoitettiin olevan ominaisuuksiltaan liian erilaisia, jotta niitä voitaisiin pitää substituutteina sijoitusportfoliossa. Tämän johdosta asuntosijoitusten suurta pääomatarvetta ei voi kiertää sijoittamalla kiinteistösijoitusyhtiöihin osakemarkkinoiden kautta.

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In Lappeenranta 25.4.2015 Joonas Kainulainen

Table of Contents

1. Introduction

The economic downturn that started in 2008 has impacted the financial market returns significantly. Following the modern portfolio theory, investors have always been interested in alternative investment assets that could diversify the portfolio's risk and reduce the volatility of a pure stock portfolio. Real estate represents one of the most common alternative investment assets. For example, considering that in Finland the homeownership rate was 73 % in 2013 (Eurostat 2015), a careful investigation of the Finnish real estate and housing markets would have economy wide benefits and implications. Since the housing market is a substantial part of the wealth of the homeowners, understanding the dynamics of the housing markets helps governments to forecast the state of the economy and intervene if the economy seems to overheat. In addition, understanding the dynamics between real estate and securities markets benefit both retail and institutional investors in portfolio optimization tasks.

Investing in real estate can be achieved both directly and indirectly. Moreover, real estate assets can be divided into different sectors, such as residential, office or retail real estate. Individual investors often participate in direct real estate markets through the housing sector, whereas companies and institutional investors have a capability to invest in whole apartment buildings and office property or retail venues that are usually unachievable to a retail investor due to the capital intensiveness of direct real estate investments. Indirect real estate investments mean stakes in real estate companies that are traded publicly in stock markets.

Traditionally housing and real estate have been considered as good diversification tools for a stock portfolio because of their perceived low or even negative correlation with stock markets (Ling & Naranjo 1999). In addition, while real estate investments have typically yielded lower returns than stocks, their risk, measured as volatility, has also been lower. Flavin & Yamashita (2002, 350) found that real estate investments had had an average return of 6,6 %, while the volatility was 14 %. The results for stock investments were 8 % and 24 %, respectively. Other studies have found that real estate investments have had the highest Sharpe index compared to stocks and fixed income investments (e.g. Lee 2008).

1.1. Research questions

This thesis studies the dynamic linkages between the Finnish stock market, the securitized real estate market and the direct real estate market depicted by the housing sector. Dynamic linkages mean interrelationships of variables where lagged values of one variable have causal effects on the contemporary values of another variable. Price series are said to be cointegrated if they have a stationary linear combination even when the series themselves are non-stationary. In effect this means that while in the short-run the series may seemingly fluctuate apart from each other, in the long-run they are “bounded” to a common equilibrium, towards which the series tend to converge (Granger 1986, 213).

Thus, mere correlations or static return-volatility comparisons do not illustrate the true interrelationships between the asset classes. As real estate and stock markets are influenced by the same macroeconomic factors, they may have dynamic linkages which would suggest that – at least in the long-term – the two asset classes would experience co-movement and thus not provide diversification benefits in a portfolio. As direct real estate, such as housing, tends to be quite a long-term investment by nature, the hypothesized co-movement would be a misfortune at least for the homeowners who are often constrained by the capital intensive direct real estate investment. In another words, since direct real estate investments are very expensive, they often hold a larger than optimal weight in investors’ portfolios (Englund, Hwang & Quigley 2002, 168). Therefore, it is important to recognize the dynamics between housing and stock markets. The first research question asks the following:

1. **Are there long- and short-term dynamic linkages between housing and stock markets?**

Securitized real estate stocks and Real Estate Investment Trusts (REITs) provide a more liquid and less capital intensive way to participate in the real estate markets than direct real estate investments (Devaney, Xiao & Clacy-Jones 2013, 3). Some institutional investors, such as pension funds, prefer REIT investments over direct real estate due to the higher liquidity that allows flexibility in meeting the fund's liabilities (Ciochetti, Craft & Shilling 2002, 592). It has also been shown that the inclusion of REITs to a mixed-asset portfolio creates benefits by enhancing returns and decreasing risk (Lee & Stevenson 2005, 67). The issue with studies that are performed with differenced price (i.e. return) series is that they exclude the long-run dynamics. Thus, if securitized real estate performs much like common stocks in the long-run, the diversification possibilities are limited. Thus, it is of interest to know how the securitized real estate and stock markets interact at different time horizons:

2. **Are there long- and short-term dynamic linkages between securitized real estate and stock market returns?**

The direct real estate investments are capital intensive and also suffer from sluggish adjustment due to decentralized markets (Clayton, Geltner & Hamilton 2001, 340). The securitized real estate market would provide a more practical way to participate in the real estate markets, for example, to satisfy short-term capital allocation needs. Thus, we are interested to see whether the securitized real estate market depicts the underlying direct real estate market and if the listed sector could be used to replace the direct market in a portfolio:

3. **Is the securitized real estate market a good proxy for the underlying direct real estate market?**

1.2. Research methodology

The methodology largely follows the studies of Oikarinen (2007) and Hoesli and Oikarinen (2012). Oikarinen (2007) studied the dynamic linkages of Finnish housing and stock markets during 1970-2006. Hoesli & Oikarinen (2012) used extensive data from USA, UK and Australia when they studied the interrelationships between the stock, the direct and the securitized real estate markets. This thesis combines the research of dynamic linkages between the three different asset types in the Finnish markets.

The dynamic linkages are studied with Vector Autoregressive (VAR) models. The VAR structure is a practical way to examine linkages between time series, because it allows multivariate modelling, and thus macroeconomic control variables can also be used. Moreover, the VAR methodology does not require the identification process of the variables, since all of the variables are treated as endogenous. This simplifies the research process.

The long-run cointegrating relations are studied with a modification of the general VAR model, called the Johansen's Vector Error Correction model. By using non-stationary price series, the Johansen's test captures the number of cointegrating vectors between the variables. In addition, the robustness of the cointegrating vectors can be tested with restrictions on the coefficients of the error correction model. The short-run dynamics are inspected with return series using multivariate Granger-causality tests. In addition, impulse response and forecast error variance decomposition analyses are incorporated for robustness checks of the results.

1.3. Limitations of the study

The availability of data generates some limitations for the study. As mentioned, the direct real estate sector is represented by a Finnish apartment price index. Therefore, it does not include data from the private commercial real estate sector. This forces the perspective of the study to those of a retail investor -homeowner or an institutional investor who has residential real estate in his portfolio. In contrast, the Finnish securitized real estate index includes companies that invest in various real estate sectors, not just in residential real estate. This could diminish the perceived linkages between the housing and securitized real estate indices. Therefore, also a securitized residential real estate market – proxied by a European residential REIT index – is used.

Moreover, the housing price index represents the overall Finnish housing markets. Separation of the housing market into different geographical sections is left out of the study. For example, Sim & Chang (2006, 110) show that in the Korean markets Granger-causality from housing to stock markets is evident in the economically powerful southern region of the country, whereas in the north no causality in either direction was found. However, Oikarinen (2007, 247) found that in Finland the house price changes in the Helsinki Metropolitan area Granger-caused housing prices in other regions of Finland, and that the regional centers Granger-caused housing prices in the surrounding areas. Therefore, there is evidence that the regional housing markets in Finland are interconnected and share common trends that would create very similar results regarding the long-run co-movement with the securities markets.

In addition, other asset types, such as bonds are left out of this study. Glascock, Lu & So (2000, 191-192) showed that in the US markets REITs were cointegrated with bond markets until the early 1990s. Westerheide (2006, 15) confirms the absence of cointegration between REITs and bonds after 1990 in US and most European markets. Also, Oikarinen (2007, 301) found that in the Finnish markets the dynamic linkage between bonds and housing markets is significantly weaker than the co-movement between stock and housing markets.

2. Literature review

The research for dynamic linkages between stocks and real estate has developed over the years from the correlation focused and short-run centered integration studies to cointegration studies which are better suited for the long-run dynamics inspection. The reason why integration studies are short-run focused by construction is that they deal with differenced asset series, i.e. returns, which neglect the long-term dynamics of the time series. Cointegration studies, on the other hand, are performed with the price series which incorporate the long-run dynamics and enable to identify common driving forces between the assets.

For example, in one of the early integration studies of real estate and stock market by Liu, Hartzell, Greig & Grissom (1990, 261) integration is defined as two asset classes sharing a common systematic market risk, which is the only risk priced in the assets. Segmentation is defined as there being unique systematic risk factors for the different asset classes, which in effect creates different risk adjusted expected returns (Liu et al. 1990, 262). Thus, integrated assets are good substitutes in a portfolio and provide poor diversification benefits if held together in a portfolio. However, the study is done in the Capital Asset Pricing Model framework, neglecting dynamic linkages between the assets.

In the literature of real estate and stock market cointegration the results generally differ vastly depending, e.g. on the methodology used or the market studied. For example, Westerheide (2006, 15) fails to find almost any cointegrating vectors between securitized real estate and stock markets in an international market data, including the US market. Chaudhry, Myer & Webb (1999, 347), however, find a cointegrating relationship between commercial unsecuritized real estate and stock markets in the US. Both studies used Johansen’s cointegration tests but only Chaudhry et al. included macroeconomic variables, such as the consumer price index (CPI) to the model.

In the next subsections the theories and reasons behind existing or missing linkages between the different asset classes are discussed. We begin by inspecting the impact of informational efficiency of the asset markets, and then the differentiating factors between the assets are examined. In addition, we investigate the theories of wealth and credit-price effect that explain causality between real estate and financial markets, and review the extant literature covering the topic.

2.1. Informational efficiency

The concept of informational efficiency of the markets is important when studying the price behavior of assets and dynamic linkages between different assets. One of the roles of capital markets is to allocate capital in an efficient way, so that companies are able to make production and investment decisions and investors can choose which companies' equity they want to acquire based on their risk-return requirements (Fama 1970, 383). An efficient allocation of funds and an accurate decision-making requires that the market prices reflect the available information. Thus, informational efficiency indicates to what extent and how fast information reaches different market participants and how the new information affects the market prices (Sharpe, Alexander & Bailey 1999, 93).

In an informationally efficient market any new information is spread quickly and widely among all market participants and the prices react instantaneously. Hence, all available information is incorporated in the stock market prices and excess returns cannot be achieved regularly. This notion is known as the efficient market hypothesis (EMH) (Bodie, Kane & Marcus 2005, 371). The general assumptions are that access to information is costless, market participants are skillful analysts and at least the marginal investors who correct the prices follow the markets closely and reallocate their capital accordingly (Sharpe et al. 1999, 93, 106). Fama (1970, 388) divided the EMH into three subcategories:

- **Weak form** efficiency: All past information is reflected in the prices.
- **Semi-strong form** efficiency: All publicly available information is reflected in the prices
- **Strong form** efficiency: All available information is reflected in the prices.

For example, if the strong form hypothesis were to be supported, it would mean that even the private managerial information would be immediately reflected in the prices, preventing abnormal returns. The extreme strong-form hypothesis is rarely supported, and indeed one of the tasks of the Securities and Exchange Commission (SEC) is to prevent insider trading that exploits non-public information (Bodie et al. 2005). However, for the two less restrictive hypotheses there is much wider support (e.g. Malkiel 2003).

While the securitized markets may generally be efficient, the same does not necessarily apply to the real assets. Granger (1986, 218) suggested that if two asset price series are from a jointly efficient market, they cannot be cointegrated. Considering the real estate and stock markets, if it was found that there exists a causal relationship, short- or long-term, such as Granger-causality or cointegration between (securitized) real estate and stock markets, it would mean that the prices in one market could be forecasted, at least *ex-post*, by the other market's price behavior. Then it can be argued that not all the information was instantaneously reflected in the market prices if the lags of the stock price index were significant in explaining the real estate indices or vice versa. This would be in opposition to the informationally efficient markets hypothesis.

But even if inefficiencies were to be found it is entirely another question whether these anomalies can be systematically exploited. Dwyer & Wallace (1992) show that if market efficiency is not defined by the random walk condition but a no-arbitrage condition, the connection between cointegration and efficiency needs not hold. Subsequently, Lence & Falk (2005, 888) show that market efficiency and cointegration are separate restrictions and that other parameters, such as technology, endowments and preferences may account for the generation of equilibrium.

Fu and Ng (2001, 229, 248) studied the market efficiency of Hong Kong real estate and stock markets using quarterly price indices and a VAR forecasting model and found that the speed of adjustment to news in the real estate and stock markets affect volatility and correlation statistics of excess returns. They also found that the real estate sector only incorporates about half the effect of news in a quarter with the remaining effect showing up in the latter periods' excess returns. The stock market, however, captured fully the effect of news in a quarter. The slow speed of adjustment was found to induce autocorrelation to the series as well as weaken the correlation between real estate and stock markets.

Brox, Carvalho & Duckett (2007, 20-22) examined whether the weak-form hypothesis holds true for the Greater-Toronto Area residential real estate market. They found that since the excess returns were not found to be normally distributed they could not be modelled with a random walk process which is a prerequisite of the weak form efficiency. In addition, they forecasted the excess returns with univariate time series modelling and while it was argued that the point forecasts may not be very robust, the overall conclusion was that the residential real estate markets were not considered informationally efficient.

Some of the main reasons why the real estate markets fail in informational efficiency are decentralized markets, illiquidity and high transactions costs. The next subsection discusses the unique features of real estate investments and details the reasons why informational inefficiencies may occur in the real estate market.

2.2. Differentiating factors between direct real estate and financial assets

Even though the price formation of real estate assets is based on the discounted future cash flows as with other asset types, (direct) real estate, being a physical asset, possesses several unique features that distinct it from securities. These features may weaken the dynamic linkages and interdependence between direct real estate and the stock or the securitized real estate markets. In addition, if the securitized real estate sector follows the underlying direct market closely, then these features could also weaken the interdependencies between the securitized market and the overall stock market.

Oikarinen (2007, 33-38) has listed some special features of housing investments but they are, by and large, generalizable for the other types of real estate as well. Unlike in the securitized markets, direct real estate does not have an established market place for price setting (Oikarinen 2007, 33-34). One reason for this is the heterogeneity of housing and direct real estate. For example, the price is affected by several variables, such as the location of the property or the features and equipment (e.g. air conditioning, balcony, sauna, new appliances). The problem of assessing the impact of qualitative features on real estate prices have been tried to solve with hedonic pricing models (Laakso 1997, 25).

The lack of a centralized market place makes the direct real estate market more illiquid and diminishes the diversification possibilities compared to securities. This in turn makes the price determination and information transferring more costly and time consuming (Devaney,et al. 2013, 3). In addition, the difficulties to short sell housing assets (Case, Cotter & Gabriel 2010, 13) and transaction costs such as transfer tax and moving costs increase illiquidity. Heterogeneity makes comparing the prices and returns of different properties more complicated since the transactions are based on unique and individual interests that may not be satisfied elsewhere due to the illiquidity of the market (Devaney et al. 2013, 3). Moreover, real estate markets differ from other heterogenic goods by offering both new and old properties for trade (Miettilä 2001, 24-25).

Due to the heterogeneity and infrequent trading the real estate data gathering methods and hence the quality of data may vary across different data providers and countries. For example, Clayton, Geltner & Hamilton (2001, 340) explain that some constituents of the benchmark real estate indices are not necessarily valued at the same frequency as the benchmark, which can in effect make a quarterly index an annual index with partial quarterly updates. Furthermore, since an appraisal is an estimate of a contemporaneous market value and the true market value is unknown, there is a lag between the appraised and true contemporaneous market value. Because an estimate is more unreliable due to imperfect information than the previous periods' observed valuations, the appraisers may at least partly rely on historical values during the estimation process and anchor their value estimate on the older valuation (Devaney et al. 2013, 4; Clayton et al. 2001, 340). This partial adjustment creates appraisal smoothing in the data which reduces the variance (Geltner 1989, 471). The quality differences of data may affect research results (e.g. Hoesli & Oikarinen 2012).

Another important feature of real estate, and especially housing assets, is that housing is both an investment and a consumption good (Oikarinen 2007, 34). The demand for consumption causes a so called housing constraint in a small investor's portfolio. Since a house is often a significant economic investment, and because the consumption aspect may be heavily influencing the purchasing decision, the weight of housing in the investor's portfolio may rise over the optimal level (Flavin & Yamashita 2002, 345; Englund et al. 2002, 168). Hence, the overall diversification of the portfolio is sub-optimal, affecting the risk and return of the portfolio. Institutional investors, on the contrary, are better equipped to participate in direct real estate markets without having the portfolio being over weighted by real estate investments.

Moreover, because of the indivisible nature of real estate assets, the capital requirement for investing in real estate is generally large relative to an investor's wealth. Hence, because of the large capital requirement and the housing constraint in a small investor's portfolio, housing is a significant part of the households' welfare. This encourages governments to intervene in housing markets, for example, by building rental apartments with fixed rental fees which can affect housing returns in the private sector as well (Oikarinen 2007, 35). In addition, the housing sector has a notable influence on the economy as a whole through the wealth effect on consumption (Carroll, Otsuka & Slacalek 2011, 18). The effect has been shown to be even larger than the wealth effect of financial assets (Case, Quigley & Shiller 2005, 26). Moreover, the real estate price fluctuation has been shown to have a significant role in financial crises (Reinhart & Rogoff 2008, 340-341).

Due to the capital intensiveness, debt is usually needed in purchasing real estate. This makes real estate investments often highly leveraged (Yao & Zhang, 2005, 198). When listed real estate companies buy their properties with debt funding, the leverage effect is directly "transferred" into the share price, whereas the leverage effect of the direct real estate market is not usually calculated in indices measuring its performance (Devaney et al. 2013, 3). This should be kept in mind when comparing the performance of securitized real estate and the underlying direct real estate markets. In addition to affecting the returns of the markets, the leverage effect makes the responses to shocks more pronounced which affects, for example, the interpretation of impulse response results. In Hoesli & Oikarinen (2012, 1829-1830) the direct real estate data does not cater for the leverage by default whereas the REIT data does. Hence, if the shock response in unlevered direct real estate prices was half of the corresponding levered REIT price change, then 50 % leveraged direct real estate would create similar shock responses.

According to Devaney et al. (2013, 3) the investor types or strategies in direct and securitized real estate markets differ. The more liquid and less capital demanding securitized market attracts small investors and short term investors to invest in real estate through capital markets. Conversely, the direct market in general is more influenced by institutional investors with long-horizon strategies (Devaney et al. 2013, 3). However, Oikarinen (2007, 37-38) argues that the share of professional investors in housing markets is typically substantially less than the share of homeowners, which could weaken the linkages between financial assets and housing because of the different structure of investor types in the markets. The emphasis on long-horizon strategy in direct real estate has implications for portfolio analysis as well. Oikarinen (2007, 36) states that relatively long-term correlations and volatilities should be used when assessing the diversification possibilities of housing in a multi-asset portfolio.

For a retail investor or a homeowner participating in the direct real estate market, the capital intensiveness of the investment affects their ability to allocate their capital in the securitized market. Flavin & Yamashita (2002, 359) show that especially young home owners, who have highly leveraged housing investments, use their net worth to pay the mortgage or buy bonds instead of investing in riskier stock markets.

Since a physical asset is bound to a geographical location, the direct real estate indices should depict the price changes of a certain area. The listed real estate companies, however, may invest to other geographical locations or countries besides where they are listed, which predisposes their performance to different risk and return characteristics from the corresponding direct real estate in the company’s listing country (Devaney 2013, 4). In some cases, the direct real estate indices may also include the aforementioned effect if the institutional investors, whose performance is the base of the direct real estate indices, invest also indirectly through REITs (Malpezzi & Shilling (2000, 135).

Oikarinen (2007, 34) lists additional features that stem from the physical nature of the asset. First, the physical depreciation and real estate taxes increase the maintenance costs compared to financial assets. Second, personal time and effort must be spent in order to find tenants to pay rents. Third, there are real options or options to change the physical property structure. Fourth, because the physical depreciation is slow and the construction of new real estate is slow, the reactions to macroeconomic changes are slow as well. This may induce significant autocorrelation to the prices regardless of the rationality of the market participants (Oikarinen 2007, 34; Dolde & Tirtiroglu 1997, 542).

2.2.1. Inflation hedging properties of real estate and stock markets

A controversial topic in the past has been the inflation hedging properties of real estate and stock markets. Past studies have found that the inflation hedging property of real estate assets is better than in stock market. For example, Gultekin (1983, 64) found that stock markets do not vary in a one-to-one positive correspondence with inflation, and Fama & Schwert (1977, 144) concluded that a direct residential real estate market hedges completely even against the unexpected inflation, while the stock market largely fail to hedge against inflation. Liu, Hartzell & Hoesli (1997, 219) used a similar methodology as Fama & Schwert and found that securitized real estate returns also provide no hedge against inflation. Rubens, Bond & Webb (1989, 50-51) showed that residential real estate hedged poorly against expected inflation but very well against unexpected inflation. However, the authors also fail to find hedging abilities from stock investments.

While the methodology in the studies cited above use return series, i.e. they exclude the long-run properties of the asset price fluctuation, somewhat contradicting results have been found when long-run error correction or similar methodologies have been used. Hoesli, Lizieri & MacGregor (2008, 200-201) found that the US stock markets hedged against the expected inflation in the long-run, while direct private real estate's hedging abilities were poor. The analysis of the UK markets provided similar results. However, they showed that the stock market was unable to hedge against the unexpected inflation while the direct real estate hedging ability was good. Thus, even in the long-run the hedging properties against unexpected inflation follow the general conceptions. Inflation hedging characteristic of direct real estate has also been confirmed by Schätz & Sebastian (2009, 187). Zhou & Clements (2010, 276) reported that neither stock nor real estate markets provided hedging against inflation in China during 2000-2008. The differencing results may be due to the fact that their long-run models do not account for macroeconomic variables other than inflation.

2.3. Integration and cointegration between real estate and stock markets

Integration and cointegration between stock and real estate markets may arise for several reasons. Macroeconomic variables affecting both assets can generate long-term cointegration. For example, inflation and the interest rates are used as a base for the discount rates of valuation calculations. In addition, the economic activity as a whole and hence the business cycles are a common driving force for the assets. Chan et al. (2011, 1423) studied asset market linkages in the US market in 1987-2008 and found that during recessions the correlation between stock and housing markets was approximately three times as large as during times of growth. It should be noted, though, that the globalization of the economy may have weakened the effect of business cycles, as international investors influence the national stock markets more nowadays. The real estate markets, especially housing markets are still largely influenced by the national economies and market participants. (Oikarinen 2007, 265)

Liu et al. (1990) studied the level of integration between commercial real estate and stock markets, and found that the securitized commercial real estate markets were integrated with stock markets but the underlying direct real estate markets were segmented from the stock markets. Contradicting results is reported by Quan & Titman (1999). They found that internationally real estate was significantly positively related to stock markets. Clayton & MacKinnon (2003) findings extend Liu et al.'s (1990) study. They found that during the 70s and 80s the REIT market in the US was more integrated with large cap stocks because of the same macroeconomic factors affecting both assets. However, during the 1990s a significant change happened in the integrating relationships. Commercial real estate started to become more related with small cap stocks and with the underlying unsecuritized real estate. The increased relation here means that the REIT market became more efficient in portraying the underlying assets' returns but also the idiosyncratic risk of REITs increased. Short-term integration between REITs and stock market in the US has also been found by Ling & Naranjo (1999).

Contradicting results to Clayton & MacKinnon (2003) are reported by Glascock, Lu & So (2000) who studied the effects of structural breaks to securitized real estate behavior. They report that in the US REITs were more like fixed income securities during 1972 to 1991 because REIT and bond markets were cointegrated during this period while no cointegration between REITs and stock markets was found. After 1992 REITs started to act more like common stocks. The authors also found that before 1992 REITs were cointegrated with inflation but not after that, implying that in the last two decades REITs have been a good hedge against inflation.

Liow (2009) reports long-run cointegration of stock and real estate market volatilities in various Asian markets but only weak evidence for long-run volatility integrations in other Asian and Western developed countries. It was also noticed that the direct real estate volatilities differ from securitized real estate in long-run memory characteristics, stating that securitized real estate does not accurately depict the underlying asset.

Lin & Lin (2011) report mixed results of stock and real estate market cointegration in Asian economies. During 1995-2010, in China, Hong Kong and Taiwan these two asset classes were non-linearly cointegrated but in South Korea and Singapore the stock market seemed to be segmented from real estate markets, implying that in these economies real estate provides diversification possibilities. Moreover, Granger-causalities from stock market to real estate were not found in any country. Lin & Lin (2011) report Granger-causality from real estate to stock market in Singapore and Taiwan. It would imply that real estate market is very well grounded into Singaporean economy. For the US data, Okunev, Wilson & Zurbruegg (2000, 260) also find the causal relationship running from real estate to stock markets despite no linear long-run relationship. Liow (2006, 375) finds partially contradicting results considering the cointegration in Singapore. His earlier data period from 1985 to 2002 shows significant co-movement in the long-run. However, after controlling for macroeconomic factors, both the long- and short-run co-movements reduced. One reason for Lin & Lin (2011) findings of the segmented markets could be that their time series covers the financial crisis, but because of infrequent quarterly data they were unable to split the data into pre- and after crisis subsamples.

Cointegration and Granger-causalities in the Finnish stock and housing markets has also been a subject of research. Oikarinen (2007) used a weight restricted OMX Helsinki Cap index as a stock market variable, since the maximum weight of 10 % for a single company in the index effectively limits the influence of large companies. For example, Nokia's weight on the OMX Helsinki index was at most 70 % during the sample period. The housing index represents the development of the whole country and is constructed from a quality adjusted hedonic price index and an average sales price index. In addition, several control variables (GDP, inflation, 12-month Euribor etc.) are used. (Oikarinen 2007, 277-278)

The methodologies adopted were the Johansen cointegration model, Granger-causality F-tests and innovation accounting (OIkarinen 2007, 283-286). The correlation analyses seemed to entail some kind of long-term relationship with the variables, since the correlation coefficients increased as the observation window was increased. The quarterly correlations were relatively high, approximately 0.45-0.52 depending on the sample time.

However, cointegration was non-evident during the full sample period of 1970-2006 even with the inclusion of control variables, but when the sample was divided into pre- and post-1994 subsamples based on a found structural change, long-term dynamic interdependencies were found. In the 1970-1992 period a pairwise cointegrating vector was found between housing and stock without the control variables and the stock market was identified as weakly exogenous, meaning that only the housing markets adjusted to the equilibrium by 10 % per quarter. In the 1994-2006 sample a cointegrating vector was found when housing and weakly exogenous stock variables were used. The inclusion of 12-month Euribor and GDP decreased the rejection value of the result from 15 % to 3 %. However, both the control variables could be excluded from the cointegrating relation. (Oikarinen 2007, 291-292, 295)

It was hypothesized that due to the sluggish adjustment of housing markets, the stock markets were going to lead the causality. Exactly this was found with Granger-causality tests. In addition, housing markets were caused by the deviation from the long-run equilibrium. Moreover, after 1994 the housing market seems to be caused only through the long-run relation. The impulse response analysis confirms the causality findings. After 1994 a shock in the stock market seems to have inconsequential effect on housing market. The forecast error variance decompositions show that in the 1971-1992 sub-sample stock market accounted up to 49 % of housing market variance after ten quarters from the shock. Meanwhile, the effect of housing market to stock market variance was negligible. In the latter 1994-2006 sub-sample period, the effect of stock market to housing variance decreased to 30 % in the ten quarter period, and the housing market accounted approximately 10 % of the stock market variance after ten quarters from the shock. (Oikarinen 2007, 295, 309)

The results of Oikarinen (2007) seem to imply that the dynamic linkages of the Finnish housing and stock markets have decreased after the early 90s. The direction of causality seemed to run from stocks to housing and the connection has been decreasing since 1994. The found cointegrating vector was not highly statistically significant until macroeconomic control variables were added to the equation and even then only the housing markets adjusted to the long-run equilibrium, suggesting that the stock market leads housing markets. Regarding the use of macroeconomic variables, Liow (2006, 375) found that the use of fundamentals weakened the established long-run interdependence between stock and property markets in Singapore.

Yunus (2012, 127) examined the long- and short-run dynamics of securitized property markets, stock markets and key macroeconomic factors with an international dataset during 1990-2007. The Johansen cointegration technique was used to track the long-run dynamics while multivariate Granger-causality tests and impulse responses were used to model the short-run interdependencies. As with Oikarinen (2007), the Granger-causality VAR model was based on the Vector Error Correction (VEC) model to account for the possibility that the short-run dynamics work through the long-run equilibrium (Yunus 2012, 138).

The results showed that in the economies of well-developed and mature REIT structures with high market capitalization (e.g. US, UK) more cointegrating vectors exist between the securitized real estate, stock market and macroeconomic variables than in the less matured markets such as Germany or Italy (Yunus 2012, 141). According to this we would expect to find only a few cointegrating vectors in the Finnish markets with similar variables as well. Moreover, the existence of cointegrating vectors means that the diversification possibilities are limited in the long-run.

The Granger-causality tests indicate that for all the markets the causality runs from macroeconomic and stock variables to property markets through the short-run dynamics as well as through the long-run equilibriums. The impulse response functions show that, generally, shocks to the stock market, GDP, money supply and inflation cause a positive and temporary effect in listed property market returns, while interest rate changes cause a negative and temporary effect. (Yunus 2012, 142)

The study by Yunus (2012) shows that that macroeconomic control variables are useful in the market dynamics estimation, since it was established that the causality runs through them consistently in all the markets and helps to find more cointegrating vectors. For example, Chen (2001, 220) is unable to find cointegration between housing and stock market in Taiwan and one reason may be that he works with a bivariate system that does not include any macroeconomic factors. However, Yunus (2012) did not report whether cointegrating vectors were found in a bivariate listed property and stock market setting. Moreover, while exclusion tests were performed, no weak exogeneity of variables was tested. This would have provided additional information about which variables do not adjust to the long-run equilibrium.

Either long- or short-term causality has been found to be due to wealth and credit-price effects. Wealth effect theory suggests that rising stock market prices increase consumption and encourage real estate purchases. In addition, the rising stock prices generate the need to re-balance investment portfolios by buying more real estate (Kapopoulos & Siokis 2005, 126). Evidence on wealth and credit-price effects is more thoroughly discussed in the next subsection.

2.3.1. Wealth effect and credit-price effect

Positive short-term causality between real estate and stock markets can be explained with wealth and credit-price effects. Generally, the wealth effect means that the aggregate consumption increases when the current and total wealth of individuals increases. The total wealth here is defined as the present value of all future financial, real and human wealth (Kapopoulos & Siokis 2005, 126). Thus, an increase either in the financial assets or in property assets increases an individual's consumption (Case et al. 2005, 26).

The wealth effect affecting investment decisions has also been recognized, and in the literature the causality from stock market price increases to real estate price increases is called the wealth effect and the causality from real estate to stock markets is named as the credit-price effect. To be accurate, causality in this context is usually defined as Granger-causality, which means that current and past observations of one time series are significant in explaining the fluctuation of another time series (Granger 1969, 428).

As housing is both a consumption good and an investment asset, the wealth effect of stock market on housing can appear through the consumption aspect of housing as well as through the investment aspect. According to the modern portfolio theory, an investor aims to maximize the expected return of his portfolio with a chosen risk level, or alternatively, minimize the risk with a chosen return level by allocating his funds on different assets and thus diversifying the portfolio (Markowitz 1952). Hence, because of the portfolio allocation and re-weighting mechanism, when stock market prices increase, the investor should either sell the shares or increase the portion of real estate in his portfolio. In practice such rebalancing is not always possible for small investors because of the special features of real estate assets discussed previously.

The credit-price effect works through the collateral value of real estate assets. When real estate prices rise, it increases the collateral value of real estate for individuals and firms alike, and stimulates the economy through the wealth effect on consumption. In the economic upturn especially the credit constrained firms are able to borrow at lower cost because of the higher collateral values of their real estate. In addition, the availability of financing for firms and individuals increase, feeding investments and the economic upturn and bidding equity prices higher. Moreover, as the property and land values in companies' balance sheets increase, the expected profits from selling those assets increase, driving up the equity prices. In the economic upturn the higher demand for land and properties further increase the real estate prices. (Chen 2001, 217-218; Kapopoulos & Siokis 2005, 126)

Okunev, Wilson & Zurbruegg (2000) studied the causal relationship in the US between REIT and stock markets during 1972-1998. They found significant unidirectional linear causality running from REIT to stock markets, indicating credit-price effect. However, when a structural break was taken into account and the data divided into two subsamples, the results showed that after the structural break the stock markets caused changes in REIT prices. The non-linear causality tests confirmed the causality from stocks to REITs. Still, because the relationship is non-linear, it is very difficult to forecast REIT returns from stock returns even though the lag time is known (Okunev et al. 2000, 260).

Chen (2001, 218-220) examines the Granger-causality in the Taiwanese residential housing and stock markets in Q3/1973-Q1/1992. It was found that the stock prices Granger-cause housing prices. First of all, the cross correlation statistics show that the lags of stock prices have consistently higher correlation with contemporaneous housing prices than vice versa. Then the bivariate vector autoregressions were estimated and the results showed that lagged stock and housing prices are significant in explaining contemporaneous housing prices but the stock prices are only explained by their own lagged values. By dividing the sample into two sub-sets based on observed housing market cycles, the robustness of the results strengthened.

The variance decomposition and impulse response functions detailed the causality results showing that over 50 % of housing price forecast error variance was due to shocks in stock prices by the fifth quarter from the shock. However, shocks in housing prices never accounted for more than 3 % of stock price forecast variance. Impulse responses showed that while the magnitudes of housing price responses to stock market shocks were similar to the stock price responses to housing shocks, the persistency of housing price responses to shocks was up to three times longer than the stock market responses (Chen 2001, 221). The persistence of the shock effects in the housing market is probably due to the sluggish response of construction projects to changes in the economic conditions due the long construction time of the buildings, since the housing index is mainly represented by the to-be-constructed housing prices. Finally, the Granger-causality F-tests showed that stock market Granger-caused housing markets but not the other way around. The results thus indicate the wealth effect, or uni-directional causality from stocks to housing market.

Similar findings are presented by Kapopoulos and Siokis (2005, 127). They examine the causality of the Greek housing and stock markets with quarterly data from Q1/1993 to Q2/2003. The housing market was divided into the capital city area (Athens) and the rest of country regions. Like Chen (2001), they also found that the cross-correlations between the contemporaneous housing and lagged stock prices are higher than the other way around, indicating that stock markets lead the housing markets.

The Granger-causality tests showed that housing markets did not cause stock price movements. Stock prices Granger-caused Athens house price movements but not the other urban areas' house prices (Kapopoulos & Siokis 2005, 128). The results point lightly toward the wealth effect theory. However, the authors conclude that as the stock holdings were not very wide-spread during the sample period and stock market increase was not independent of discount rate changes, the result points more toward the portfolio re-allocation mechanism in the Athens Metropolitan area (Kapopoulos & Siokis 2005, 128).

Sim & Chang (2006, 106-108) studied the Korean real estate and stock markets and found evidence for credit-price effect. Their data consists of price weighted Korean Stock Index, appraisal-based regional house price indices from Q1/1986 to Q1/2005 and land prices divided by region and type from Q1/1987-Q1/2005. In addition, macroeconomic control variables, namely GDP and a three-year corporate bond yield were used.

Stationarity of the variables was tested with Phillips-Perron test, which showed varying stationarity results for different regional house price and land price variables. No other stationarity tests, such as ADF or KPSS tests were employed to confirm, for example some weak stationarity results. Johansen cointegration test found no evidence of cointegration. Thus, a VAR model with stationary variables was used. (Sim & Chang 2006, 108)

Granger-causality tests implied that for the southern regional area as well as for the metropolitan and mid-sized cities house prices caused stock prices, whereas for the northern regional area no causality was found in either direction (Sim & Chang 2006, 110). This result has some similarities to the results by Kapopoulos & Siokis (2005) in the sense that in the metropolitan and more economically powerful regional area causality may be found between stocks and real estate. It should be noted, though, that the evidence for causality runs in opposite directions in these two studies. Causality from most of the land price indices to stock markets was also found while no causality to the oppose direction was evident. These results support the credit-price effect, though the authors remind that as the stock ownership was not as popular in Korea as it was in other developed countries, and because Korean firms traditionally invest heavily in real estate the results may differ from studies made in other markets (Sim & Chang 2006, 110).

The variance decompositions show that most of the shocks in real estate prices have been absorbed in stock prices by the fifth quarter, as was the case in Chen (2001), though the direction of shocks was the opposite. In mid-sized cities up to 25

% of stock market variance is due to shocks in house prices. The land price indices showed that there may be substantial differences between different sectors. In the rural areas almost 37 % of stock variance was explained by commercial real estate, whereas the industrial sector's effect on stock price variance was 23 %. Residential real estate accounted approximately 20 % of stock variance in different areas and sectors, except in the rural areas where residential real estate land prices explain nearly 34 % of stock variance. In general, commercial and industrial real estate have bigger impacts on stock market variance than residential real estate. (Sim & Chang 2006, 113)

The generalized impulse responses reveal that shocks to housing prices cause positive responses in stock prices, and the response generally lasts up to four quarters. For some areas, eventual negative impact on stock prices is also found. The cumulative impulse responses show a longer impact time on stock prices for industrial sector than for residential or commercial sectors. (Sim & Chang 2006, 114-116)

Liu & Su (2010) examined the wealth and credit-price effects in the Chinese stock and real estate markets in the period 1/1996-10/2008. Adopting asymmetrical threshold cointegration tests, they found that the direction of causality varies over time. In the short-run, the wealth effect is supported, but in the long-run and in presence of a cointegrating vector, both effects became evident when a certain threshold level was recognized (Liu & Su 2010, 1741).

Traditional linear cointegraiton tests may fail to find the cointegrating vector(s) if the adjustment process toward the cointegrating equilibrium is asymmetric instead of linear (Enders & Siklos 2001, 175). Liu & Su (2010, 1745) use both linear Engle-Granger cointegration model and the Momentum Threshold Autoregressive (M-TAR) model and find that the asymmetric threshold model is better suited for the adjustment mechanisms in the Chinese markets since both cointegration and asymmetric adjustment to cointegrating equilibrium were found.

Because a cointegrating vector was found, the equilibrium error term was added to the Granger-causality tests. In the short-run, unidirectional causality from stock markets to real estate, i.e. wealth effect was evident. However, in the long-run it depends on a certain threshold level which market adjusts more to the long-run relationship. (Liu & Su 2010, 1747)

A recent working paper study by Bouchouicha (2013) also uses the M-TAR model to account for the asymmetric adjustment of the variables to examine the wealth and credit-price effects in UK and US real estate and stock markets in 1/1987 – 10/2012. In addition, Markov switching (MS) models, which take into account the differentiating means and variances during growth and recession cycles, are used (Bouchouicha 2013, 8-9). With these models it is possible to examine the causality effects in economic booms and busts and to see whether one effect is more dominant than the other in different economic states. For example, it is hypothesized that wealth effect is more pronounced during a growth cycle because the rising stock prices would lead to increased real estate investments through portfolio reallocation (Bouchouicha 2013, 18-19). However, no significant evidence for wealth effect was found. The results show that in the US higher returns in the housing markets reduce the probability of increasing stock market returns in the following month, indicating negative credit-price effect. The effect turns positive with a two month lag, i.e. higher returns in housing markets increase the probability of rising stock prices in the following two months. In the UK the housing market contains more information about the rising stock prices, indicating positive credit-price effect. (Bouchouicha 2013, 20, 23-24)

When REIT indices are used as the real estate proxy, the results indicate that in the US expanding REIT markets increase the probability of rising stock markets and decrease the probability of stock market recession, whereas in the UK the rising REIT market increases the probability of recession in the stock markets in the following month (Bouchouicha 2013, 20). Thus, in the US the securitized real estate markets move in the same direction as stock markets, whereas direct real estate (housing) moves in the opposite direction with one month lag. With higher lags the credit-price effect turns positive for both direct and securitized real estate markets. This might be due to the slugged adjustment and appraisal based valuation problems in the housing index. The effect could also be explained by the fact that the REIT index is not divided into sectors and thus the results of different portfolio reallocation strategies based on sector level differences mix up in the REIT index performance. The MS model results are confirmed with M-TAR results, which show that in the US higher REIT prices lead to higher stock prices and in the UK higher REIT prices lead to lower stock prices. It is argued that the UK investors are more inclined to buy more real estate and less stocks when real estate prices rise while in the US higher real estate prices encourage to invest more in stocks (Bouchouicha 2013, 22).

Regarding the articles reviewed in this subsection, it seems that positive causal relationship between real estate and stock markets may depend on the regional differences in real estate markets, macroeconomic control variables and the time horizon of the investment. In addition, acquiring similar performance between direct and securitized real estate may require the use of sector level data.

2.4. The relationship between securitized and direct real estate

Barkham & Geltner (1996, 48-50) investigate the linkages in the performance of a securitized residential real estate company and a housing price index in the UK. While the selected listed company has a regionally diversified real estate portfolio, the results of the study may still be affected by the fact that only one company's performance is regarded as a proxy for the listed market's performance.

The results indicate that the direct housing market incorporated significant autocorrelation and was thus informationally inefficient. The Granger-causality tests found that the securitized market lead the housing market by two months and due to an annual seasonality cycle the effect was echoed again after 14 months while no causality running in the opposite direction was found. Moreover, Johansen cointegration tests indicated a cointegrating vector between the series. However, no control variables were used and the weak exogeneity or the exclusion of variables was not tested in the cointegration calculations. (Barkham & Geltner 1996, 53-54, 57-58)

Devaney et al. (2013, 18) study how well the direct and listed real estate markets are connected in the US and in six European countries. This is done by comparing the capital returns and investigating how tightly the business cycles of the markets are connected. Their study incorporates appraisal based indices (ABI) as well as transaction based indices (TBI) of direct real estate. While the ABIs have significant autocorrelation due to the sluggish adjustment and updating of the series, the TBIs behave more like the weak-form efficient listed real estate indices which have no significant autocorrelation (Devaney et al. 2013, 12).

The results of Devaney et al. (2013) indicate that there exists long-term interrelationships between direct and listed real estate markets and in several cases the securitized market leads the underlying direct market regardless of the index type used for the direct market. In addition, despite the more severe autocorrelation problems of the ABIs, both direct market index types behave in similar manner in terms of correlations and business cycle phases (Devaney et al. 2013, 18). This suggests that the invalidity of the research results is not a concern even if only appraisal based indices are available when the aim is not to study capital returns and volatilities, but to concentrate on long-term interdependencies.

He (2000, 366-367) researched the causal relationships of listed and direct real estate in the US markets and found contradicting results to Devaney et al. (2013). His study used an apartment REIT index consisting of several residential real estate companies contradicting to Barkham & Geltner's (1996) listed real estate variable that was constructed from the performance of one company. A transaction based house price index was used as the direct market variable. The data frequency is monthly but covers only the 1994-1997 period. He (2000, 367-368) reports that the series were significantly cointegrated according to the Dickey-Fuller test. An issue with this result might be that no control variables were used and the exclusion or weak exogeneity of the variables was not tested. Also, the time span of four years is short compared to what is usually employed in the cointegration analyses. The results indicate only a weak existence of causality from listed to direct market (i.e. wealth effect) with one month lag. However, evidence of causality running from home prices to listed market (credit-price effect) with one and two month lags was highly significant. A significant contemporaneous causality between housing and REIT prices was found. Such causality is argued to be due to interest rate changes that affect both markets simultaneously. (He 2000, 368-369)

Li, Mooradian & Yang (2009, 95) incorporated VAR and Autoregressive Conditional Heteroskedasticity (ARCH) models to examine Granger-causality and information transmission between a commercial unsecuritized (NCREIF) and a securitized real estate (NAREIT) index. Their data runs from Q4/1977 to Q4/2001 and they also use several macroeconomic control variables, such as GDP, effective rate on federal funds and credit spread between BAA rated bonds and 10-year Treasury bonds. The causality tests revealed that the listed market leads the direct market but not vice versa which supports the wealth effect hypothesis. The ARCH test showed that the direct market receives information from the listed market, supporting the assumption that the listed market is informationally more efficient (Li et al. 2009, 113).

A deficiency of Li et al. (2009) is the lack of long-term interdependency tests. Oikarinen, Hoesli & Serrano (2011, 74-75) extend the research of Li et al. (2009) by studying the US listed and direct real estate markets incorporating the Johansen cointegration tests and using a transactions-based NCREIF index. Their data also covers a longer period, from Q4/1977-Q4/2008. Their main findings suggest tight long-term relationship between the NCREIF and NAREIT indices and no cointegration between either of real estate indices and stock market, which indicates that the listed and direct market would be substitutes in a multi-asset portfolio due to the similar diversification properties over a very long time period. The results also support the higher efficiency of the listed market, since only the direct market adjusts to the long-run equilibrium. The speed of adjustment is found to be 3 % to 4 % per quarter. The causality tests indicate that after 1991 the causality has run from listed to direct market, regardless of the valuation method of the direct market index. This result, added to the found long-run equilibrium, means that the performance of the listed market cannot be predicted from the direct market performance, whereas the opposite is possible. (Oikarinen et al. 2011, 88-95)

Hoesli & Oikarinen (2012) further extend the study by Oikarinen et al. (2011) by dividing the securitized and direct real estate data into sector level variables: apartments, offices, industrial and retail. Beside the US markets, they also study the UK markets at the sector level, as well as the Australian market at the overall level. Using Johansen cointegration tests, impulse response and variance decomposition analyses they show that in most markets inspected, a cointegrating vector between stock market and direct and securitized real estate markets is found. However, the stock market can be excluded from these linkages, making the cointegrating vector a pairwise linkage between direct and securitized real estate. In the Australian market, no pairwise cointegration is found, which is suspected to be caused by the lack of sector level data. (Hoesli & Oikarinen 2012, 1831-1834)

The innovation accounting analysis indicates that the REIT sector is not driven by the direct real estate or stock markets. Still, the relationship between REIT and direct real estate is strong because a significant amount of the forecast error variance of direct real estate is due to shocks in REIT returns. Thus, if anything, REITs seem to lead the direct market. For the Australian market the analysis shows dependency of REIT to stock market, but the analysis is not very robust to the variance ordering of the orthogonalization method. (Hoesli & Oikarinen 2012, 1838-1840)

The results of Hoesli & Oikarinen (2012) indicate that sector level division of real estate data is important to help detect cointegrating relations. Moreover, the REIT industry in the US and UK is more mature than the Australian market since stronger interdependencies between the real estate indices were found, whereas the stock market did not have much effect on REITs in the causality analyses. Moreover, the results confirm the findings of other studies showing that securitized markets lead direct real estate.

3. Data

To study the dynamic linkages of real estate and stock markets, several asset variables as well as macroeconomic control variables are used in this thesis. All time series are quarterly and cover the period Q4/1992-Q3/2014. Following Oikarinen (2007, 277) the asset variables are all price indices from which the differenced return series are calculated. The price series are used to study the long-run linkages between assets while the return series are used in the short-run dynamics inspection. The variables and their abbreviations are listed below:

- Housing price index – Finland (H)
- Securitized real estate index – Finland all sectors (FRE)
- Securitized real estate index – European residential (EREIT)
- Stock market index (S)

- Inflation rate (CPI)
- Gross domestic product (GDP)
- Three-month Helibor/ Euribor (IR)
- Money Supply M1 (M1)

The variables are indexed to have the fourth quarter of 1992 as the base year. However, the IR is not indexed. The asset price variables, money supply and the interest rate variable are nominal by default and are deflated by the CPI. The GDP variable is in real terms and seasonally adjusted by default. Finally, the variables are transformed into logarithmic terms. Since the effect of inflation is indirectly being taken into account (Liow 2006, 372), each model includes at most six variables (three asset variables plus three macroeconomic control variables).

3.1. Real estate and financial asset variables

The direct real estate market in this thesis is depicted by the housing price index *H* constructed by Statistics Finland. The index tracks the prices of dwellings in old apartment buildings and terraced houses and includes different size dwellings from single- to multiple-room apartments (Statistics Finland 2014). While the housing indices are based on the Finnish Tax Administration's asset transfer tax calculations and thus are derived from transactions, a graphical examination reveals that the data seems to suffer to some extent from the smoothing effect familiar to appraisal based data (Figure 1).

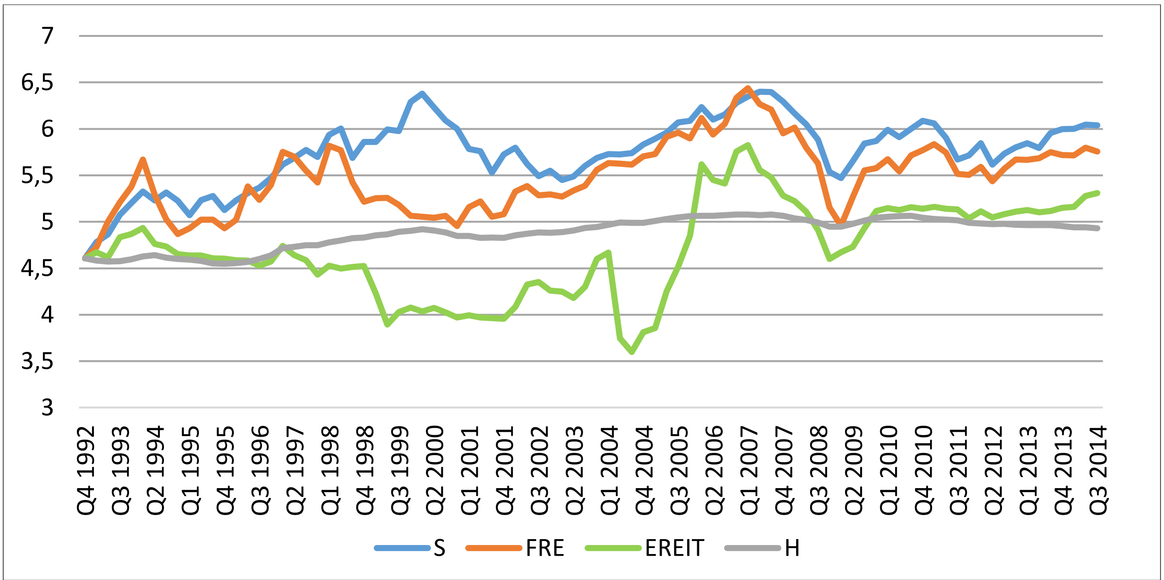

Figure 1. Logarithmic real indices of the asset variables

The securitized real estate is represented by two variables: *FRE* and *EREIT*. *FRE* is an index constructed by the European Public Real Estate Association (FTSE EPRA/NAREIT) and it tracks real estate investment, holding and development companies traded in the OMX Helsinki Stock Exchange. Hence, the index constitutes not only companies involved in the residential real estate business, but companies from other real estate sectors as well. Because of this, the direct market variable *H* which only tracks housing prices does not completely underlie the *FRE* variable. There are not enough real estate companies involved solely in the residential sector with a sufficient history in the OMX Helsinki Stock Exchange so that a residential real estate index could be calculated. In addition, Statistics Finland does not produce data of the unsecuritized commercial real estate market that would more accurately underlie the EPRA/NAREIT index. Such data is provided by a Finnish company KTI Kiinteistötieto Oy but it is only annual and available from 1998 onwards, making it unsuitable for the purpose of this thesis because of too few observation points.

The *EREIT* variable, provided by Datastream, is used as a proxy for securitized *residential* real estate market. The index constitutes of five European listed companies involved in the residential sector, which could render it a better representative of the housing market than an overall real estate variable. For example, Hoesli & Oikarinen (2012, 1834) showed that the sector level division of the real estate variables may help in finding a cointegrating relation. The downside of *EREIT* is that it does not include any Finnish companies and thus its relevance in depicting Finnish real estate market dynamics is limited.

Moreover, unlike most of the *FRE* constituents, the companies comprising *EREIT* are all juridically Real Estate Investment Trusts (REIT) which means that their rules dictate them to distribute the majority of the corrected profit as dividends (generally 80-90 % depending on each country's legislation) and they are also relieved from corporate tax (European Public Real Estate Association 2014). The absence of double taxation of REIT profits with the high dividend return rate may make the REITs' performance closer to the underlying direct market than the listed real estate companies that are not under REIT legislation.

Following Oikarinen (2007, 278) the OMX Helsinki CAP (OMXHCAP) index is used as the stock market variable. The OMXHCAP is a weighted index in which the maximum weight for a company is restricted to 10 % of the index. This limits the weight of large companies such as Nokia, which at its peak years accounted for 70 % of the OMX Helsinki (Oikarinen 2007, 278). Thus, the OMXHCAP captures the overall stock market development in Finland during the sample year better than an unrestricted index.

3.2. Macroeconomic variables

The macroeconomic control variables are presented in Figure 2. The gross domestic product measures the economic activity and has been shown to have significant effect on housing prices (Englund & Ioannides 1997, 133). In addition, Ewing & Payne (2005, 299) state that real output growth has significant influence on the securitized real estate market. The GDP is used as a macroeconomic variable in various cointegration studies regarding stock and real estate markets (e.g. Hoesli & Oikarinen 2012; Yunus 2012; Liow 2006).

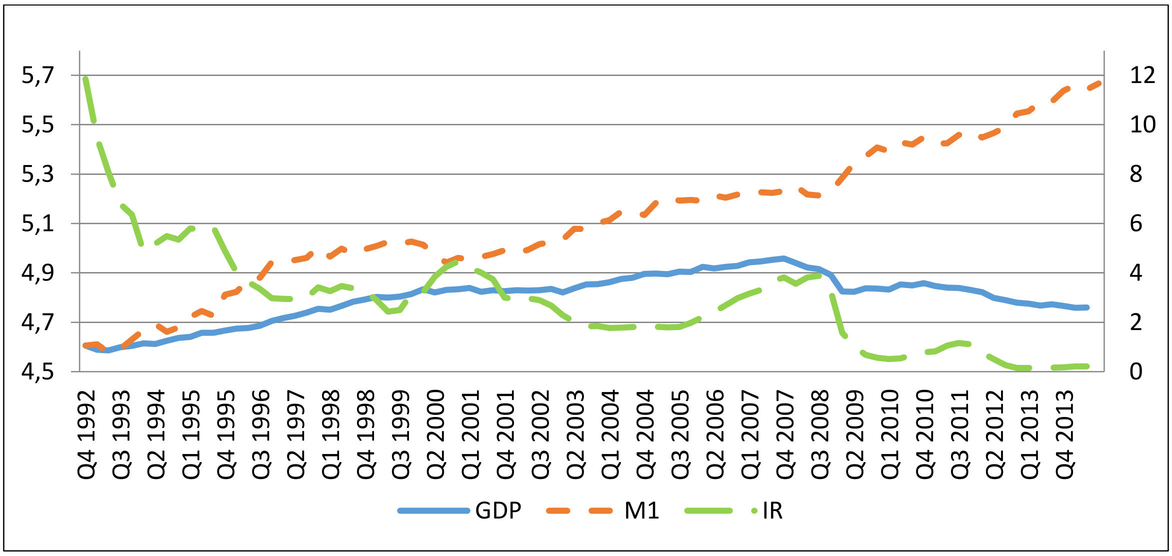

Figure 2. Macroeconomic control variables

* Left axis for GDP and M1, right axis for IR

The interest rate variable in this thesis is the three-month Helibor rate for the period Q4/1992-Q4/1998 and from there on a corresponding Euribor rate. Interest rates are used as a basis for the discount factors in the present value calculations of assets and thus a rise in the interest rates negatively affects the valuation of expected cash flows (Yunus 2012, 135). In addition, Ewing & Payne (2005, 294) state that at least in the short run the interest rate changes affect lending returns and borrowing costs, which would have an impact in the often highly leveraged real estate sector. According to McCue & Kling (1994, 284) interest rates explain significantly large proportion of equity REITs' returns.

There may be several ways in which money supply and asset markets are linked together. For example, increased money supply provides liquidity in the markets which can boost the economy as a whole and thus real estate prices as well. Increased money supply can also drive up the real estate markets by lowering interest rates which affect mortgage rates, or by leading to a portfolio shift from non-interest bearing money to financial assets. On the other hand, if money supply induces inflation uncertainty it may have a negative effect on asset prices. Moreover, as discussed above, the credit-price effect theory states that rising real estate prices increase the collateral value of those assets, which enables the banks to offer more loans to home owners and companies, driving the supply of money up. (Yunus 2012, 135; Greiber & Setzer 2007, 1)

Greiber & Setzer (2007, 25) showed that the housing price boom in US and euro area preceding the 2008 financial crisis was related to the loose monetary conditions. They also found out that while these monetary policy decisions were transmitted through interest rates to some extent, especially in the US the increased liquidity and hence asset inflation was more pronounced of the transmission channels.

In this study the money supply variable is represented by the contribution of Finland to the Euro area money supply statistic that is upheld by Bank of Finland. Money is defined as a narrow aggregate M1 which includes currency in circulation and overnight deposits.

4. Methodology

The methodology in this thesis follows Oikarinen (2007), Hoesli & Oikarinen (2012) and Yunus (2012). Oikarinen studied the long- and short-run linkages in the Finnish housing and stock markets while Yunus examined the securitized real estate and stock market cointegration in several markets. Finally, Hoesli & Oikarinen incorporated unlisted and listed real estate and stock market cointegration tests in their study. All these articles have used the Johansen cointegration tests for long-run dynamics inspection, and Oikarinen (2007) and Yunus (2012) have incorporated the Granger causality tests for short-run dynamics. Moreover, innovation accounting has been used in all the articles for robustness checks.

4.1. Stationarity

The concept of stationarity is important in a time series analysis. Studying the dynamic linkages of stock and real estate markets can be quite problematic with the basic Ordinary Least Squares (OLS) regression analysis because the price series of these two asset classes often suffer from non-stationarity. A stationary process has a constant mean, a constant variance and a constant autocovariances for each time *t*. Autocovariance measures the relatedness of a variable to its previous values, so a constant autocovariance means that the autocovariances do not depend on time *t*, but only on the time period *h* between two time points (Brooks 2014, 253; Lutkepohl 2005, 24). In other words, the covariance between y_t and y_{t-1} is the same as between y_{t-1} and y_{t-2}.

Non-stationarity violates these definitions and implies that the process has a trend. Non-stationarity is a problem because it may generate spurious regressions, which means that the regression results show relation between two variables that in reality do not have anything to do with each other. The seeming relation arises just because the two variables share a common (stochastic) trend. Another issue with non-stationarity is that an influence of a shock or an unexpected change to the system will not decay over time but has an infinite effect which is against intuition in many econometric cases. (Brooks 2014, 353-355)

A random walk with drift is a useful model to depict non-stationarity and the way to overcome it:

$$Y_t = \mu + Y_{t-1} + u_t \tag{1}$$

The equation states that the variable *Y* is a process of a constant drift term *μ*, the previous value of itself Y_{t-1} and an error term u_t. Subtracting Y_{t-1} from both sides we get:

$$Y_t - Y_{t-1} = \mu + u_t \tag{2}$$

$$\Delta Y_t = \mu + u_t \tag{3}$$

Now the process does not depend on the time *t* but only on the difference between two time periods and the new variable ΔY_t is stationary. By subtracting the previous value of *Y* in (2) we have differenced the series once. If a process achieves stationarity by differencing once, it is called to be integrated of order one [I(1)]. An I(1) process is said to have one unit root because the root of its characteristic equation is unity. (Brooks 2014, 357)

To measure for stationarity, unit root tests will be applied. The Augmented Dickey Fuller (ADF) test is used commonly (e.g. Glascock et al. 2000) and can be mathematically expressed as:

$$\Delta Y_t = \alpha + \beta Y_{t-1} + \sum_{k=1}^{n} a_k \Delta Y_{t-k} + e_t \tag{4}$$

Where ΔY_t is the change in stock/real estate price index and *α*, *β* and *a* are the parameters to be estimated, while *k* is the number of lags. The lags of the dependent variable are included in the left hand side to account for the possible autocorrelation of the dependent variable (Brooks 2014, 363). The *H0* is that unit root is present in the series, so the series is stationary if β is significantly different from zero (Brooks 2014, 361-362).

Additionally, A Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for unit root will be applied to confirm the results. While the PP test includes an automatic correction to the Dickey-Fuller procedure to allow for autocorrelated residuals, it usually gives similar results to ADF and suffers from low power in cases where the characteristic root is close but not equal to unity, especially when there is a low number of observations (Brooks 2014, 364). The KPSS tests for stationarity, i.e. the *H0* is that the series is stationary. All the variables will be tested for unit root (ADF, PP) and stationarity (KPSS) in levels and in first and second differences to make sure that at least two of the variables are of the same order $I(1)$, which is a requirement for the cointegration test (Yunus 2012, 136).

4.2. Vector Autoregression

This thesis uses VAR models and cointegrated VAR models to study dynamic linkages between stock and real estate markets. VAR models allow for a variable to depend on its own past and contemporaneous values as well as other variables' lagged and present values. Moreover, VAR does not require identification of variables as endogenous or exogenous, since all the variables are treated as endogenous by the structure of the model. Sims (1980, 1) argued that the identification procedure in other types of multivariate time series models is often done inappropriately in a way that may not follow economic theory.

A general VAR model used in this study can be presented as follows:

$$\underset{p\,x\,1}{Y_t} = \underset{p\,x\,1}{\mu} + \underset{p\,x\,p}{\beta_1}\underset{p\,x\,1}{Y_{t-1}} + \cdots + \underset{p\,x\,p}{\beta_k}\underset{p\,x\,1}{Y_{t-k}} + \underset{p\,x\,1}{e_t} \tag{5}$$

Where p is the number of variables used in an equation, k is the number of lags incorporated, Y_t is a matrix of the variables, μ is a matrix of the intercept terms, β_1... β_k are the coefficient matrices of the lagged values and e_t is a matrix of the error terms. Following Oikarinen (2007), the appropriate lag k is estimated by the multivariate version of the Hannan-Quinn (HQ) information criterion.

4.2.1. Granger-Causality

Granger-causality (GC) tests are used to investigate short-run dynamics and causal relationships. A definition of Granger-causality is that a variable *X* Granger-causes *Y* if the inclusion of past values of *X* gives better forecasts of *Y* than the exclusion of *X*'s past values. In other words, When *X* Granger causes *Y*, it does not necessarily mean that *X* causes *Y* but that the past values of *X* have significance in explaining the future values of *Y* (Brooks 2014, 348; Oikarinen 2007, 285). Since GC tests are done by applying VAR models, the variables used need to be stationary (Hill et al. 2012, 498). To achieve this, the variables are first differenced. The differencing process eliminates the long-run dynamics information. Hence, only short-run interrelationships are examined. However, as the short-run dynamics between the variables can run also through the long-run cointegrated vector, the equilibrium-error is also added to the GC test *if* such relationship is found (Oikarinen 2007, 285):

$$\Delta Y_t = \mu + \sum_{j=1}^{n} \Gamma_j \, \Delta Y_{t-j} + EQE_{t-1} + D_t + e_t \tag{6}$$

Where Γ_j is a matrix of the lagged value coefficients, D_t is a matrix of centered seasonal dummies and EQE_{t-1} is a matrix of the lagged long-run equilibrium-errors. Centered seasonal dummies differ from regular dummies in a way that for quarterly series they get values of 0.75 in the relevant quarter and -0.25 otherwise, instead of one or zero. Thus, the sum of the dummy values is zero. According to Johansen (1995, 84) the inclusion of centered seasonal dummies does not influence the critical values. Moreover, Johansen (1991, 1561) states that seasonal dummies constructed like this do not contribute to a possible linear trend in the equation. The multivariate Granger-causality test provides with a Chi-squared (Wald) statistic that measures whether the lagged coefficients of $Y_2 \ldots Y_i$ have predictive power on Y_1 (Quantitative Micro Software 2010, 463). To be accurate, the GC test is actually a non-causality test since the *H0* assumes no linear causality.

4.3. Cointegration and error correction

The concept of cointegration is important when investigating the dynamic relationships between assets. Granger (1986, 213) states that in the long-run “certain pairs of economic variables should not diverge far from each other”, even if in the short run they drift apart. Engle & Granger (1987, 251) state that two variables (x_t, y_t) are said to be linearly cointegrated of order (d, b), $b > 0$ when the two variables are non-stationary in levels but stationary in first differences and there is a linear combination of the variables that is stationary in levels, i.e. $z_t \sim I(d - b)$. Moreover, Johansen (2000, 361) states that in a multivariate system the lack of stationarity may be caused by common stochastic trends, which can be eliminated with appropriate linear combinations of the process. Like the vast majority of the literature reviewed in this thesis that study equity and asset price linkages (e.g. Oikarinen & Hoesli 2012, Oikarinen 2007), this thesis too will concentrate on the case where $d = b = 1$ so that the variables are cointegrated of order (1,1) and the linear combination of the variables z_t, or cointegrating vector will be $I(0)$.

As told above, in a cointegrated process the variables need to be “bounded” to the cointegrating equilibrium in a long-run time period only. This means that the adjustments to the equilibrium may not happen very quickly and that only some portion of a period’s disequilibrium will be corrected in the next period (Engle &

Granger 1987, 254). Thus, the changes of a variable in an error correction model depend on the deviations from an equilibrium relation (Lutkepohl 2005, 246). In a case of housing and equity assets, a reason for sluggish adjustment or error correction may be the inefficiency of the housing market caused by informational asymmetries, transaction costs or irrational investor behavior (Oikarinen 2007, 73). A Vector Error Correction (VEC) model is a restricted VAR model where the long-run dynamics of the endogenous variables are restricted to converge to their cointegrating relationships while allowing for short-run adjustments.

A simple formulation of a VEC model can be presented as follows. Consider a two variable system, let y_t and x_t be $I(1)$ and their equilibrium or cointegrating equation is given by

$$y_t = \beta x_t + e_t \tag{7}$$

Let the changes of y_t depend on the deviations from this equilibrium in the previous period *t-1*. The vector error correction model will be

$$\Delta y_t = \alpha_1 (y_{t-1} - \beta_1 x_{t-1}) + e_t$$

$$\Delta x_t = \alpha_2 (y_{t-1} - \beta_1 x_{t-1}) + e_t \tag{8}$$

The right hand side for both equations is the same error correction term, or the same cointegrating relationship $y_{t-1} - \beta_1 x_{t-1}$. The beta is the long-run cointegrating coefficient and the alphas can be interpreted as adjustment parameters that measure the proportion of last period's disequilibrium that is corrected for in this period. From Equation (8) it can be seen that in order to achieve the form of Equation (7) the adjustment parameter should be negative in sign and also less than unity to achieve error correction instead of error magnification. The model can also be introduced with intercepts and/or trend terms in the error correction term or in the model or in both. In addition, lagged and contemporaneous difference terms of the variables can be added to the model to account for short run dynamics. (Brooks 2014, 375-376; Lutkepohl 2005, 246)

4.3.1. Johansen's Vector Error Correction Model

Johansen's (1991, 1552-1553) test for cointegration can be utilized by turning an appropriate VAR model (Equation 5) into a vector error correction model:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta Y_{t-i} + e_t \qquad (9)$$

where Y_t is a p-dimensional vector of the stochastic variables, Γ_i are $p \times p$ coefficient matrices of the lagged differences of the stochastic variables at lag i which account for the short term dynamics, e_t is a p-dimensional vector of independent and identically distributed (i.i.d.) errors and k is the number of lags in the corresponding VAR in levels. Hence, if the optimal lag level for the corresponding VAR in levels is 2, in the VEC model a lag of 1 is used since the lagged terms of the model are differenced. The test concentrates on the Π matrix, which accounts for the long-run dynamics of the process. The Π matrix can also be presented as $\Pi = \alpha\beta'$ where α is a vector of adjustment parameters and β represents the cointegrating vector(s). Both vectors are $p \times r$ matrices.

Intuitively, there can be $p - 1$ cointegrating vectors at most between the p variables of a cointegrated process. According to Oikarinen (2007, 67) the rank r of the Π matrix determines the number of cointegrating vectors in the model. The variables are stationary if Π is a full rank $p \times r$, ($p = r$) matrix. If $r = 0$ there is no cointegration present in the process. When the rank of the Π matrix is $0 < r < p$, the variables are cointegrated.

According to Brooks (2014, 387) the rank of Π matrix is equal to the number of its characteristic roots, or eigenvalues (denoted λ_i) that are significantly different from zero. Two test statistics exist for determining the rank in the Johansen cointegration method, the Trace and Maximum Eigenvalue statistics. Lutkepohl, Saikkonen & Trenkler (2000, 305) prefer the trace test and state that there are situations where the trace test has superior performance. Thus, in this thesis only the trace test statistics are reported in the results, and in case of contradictory results the trace test is preferred. The equations for the statistics are given by:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{n}\ln(1-\lambda_i) \tag{10}$$

$$\lambda_{max}(r, r+1) = -T\ln(1-\lambda_{r+i}) \tag{11}$$

where T is the number of usable observations, *λs* are the estimated eigenvalues of the Π matrix. The null hypothesis of the Trace statistic is that the number of cointegrating vectors is less than or equal to r against the alternative that there are more than r cointegrating vectors. If the test statistic is greater than a critical value, the null hypothesis of r cointegrating vectors is rejected in favor of the alternative that there are more than r cointegrating vectors (Brooks 2014, 388). The value of r is increased until the null cannot be rejected. The null of the Max test is that the number of cointegrating vectors is r against the alternative of $r + 1$. MacKinnon-Haug-Michelis (MHM) p-values provided by Eviews are used as critical values for both tests.

The model in Equation 9 is a simplistic VECM and it can be modified by adding drift and trend terms in the short- and long-run sections of the model. Oikarinen (2007, 69) suggests that a trend term in the cointegrating section of the model is needed if the growth rates of the variables differ from each other, which seems to be the case when inspecting the graphs in Figure 1. Moreover, when imposing a trend term in the cointegrating equation, Eviews also imposes a constant, or a drift term in the short-run section of the equation, accounting for a linear trend in the level of the data. Thus, the model used in the empirical tests is

$$\Delta Y_t = \alpha(\beta', \beta_1)(Y'_{t-1}, t) + \sum_{i=1}^{k-1}\Gamma_i\,\Delta Y_{t-i} + \mu + \Phi D_t + e_t \tag{12}$$

Where t is the linear time trend and β_1 its coefficient, μ is the drift term and D is the three-dimensional matrix of centered seasonal dummies.

If a long-run interdependence is found between several variables, it will be of interest to analyze whether some variables can be excluded from the cointegrating relation(s). This is done by imposing restrictions on the beta parameters, i.e. setting a variable's beta to zero. Then the restricted model will be tested for significance with a likelihood ratio (LR) test. Additionally, restrictions can be put to the speed of adjustment parameters. By restricting a variable's alpha to zero, it is assumed that the variable does not adjust to the long-run equilibrium and such a variable could be called weakly exogenous (Harbo et al. 1998, 389). In essence, since the null for the restriction tests is that α, $\beta = 0$, rejecting the null in the LR-test means that the restrictions are not binding.

4.4. Innovation accounting

To check the robustness of the Granger-causality tests, impulse response and forecast error variance decompositions will be analyzed. Impulse response analysis shows how a variable reacts to an impulse in another variable in the VAR system (Brooks 2014, 336). If a variable y_2 reacts to a shock in variable y_1, it can be said that y_1 causes y_2, at least in the Granger-causality sense (Lutkepohl 2005, 51). Thus, impulse response analysis complements Granger-causality tests by indicating the direction of the causality, i.e. whether the lagged values of y_1 have a positive or negative effect on y_2. It also indicates the length of time within which a shock in y_1 has an effect on y_2. Hoesli & Oikarinen (2012, 1829) state that two assets are good substitutes if their reaction or relative reaction magnitudes to shocks are similar.

Impulse responses are generated by applying a unit shock to an error term of a variable in the VAR system. Brooks (2014, 336-337) illustrates the operation of impulse responses by representing a VAR (1) as a vector moving average (VMA). Consider a VAR:

$$y_t = A_1 y_{t-1} + u_t \tag{13}$$

where $A_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix}$

The VAR in a matrix form:

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-2} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix} \tag{14}$$

Consider a unit shock to $y_{1,t}$ at $t = 0$

$$y_0 = \begin{bmatrix} u_{1,0} \\ u_{2,0} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \tag{15}$$

$$y_1 = A_1 y_0 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} \tag{16}$$

$$y_2 = A_1 y_1 = \begin{bmatrix} 0.5 & 0.3 \\ 0.0 & 0.2 \end{bmatrix} \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.25 \\ 0 \end{bmatrix} \tag{17}$$

and so on. Now the effects of a unit shock in $y_{1,t}$ would be possible to plot in a graph. Since the VAR system is stable, the effect of a unit shock gradually fades away. Because the variables used in this thesis are not all in the same scale, it is useful to apply one standard deviation shock to the error term instead of a unit shock (Lutkepohl 2005, 53).

A shock in one variable in the VAR system has a direct effect on the variable itself, but also on the other variables in the system due to the dynamic and interdependent structure of the VAR. Forecast error variance decompositions show how much of an h-step-ahead forecast error variance is explained by the variables' own shocks and how much is due to shocks in other variables (Brooks 2014, 337; Lutkepohl 2005, 64).

In the impulse response example above it was estimated that the error terms of y_1 and y_2 were uncorrelated since a unit shock in one error term did not change the other. In practice, due to the dynamic nature of the VAR system, the error terms are likely to be somewhat correlated too. In order to account for this, an orthogonalisation is done for the impulse responses and variance decompositions. This means that the variables are set in a specific order and the impulse responses or variance decompositions are estimated in that order. Conforming to the methodology of Hoesli & Oikarinen (2012, 1836) the orthogonalisation method is the Cholesky decomposition and the ordering of variables is: money supply - GDP - interest rate - stock market - REIT - housing. Money supply is put first since it is assumed that a shock in Euro area money supply affects all other variables, including the GDP of Finland. Stock market comes before the securitized real estate since the REIT sector is a subsection of the stock market. Finally, housing is placed last because it is assumed to be the most sluggishly adjusting and informationally inefficient among the asset variables. However, not all the variables are used simultaneously in the equations. Also, different orderings of the variables are tested to see whether the results change.

5. Empirical results

In this section the results of the econometric models are discussed. First, some descriptive statistics and correlation of the variables are evaluated. Next, the unit root tests are performed to verify the non-stationarity of the price series. Then the Johansen cointegration method is used to reveal the long-run linkages of the variables, and the short-run linkages are modeled with multivariate Granger-causality tests. Finally, for robustness checks, impulse responses and variance decomposition analyses are incorporated.

5.1. Descriptive statistics and correlation analysis

The descriptive statistics presented in Table 1 are calculated from the differenced and deflated quarterly price series for the full sample of Q4/1992-Q3/2014. The mean and standard deviation are annualized by using the following formulae:

$$r_{annual} = (1 + r_{quarterly})^4 - 1 \tag{18}$$

$$\sigma_{annual} = \sigma_{quarterly} * \sqrt{4} \tag{19}$$

Table 1. Descriptive statistics of the differenced real price series

Variable	Mean (annualized)	Std. Dev. (annualized)	Kurtosis	Skewness	Jarque-Bera (p-value)
H	0,015	0,039	1,746	0,462	0,002
FRE	0,054	0,336	0,296	-0,157	0,776
EREIT	0,033	0,374	9,217	-0,570	0,000
S	0,068	0,261	0,017	-0,579	0,095
GDP	0,007	0,025	8,825	-1,994	0,000
IR	-0,440	0,963	6,454	-2,157	0,000
M1	0,050	0,050	0,108	0,125	0,894

The average returns of the asset series show that an average annual return in housing market has been 1,5 %, while the stock market has provided an annual return of 6,8 % during the sample period. Moreover, the Finnish securitized real estate sector has generated lower returns than the overall stock market but has had higher volatility. This makes sense since the *FRE* is a subset of the overall OMXH-index and thus the unsystematic risk in the subset market should be higher. In addition, the European residential REIT variable indicates even lower annual returns and higher risk than the Finnish securitized real estate variable. This may partly be because the firms in *EREIT* belong to one real estate sector only, whereas *FRE* constitutes from companies involved in various real estate sectors.

The Jarque-Bera test statistic is used to estimate the normality of the series. In most cases the null of normal distribution is rejected. For example, the European residential REIT variable *EREIT* suffers from excess kurtosis and is somewhat skewed to the left. The housing variable *H* is not normally distributed. However, *FRE* is normally distributed, as is the stock market variable *S* at the 5 % significance level.

Table 2 shows the correlation coefficients of the return series. All the correlations between the asset variables are significant at conventional significance levels. Table 2 shows that the correlation between housing and stock market returns has been only 0,36 (at 1 % significance) during the sample period, whereas the correlation between the Finnish listed real estate and stock returns has naturally been higher, at 0,59 (at 1 % significance).

Table 2. Correlation coefficient of the differenced real price series

	S	**H**	**FRE**	**EREIT**	**GDP**	**IR**	**M1**
S	1						
H	**0,36****	1					
FRE	**0,59****	**0,40****	1				
EREIT	**0,29****	**0,22***	**0,43****	1			
GDP	**0,28****	**0,38****	0,17	0,08	1		
IR	-0,17	-0,03	**-0,23***	-0,02	**0,31****	1	
M1	-0,02	0,15	-0,01	-0,09	-0,03	**-0,02***	1

*/** stand for 5/1 % significance, respectively

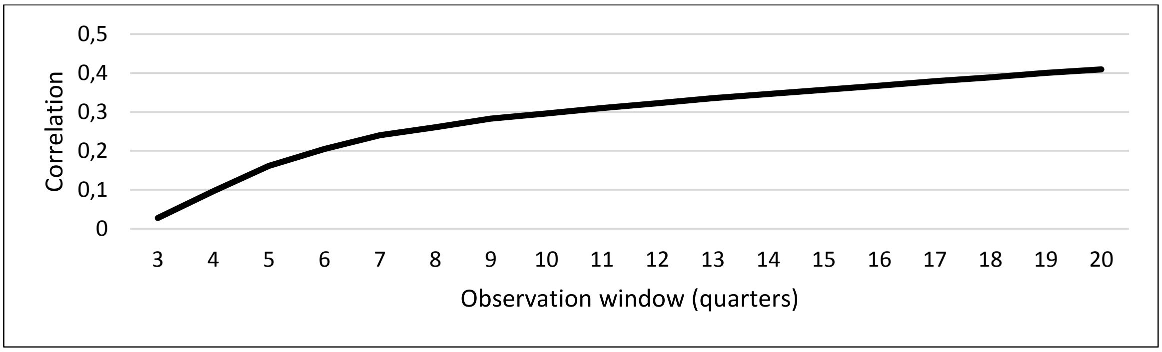

Figure 3. Correlation between housing and stock market returns

Figure 3 shows the correlation between housing and stock market returns as the observation window is increased. The figure particularly indicates that the shorter the observation window, the lower the perceived correlation. Since using the differenced asset price series produces low correlations as witnessed in the extant literature, it is of interest to study the non-differenced price series to examine the effects of long-run dynamics.

5.2. Unit root testing

The unit root test results are provided in Table 3. In general, all the variables are non-stationary in levels and stationary in first differences with conventional significance levels and thus usable for Johansen cointegration tests. For all variables the automatic lag length selector with max lag of 11 based on Schwartz Information Criterion is used in the ADF test unless stated otherwise. For PP and KPSS tests the default Eviews settings [Bartlett kernel method for spectral estimation and Newey-West automatic bandwidth selection (Newey & West, 1987 and 1994)] are used. In addition, intercept is included in the tests by default.

Table 3. Unit root and stationarity tests t-statistics

Variable	ADF		PP		KPSS	
	Level (lags)	1st diff. (lags)	Level	1st diff.	Level	1st diff.
H	-2,08 (1)	-4,85 (0)***	-1,63	-4,89***	0,95***	0,26
FRE	-2,77 (0)	-7,68 (0)***	-2,89	-7,55***	0,67**	0,08
EREIT	-2,04 (1)	-7,34 (0)***	-1,84	-7,34***	0,56**	0,07
S	-2,91(0) ^{T}	-8,29 (0)***	-3,09 ^{T}	-8,29***	0,66**	0,17
GDP	-2,47 (1)	-6,99 (0)***	-2,01	-7,28***	0,67**	0,06 ^{T}
IR	-2,48 (1)	-6,57 (0)***	-4,62	-6,57***	1,06***	0,30
M1	-0,10 (0)	-5,97 (1)***	-0,10	-10,24***	1,16***	0,10

/* stand for 5/1 % significance, respectively. ^{T} means that a trend was added to the test equation.

When using the ADF and PP tests the stock market variable *S* is stationary in levels but the KPSS test indicates non-stationarity. Moreover, both ADF and PP tests indicate non-stationarity in levels when a trend parameter is included in the test. Thus, *S* is considered to contain a unit root in levels. The ADF test shows that *IR* is non-stationary in levels when using maximum lag of 12. *GDP* is indicated by KPSS to be $I(2)$ variable unless a trend is included in the test. ADF and PP tests show that the variable is stationary in first difference at the 1 % significance level.

5.3. Johansen cointegration: Long-run linkages

The optimal lag length of an unrestricted VAR model is estimated by the HQ information criterion discussed in section 4. First differenced variables are used in VAR when estimating the optimal lag length. In most cases the HQ information criterion shows that the optimal lag length is one lag in the differenced VAR form. Additionally, in some cases the Akaike information criterion (AIC) indicated different (always higher) optimal lag structure. The effect of choosing the number of lags as per AIC was also examined, and in all cases the cointegration results were more unstable than when the lag structure was chosen according to HQ.

5.3.1. Dynamics between stock and real estate markets

No cointegrating vectors were found when using only two asset variables in the cointegration tests. Therefore, macroeconomic control variables are included to the tests. The control variables are inserted one by one until a cointegrating vector is found.

When studying the bivariate relationship between Finnish securitized real estate *FRE* and stock market *S*, there is no stable long-run relation between the variables (Table 4). A cointegrating vector is found when any one of the control variables is included. When *GDP* is used as a control, *S* is weakly exogenous at 5 % significance level, and the joint test of *S* and *FRE* both being weakly exogenous is rejected at 10 % significance level. Weak exogeneity of *S* indicates that only the securitized real estate market adjusts to the long-run equilibrium. The long-run cointegrating relation states that when stock prices change by a percentage, *FRE* is expected to change by 0,7 percentages. The coefficient for *GDP* does not make sense, however, since it claims that positive stock market returns would decrease the GDP in the long-run. The adjustment parameter of *FRE* is of the correct sign (negative) only when the stock market variable is not restricted to be weakly exogenous, and states that the securitized real estate market adjusts 9 % quarterly to the long-run equilibrium.

When *IR* is used as a control variable, the exclusion of *S* from the long-run relation cannot be rejected (p-value 0,14) (Table 4). However, both asset variables are weakly exogenous at 5 % significance level. For the long-run relation to be stable, it does not make sense if both variables are weakly exogenous, i.e. neither of them adjusts to the long-run equilibrium. Moreover, the joint test for exclusion of *S* and weak exogeneity of *FRE* cannot be rejected. Using M1 as the control variable, the joint test of exclusion of *FRE* and weak exogeneity of *S* cannot be rejected (p-value 0,11).

Table 4. Johansen test results with stock and securitized real estate price indices

Hypothesis			r = 0	r ≤ 1	r ≤ 2
Variables	**S, FRE**	(ML=0)			
Trace test	(p-value)		19,5 (0,25)		
Variables	**S, FRE, IR**	(ML=1)			
Trace test	(p-value)		52,2 (<0,01)	**20,7 (0,19)**	
P-value for exclusion of *S*=0,14, WE of *FRE*=0,44, joint test for both restrictions=0,29					
Variables	**S, FRE, GDP**	(ML=0)			
Trace test	(p-value)		55,4 (<0,01)	**15,3 (0,55)**	
P-value for WE of *S*=0,53, joint test for WE of *S* and *FRE*=0,078					
Long-run relation		S=0,70*FRE - 2,97*GDP			
(Standard error)		(0,21) (0,89)			
Adjustment speed		S= -0,023	FRE=	-0,089	
(Standard error)		(0,034)		(0,041)	
Variables	**S, FRE, M1**	(ML=0)			
Trace test	(p-value)		110,5 (<0,01)	**22,5 (0,12)**	
P-value for exclusion of *FRE*=0,13, WE of *S*=0,21, joint test for both restrictions=0,11					

ML = maximum lag of the model, WE = weak exogeneity

The general results of cointegration between the stock and securitized real estate markets do not improve by using two control variables even though the number of identified cointegrating vectors increases to two. When *GDP* and *IR* are used as controls, both asset variables are individually weakly exogenous, but the joint test for both restrictions is rejected at 5 % significance level. However, only one of the cointegrating vectors is stationary on the basis of ADF and KPSS tests. Using *GDP* and *M1* as control variables, *FRE* and *S* are individually weakly exogenous, and neither of the two cointegrating vectors is actually stationary. With *M1* and *IR* as control variables, the joint test for both asset variables being weakly exogenous cannot be rejected at conventional significance levels. When using all three control variables the number of cointegrating vectors increases to three. However, *FRE* and *S* are still individually and jointly weakly exogenous unlike none of the control variables. It is improbable that only the macroeconomic fundamentals would adjust to the long-run equilibrium.

Thus, it is concluded that a relatively stable long-run relation is found between the Finnish securitized real estate sector and the general stock market only when using *GDP* as the control variable. This indicates that the diversification possibilities are limited at long-horizon. However, since using control variables other than *GDP* does not lead to similar results, and since both asset variables were individually weakly exogenous in all cases, the cointegrating relation should be interpreted with caution. As it is, the gross domestic product seems to be the most important macroeconomic factor regulating the long-run dynamics between the securitized real estate and stock markets. The result is somewhat contrary to the findings of Hoesli & Oikarinen (2012) who found no cointegrating relationship between the US or UK stock and REIT markets. Perhaps in Finland the securitized real estate market has not matured as much as in these countries, and therefore the real estate sector follows the general stock market to some extent in the long-run.

The long-run dynamics between the stock market and the overall housing market *H* is generally as problematic as the relationship between the securitized real estate and stock market. The results are shown in Table 5. Using *IR* as control variable, *H* can be excluded from the long-run relation and *S* is significantly weakly exogenous. Using *GDP* as the control variable, the cointegration test finds three cointegrating vectors between the three variables. This would mean that the variables are stationary, which, according to the unit root tests, is incorrect. Using *M1* as the control variable all three variables can be excluded from the relationship.

Adding more than one control variable to the equations helps to find more than one cointegrating vector between the stock and housing variables. With two control variables the number of found cointegrating vectors is generally two or three. With all three control variables the number of cointegrating vectors increases to four.

When the number of control variables is increased, the restriction tests fail to find excludable or weakly exogenous variables as often as when only one control variable was used. These seemingly more robust results could arise just because more variables are added to the model.

Table 5. Johansen test results with housing and stock price indices

Hypothesis			r = 0	r ≤ 1	r ≤ 2
Variables	**S, H**	(ML=1)			
Trace test	(p-value)		**19,9 (0,23)**		
Variables	**S, H, IR**	(ML=1)			
Trace test	(p-value)		52,9 (<0,01)	**12,8 (0,75)**	
P-value for exclusion of *H*=0,65, WE of *S*=0,59, joint test for both restrictions=0,74					
Variables	**S, H, GDP**	(ML=1)			
Trace test	(p-value)		52,5 (<0,01)	31,9 (<0,01)	15,1 (0,02)
Trace test indicates 3 cointeq. vectors					
Variables	**S, H, M1**	(ML=2)			
Trace test	(p-value)		61,1 (<0,01)	**28,2 (0,03)**	
P-value for exclusion of *H*=0,09, excl. of *S*=0,93, joint test for excluding *S* and WE of *H*=0,98					
Variables	**S, H, M1, IR**	(ML=1)			
Trace test	(p-value)		111,7 (<0,01)	55,1 (<0,01)	**18,7 (0,30)**
Long-run relation*		H=-0,52*S + 1,87*IR + 0,14*M1			
(Standard error)		(0,05)	(0,26) (0,02)		
Adjustment speed		H= -0,04		S=0,40	
(Standard error)		(0,02)		(0,13)	

ML = maximum lag of the model, WE = weak exogeneity
* Long-run relation after excluding one non-stationary cointegrating vector

When more than one cointegrating vectors are found, it makes the interpretation of the coefficients and dynamics very problematic. Moreover, since the number of cointegrating vectors increases with the added control variables, it is assumed that the found cointegrating relations are more linked to the macroeconomic factors than to the asset variables. Thus, in this thesis the cases where the number of cointegrating vectors is more than one are left out of examination. However, in the cases where more than one cointegrating vector is found between *S* and *H*, it is the stock market that is weakly exogenous. This means that the stock market leads the housing market prices, supporting the theory according to which housing market prices are less informationally efficient and thus more predictable. The stock market leading the housing market also supports wealth effect mechanism in the long-horizon.

The most stable long-run relationship between the housing variable *H* and the stock variable *S* is found when *IR* and *M1* are used as controls (Table 5). Two cointegrating vectors are found in this model and no restrictions can be imposed to the variables. However, the adjustment parameters in the first vector have the wrong sign apart from the adjustment parameter of variable *S*, whereas in the second vector only the adjustment parameter of variable *S* has the wrong sign. Moreover, when the cointegrating equations are inspected for stationarity with the ADF test, we see that only one of the cointegrating equations is stationary. Thus, it is interpreted that only one cointegrating vector is found between *H* and *S* using *IR* and *M1* as control variables. The equation for this model is:

$$H = -0{,}52S + 0{,}14IR + 1{,}87M1 \tag{20}$$

Thus, if the housing prices change by a percent, the stock market is expected to change by 0,52 % in the opposite direction in the long-run. This may be due to investor behavior. When stock market prices are dropping, investors reallocate to the more stable housing assets and vice versa. The adjustment speed of *H* is 4 % which is less than half of the 10 % error correction in the Finnish markets that Oikarinen (2007, 295) has reported.

5.3.2. Dynamics between securitized and direct real estate

When inspecting the linkage between the Finnish securitized real estate and the housing markets, a cointegrating vector is found when using *IR* as the control variable (Table 6). The long-run relation states that the listed real estate market changes by 0,68 % when housing prices changes by a percent. In addition, *FRE* is found weakly exogenous. This supports the theory that only the direct market converges to the long-run equilibrium and follows the listed real estate market that is informationally more efficient. This result also implies that in the long-run the diversification possibilities diminish if both direct and indirect real estate are held in a portfolio. When *FRE* is set as weakly exogenous, the adjustment coefficient for the housing variable is approximately 0,6 % per quarter, indicating that the adjustment is extremely slow.

Table 6. Johansen test results with housing and Finnish sec. real est. price indices

Hypothesis			r = 0	r ≤ 1	r ≤ 2
Variables	**FRE, H**	(ML=1)			
Trace test	(p-value)		**18,8 (0,29)**		
Variables	**FRE, H, IR**	(ML=1)			
Trace test	(p-value)		63,4 (<0,01)	**12,9 (0,74)**	
P-value for WE of FRE=0,18					
Long-run relation		H= 0,68*FRE - 0,41*IR			
(Standard error)		(0,15) (0,05)			
Adjustment speed*			H= -0,006		
(Standard error)			(0,001)		
Variables	**FRE, H, GDP**	(ML=1)			
Trace test	(p-value)		45,9 (0,02)	**22,6 (0,12)**	
Joint test for exclusion of *H* and WE of *FRE*=0,11					
Variables	**FRE, H, M1**	(ML=2)			
Trace test	(p-value)		**37,1 (0,17)**		

ML = maximum lag of the model, WE = weak exogeneity
* Adjustment speed of *H* after setting *FRE* weakly exogenous

Using *GDP* as the control variable, a cointegrating vector is found, but it is not robust since the joint test for exclusion of *H* and weak exogeneity of *FRE* cannot be rejected. Moreover, no cointegrating vectors are found when using *M1* as the control variable.

Similar results are found when using the European residential real estate (*EREIT*) variable as a proxy for listed real estate (Appendix 1). While no cointegrating vectors are found in a bivariate (*H, EREIT*) test nor when using *GDP* as a control variable, a cointegrating vector is present when *IR* is used as a control variable. In any of the cases, no variables can be excluded but *EREIT* is always weakly exogenous. This indicates that the Finnish housing markets follow the European residential real estate sector with a lag. However, when setting the adjustment parameter of *EREIT* to zero (implying weak exogeneity) the adjustment parameter of *H* equals 0,5 % quarterly adjustment to the long-run equilibrium. Thus, while the domestic housing markets share a long-term linkage with the foreign residential sector, the adjustment is extremely slow. In addition, it makes sense that the most stable cointegrating vectors between *FRE* or *EREIT* and the housing variable are found when using IR as the control variable, since the Euribor rates are used as reference rates in mortgages.

When using a setting with a securitized real estate variable (*FRE*, *EREIT)*, a housing variable (*H*) and two control variables of which IR is one, we find similar results to the ones reported above. When *IR* is used with either *GDP* or *M1* as a control variable, the number of contegrating vectors is always two. In all of these relationships the securitized real estate can be set weakly exogenous with the 5 % significance level. When *GDP* and *M1* are used as controls, only one cointegrating vector is found when either of the two securitized real estate variables is used. Moreover, these linkages are unstable since in almost all cases the securitized real estate variable can be excluded from the equation and in all cases both asset variables are weakly exogenous. The result confirms that the interest rate variable is the most important of the employed control variables, since its presence provides the most robust long-run linkages in the models.

5.4. Granger-causality: Short-run linkages

This subsection discusses the short-run linkages of the asset variables. Tables 7 and 9 present the Chi-squared statistics and significance of the multivariate Granger non-causality (GNC) tests. Optimal number of lags is the same as established for the Johansen cointegration tests.

5.4.1. Dynamics between stock and real estate markets

When using a VAR with only housing and stock market returns and the long-run equilibrium error term found in the Johansen cointegration tests (upper part of Table 7), the results surprisingly indicate that the more informationally inefficient housing returns have Granger-caused stock returns but not vice versa. This supports the credit-price effect theory, and coincides with the results of Sim & Chang (2006). Interestingly, the causality does not run through the long-run equilibrium (EQE) in either equation. Engle & Granger (1987, 259) state that the long-run equilibrium should Granger-cause at least one of the cointegrated variables.

The implied short-term causality from housing to stock returns may be due to the favorable housing market development in the 21st century. Despite the 2008 financial crisis affecting the stock markets, the housing prices in Finland have remained stable during the crisis years partly due to low interest rates and high consumer trust to their own economic situation (Lehtinen, 2013). Thus, the appreciation of housing investments has encouraged equity investing, as per credit-price effect theory suggests.

Table 7. Chi-squared values of multivariate Granger non-causality tests, based on VARs with real estate and stock market variables

Dependent variable	Explanatory variable					
	Δ S	Δ H			EQE	Adj. R^2
Δ S	**-**	**20,52*** **			2,13	0,29
Δ H	3,90	-			3,11	0,49
	Δ S	Δ H	Δ IR	Δ M1	EQE	Adj. R^2
Δ S	-	**8,95*** *	1,15	**20,42*** **	0,16	0,46
Δ H	**5,32***	**-**	**14,34*** **	2,58	3,11	0,53
Δ IR	**17,54*** **	2,05	-	0,79	**18,91*** **	0,54
Δ M1	0,87	1,91	2,38	-	3,8	0,39
	Δ S	Δ FRE	Δ GDP		EQE	Adj. R^2
Δ S	-	2,08	0,18		0,16	0,15
Δ FRE	0,25	-	2,3		**8,67*** *	-0,04
Δ GDP	**6,65*** *	1,84	-		**7,057*** *	0,25

*/**/*** indicate significance at 10/5/1 percent levels, respectively. Adj. R^2 is the adjusted R^2 of each VAR equation

In the middle part of Table 7, the control variables that were part of the identified cointegrating relation have been taken into the VAR model. The results confirm that Granger-causality does not run through the EQE into either of the asset variables. The EQE is significant only in the equation where the short-term interest rate is the dependent variable. Thus, it strengthens the view that the found cointegrating relationship between housing and stock markets is not robust, but is due to the added macroeconomic variables. Therefore, this study fails to find any long-run dynamics between the Finnish housing and stock markets. This somewhat contradicts the results of Oikarinen (2007) who detected a cointegrating relationship in the Finnish markets, even though the long-run interdependence had been decreasing since the 90s. Based on the asset variable dynamics, there is bi-directional causality between housing and stock returns in this model, albeit that the significance level for stock returns causing housing returns is only 10 %. This also contradicts the results of Oikarinen (2007) who found no short-run causality between stock and housing returns in the 1994-2006 period in the Finnish markets, although some different macroeconomic control variables were incorporated.

The direction of causality can be inspected from impulse response functions. Figure 4 shows the impulse responses of the assets to one standard deviation shocks to housing and stock returns. A shock in housing returns causes a two-quarter long positive and increasing response in the stock returns. After that the stock markets seem to over-correct the response by staying slightly negative for about a year (quarters 5-9). After 10 quarters, or 2 ½ years, the shock effect has died. Similar effect but on a much smaller scale happens when the housing returns respond to a shock in the stock market.

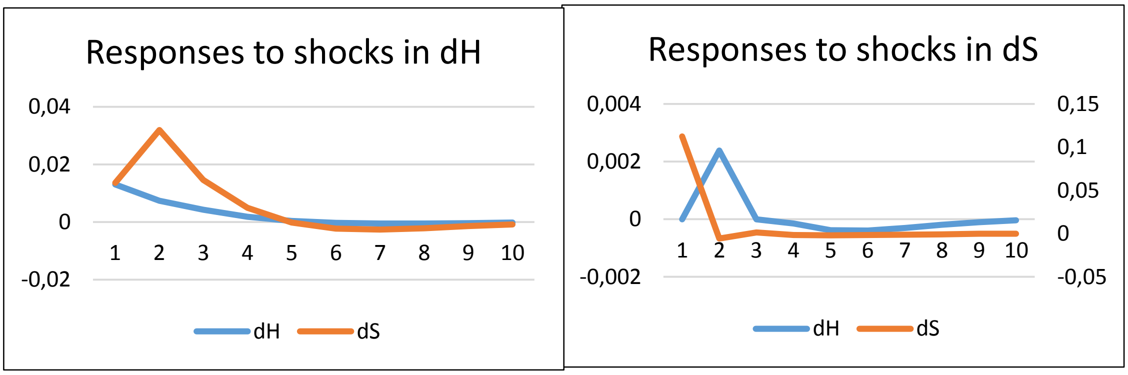

Figure 4. Impulse responses based on a VAR-model with *H, S, IR* and *M1*

*Right axis in right graph for dS

Variance decompositions (the upper half of Table 8) further show that housing return changes have a more profound effect on stock return variances than is the case the other way around. After ten quarters, 66,1 % of housing variance is due to its own shocks and only 1,7 % is due to shocks in stock market returns. In fact, the influence of *IR* and *M1* to the housing variance is much larger than the influence of stock market. Conversely, after ten quarters, the effect of housing shocks to stock market variance is 8,3 % and each of the control variables' proportion is within a range from nine to twelve percent, approximately.

The lower part of Table 7 presents the GNC test results for securitized real estate and the stock returns. The results indicate that there are no short-run bidirectional causality between the assets. However, the short-run causality runs through the long-run equilibrium to the securitized real estate only. This makes sense as the stock market was identified as weakly exogenous in the Johansen cointegration restriction test. Hence, the stock market is informationally more efficient of the two variables. In addition, the results indicate that stock market significantly Granger-causes the GDP, which is reasonable in a well-established and developed financial market.

Figure 5 shows the responses of the securitized real estate and stock returns to the shocks. Comparing the left graphs of Figures 4 and 5 it can be seen that the stock market reacts to a shock in *FRE* a bit differently than it reacts to a shock in *H*. After the increasing effect of the shock in *FRE*, the stock market responds by going slightly negative during the third quarter but corrects the negative effect more quickly, and thus the shock persists for about five quarters. The same persistence also holds true when *FRE* responds to a shock in *S*. The increasing positive initial spike response of *S* to a shock in *FRE* is also smaller in magnitude compared to the spike response of *S* to a shock in *H*. Therefore, in the short-run the securitized real estate market does not have as large an effect on the stock returns as the housing market has.

Table 8. Variance decompositions of VAR-models with real estate and stock market variables

Variance decomposition of	**Shock to**				
	dH	dS	dM1	dIR	Quarters
Housing	93,1 %	0,0 %	6,1 %	0,8 %	1
	79,4 %	2,0 %	12,3 %	6,3 %	2
	66,6 %	1,6 %	14,9 %	16,9 %	5
	66,1 %	1,7 %	14,8 %	17,4 %	10
	dH	dS	dM1	dIR	Quarters
Stock	1,4 %	96,5 %	1,6 %	0,5 %	1
	7,5 %	78,4 %	10,6 %	3,5 %	2
	8,2 %	72,3 %	11,1 %	8,4 %	5
	8,3 %	72,1 %	11,1 %	8,6 %	10
	dFRE	dOMX	dGDP		Quarters
Sec. real estate	63,5 %	28,2 %	8,3 %		1
	63,2 %	28,9 %	7,9 %		2
	62,9 %	28,8 %	8,3 %		5
	62,9 %	28,8 %	8,3 %		10
	dFRE	dOMX	dGDP		Quarters
Stock	0,0 %	88,8 %	11,2 %		1
	1,5 %	87,6 %	10,9 %		2
	1,9 %	87,3 %	10,8 %		5
	1,9 %	87,3 %	10,8 %		10

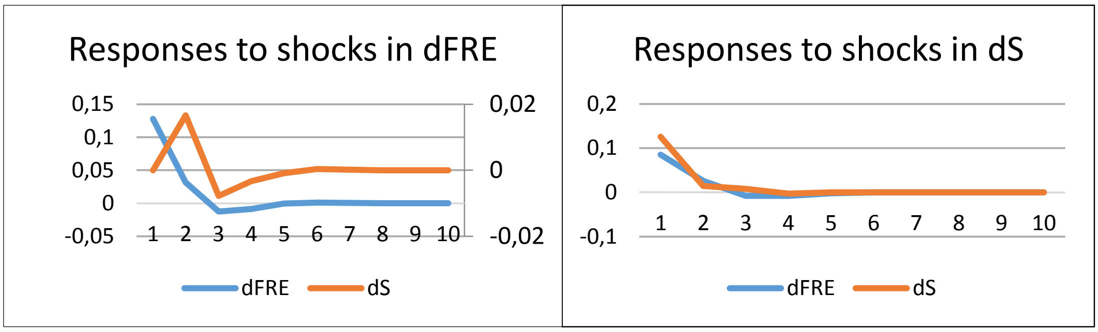

Figure 5. Impulse responses based on a VAR model with *FRE, S* and *GDP*

* Right axis in left graph for dS

The lower half of Table 8 presents the variance decompositions based on the *FRE-S-GDP* VAR model. The results indicate that the variance decomposition of *FRE* does not alter almost at all during a ten-quarter time. The effect of *FRE*'s own shocks constitute approximately 63 % of its forecast error variance, and the proportion of stock market shocks' effect remain approximately at 28,8 % during the ten-quarter horizon. When compared to the variance decomposition of the housing markets where the stock markets contribute less than two per cents at most, the effect of stock market shocks to securitized real estate is rather large. The figures are in line with some of the findings of Hoesli & Oikarinen (2012, 1839). They found that in Australian markets, where they used all-sectors REIT and overall stock market indices, the effect of stock market shocks to the variance of REITs was 28,6 % at 12-quarter horizon.

Thus, the results indicate that the overall stock market did not have much effect on the housing market in the short-run during the sample period, whereas the housing market has driven the stock market. The long-run relation was also revoked by the causality tests. On the other hand, the stock market has driven the securitized real estate market in the short-run as well as in the long-run.

5.4.2. Dynamics between securitized and direct real estate

The short-run dynamics between the housing market and securitized markets are practically identical regardless of which securitized real estate variable is used, as shown in Table 9. There is no bidirectional causality between the housing and securitized real estate variables, but the housing market is Granger-caused in the short-term by the long-run equilibrium error variable. This confirms the weak exogeneity of securitized real estate found in the cointegration tests. The result indicates that the securitized market returns cannot be used to predict the housing returns in the short-run. However, since the equilibrium error variable is significant, there are long-run dynamics between housing and securitized real estate and the securitized real estate is the driving force. Since the interest rate variable is significant in the equation where housing is the dependent variable, interest rate changes can predict housing return changes in the short-run.

Table 9. Chi-squared values of multivariate Granger-causality tests, based on VARs with direct and securitized real estate variables

		Explanatory variable				
		Δ H	Δ FRE	Δ IR	EQE	Adj. R^2
Dependent variable	Δ H	-	1,18	**23,76*** **	**5,74** **	0,54
	Δ FRE	2,07	-	0,55	0,31	0,13
	Δ IR	0,11	**4,50** **	-	**15,38*** **	0,39
		Δ H	Δ EREIT	Δ IR	EQE	Adj. R^2
	Δ H	-	1,7	**21,52*** **	**4,21** **	0,54
	Δ EREIT	0,73	-	0,06	0,08	0,07
	Δ IR	0,01	**5,54** **	-	**20,36*** **	0,42

/* indicate significance at 5/1 percent levels, respectively. Adj. R^2 is the adjusted R^2 of each VAR equation

The impulse responses in Figure 6 show that *FRE* and *H* respond similarly to shocks in the housing market with a decreasing positive response, except that the housing variables' scale of response is slightly smaller. Responses of *H* to shocks in *FRE* differ much more. First of all, the housing returns first react with a positive spike, then turn negative before converging to zero. Moreover, the persistence of the reaction of *H* is nine to ten quarters compared to the four to five quarters of *FRE*. However, the scale of response of *H* is so miniscule that in practice the response is negligible. Since the housing returns do not really react to the securitized real estate shocks but the securitized real estate reacts to housing shocks, there is some evidence that housing market Granger-causes the securitized real estate market. The Cholesky-ordering of variables was also changed e.g. by placing *H* before *FRE* or changing the ordering of control variables, but no significant differences came up. In addition, the results remain very similar also when using *EREIT* as the securitized real estate variable.

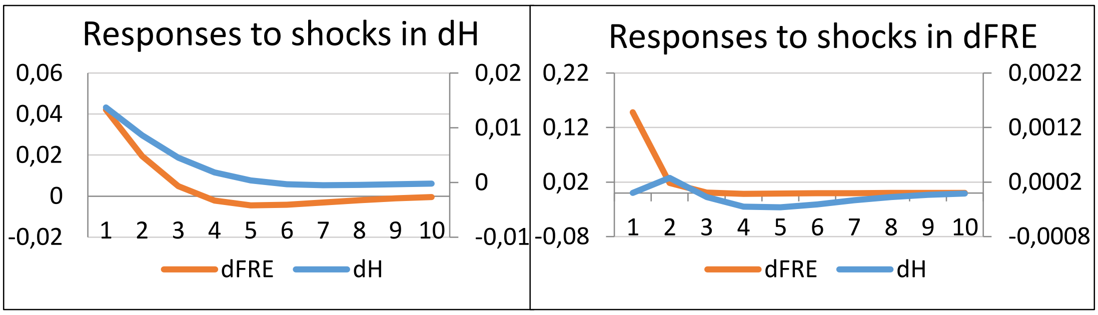

Figure 6. Impulse responses based on VAR model with *H*, *FRE* and *IR*

* Right axis for dH

The variance decompositions in Table 10 show that the *FRE*'s proportion of housing market's variance starts off at 7,4 % and decreases to 6,1 % over the ten-quarter horizon. When using *EREIT* as the listed real estate variable in the VAR model, *EREIT*'s proportion of housing market's variance after ten quarters is 2,9 %. Since the Finnish listed real estate sector has a larger effect on the housing market variance than the European residential REIT sector, it seems that the geographic location plays a bigger role than the closer relatedness of the underlying market sector. However, since the proportion of *FRE's* shock effect is decreasing over time and is just over six percent, it can hardly be taken as a considerable influence.

The interest rate has the highest contribution to the housing market variance, starting at 1,3 % and increasing to 22,5 % after ten quarters. Such large effect of interest rate is not evident on the listed real estate return variances. This may be due to the different investment horizons in the direct and listed real estate sectors. Since the direct real estate is usually a longer term investment, the effect of interest rate plays a bigger role during the investment period. In addition, there are more variables affecting the prices of listed real estate, such as the effect of management of listed real estate companies, so that the interest rate changes may not have as large an effect (Devaney et al. 2013, 4).

Table 10. Variance decompositions of VAR models with direct and securitized real estate variables

Variance decomposition of	**Shock to**				
	dH	dFRE	dEREIT	dIR	Period
Housing	91,3 %	7,4 %	2,1 %	1,3 %	1
	83,0 %	7,2 %	3,1 %	9,7 %	2
	71,9 %	6,1 %	2,8 %	21,9 %	5
	71,4 %	6,1 %	2,9 %	22,5 %	10
	dH	dFRE		dIR	Period
Sec. real estate	0,0 %	99,6 %		0,4 %	1
(FRE)	0,7 %	94,3 %	-	4,9 %	2
	0,8 %	90,9 %		8,2 %	5
	0,9 %	90,8 %		8,2 %	10
	dH		dEREIT	dIR	Period
Sec. real estate	0,0 %		99,7 %	0,4 %	1
(EREIT)	0,4 %	-	98,9 %	4,9 %	2
	0,6 %		97,7 %	8,2 %	5
	0,6 %		97,6 %	8,2 %	10

Note: *FRE* and *EREIT* were used in different VARs when measuring the variance decomposition of *H*.

The housing market contributes less than a percentage to the listed real estates' variances. Comparing to the figures of Table 8, the housing market has less influence on the securitized real estate than it has on the overall stock market. On the other hand, neither of securitized assets has a very strong effect on the housing variable. Thus, the housing market Granger-causes stock markets but is not affected largely by the securitized real estate markets in the short-run.

Lastly, the impulse responses of *H* and *FRE* to shocks in the macroeconomic control variables are inspected. If the responses are similar in relative magnitude and persistence, then the assets can be seen as good substitutes and the listed sector depicts well the underlying direct asset. The responses are shown in Figure 7, where the stock market and the European residential REIT variables are also included in for comparison.

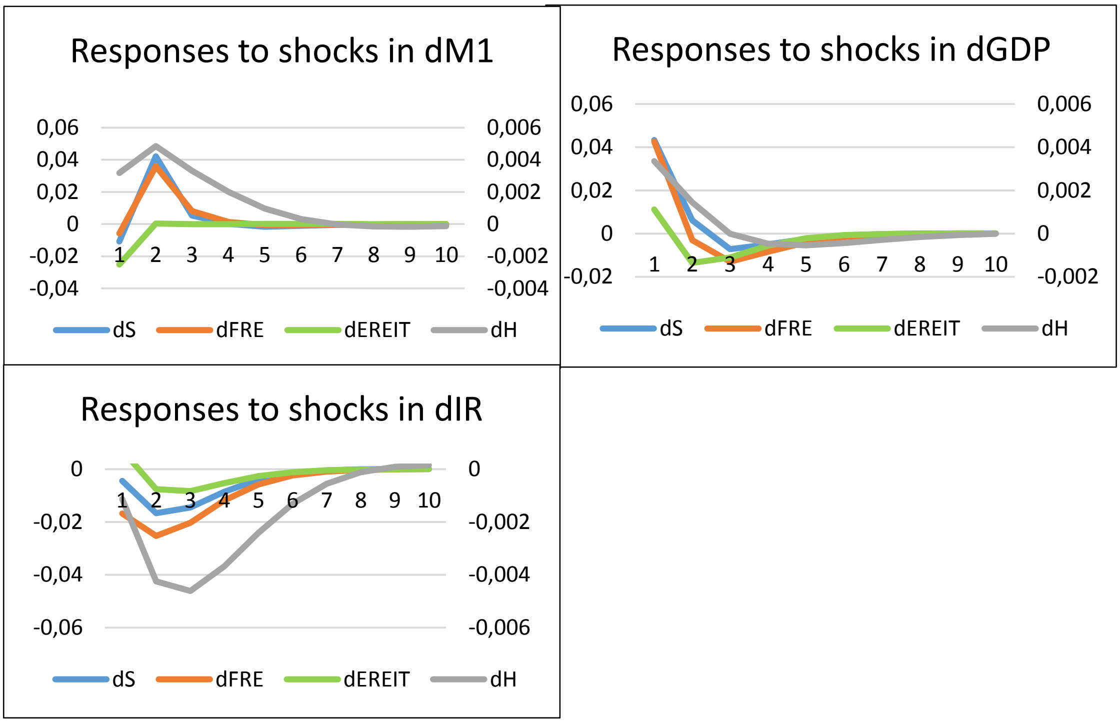

Figure 7. Impulse responses of asset variables to shocks in control variables, based on VAR model

* Right axis for dH

As shown in Figure 7, the housing market responses are of smaller magnitude and this is due to the absence of leverage in the direct market data. However, the housing market reacts with a similar persistence as the listed real estate market only to the shocks in *GDP*. The housing and listed real estate market responses to money supply and interest rate shocks differ considerably since the housing market shows significantly longer persistence to the macroeconomic variable changes. The Finnish listed real estate market seems to react much more similarly to macroeconomic shocks as the overall stock market. In addition, the housing market's impulse responses do not react similarly with the European residential REIT to the different shocks either. In addition, Appendix 2 presents the long-run impulse responses which also show that the housing and listed real estate markets react differently to the macroeconomic shocks. Thus, it is concluded that the listed real estate sector did not depict the Finnish housing market during the sample period. It should be noted that while the short-horizon impulse responses indicate that the listed real estate market behaves similarly to the stock market, in the long-horizon this similarity disappears. In the long-run the housing market impulse responses coincide with the stock market's responses, at least when it comes to shocks to GDP or interest rate.

6. Conclusions

This thesis analyzes the long- and short-run dynamics between the Finnish real estate and stock markets during Q4/1992-Q3/2014. In addition, the interrelationship between direct and listed real estate sectors is examined. The housing market is used as a proxy for direct real estate investments. A Finnish all-sectors securitized real estate index and a European residential REIT index are used as proxies for indirect real estate investments. A capped OMX Helsinki All-share index is used as a proxy for stock market returns. In addition, several macroeconomic indices are incorporated as control variables.

As the differenced and stationary return series neglect long-run dynamics, the level price series are used and the non-stationarity is tested with popular unit-root tests. Long-run dynamics are tested with the Johansen cointegration model, and Granger-causality tests model the short-run dynamics. Impulse response analysis and forecast error variance decomposition are used for robustness checks.

The Johansen test indicates a cointegrating relationship between the housing and stock markets. However, the Granger-causality test revoked this result as the long-run equilibrium is not significant in the short-run dynamics test. Thus, no long-run dynamics between housing and stock markets are found during the sample period. Absence of cointegration implies that there are diversification benefits from holding both stock and housing assets in a portfolio. However, short-run causality from housing to stock markets – implying credit-price effect – is present. While in theory the credit-price effect implies that the stock market prices could be predicted based on housing price changes, in practice market timing would be difficult due to the lag created by the housing price appraisals and the delayed information delivery to the market.

In contrast, the stock market has driven the securitized real estate market in the long-run and also in the short-run through the long-run equilibrium. However, the speed of the quarterly error correction of the Finnish listed real estate sector towards the cointegrating relation is extremely slow, indicating that the listed real estate market does not follow the overall stock market substantially. The extant literature has often found no cointegration between the listed real estate and stock markets in the developed economies like the US or UK, where the listed real estate sector has matured. In Finland the securitized property market is not as established. For example, the first and so far the only REIT fund in Helsinki Stock Exchange listed in 2013. To help the Finnish listed real estate market to develop further, the REIT legislation should be eased to allow REIT funds to invest in all types of real estate, not just in the residential sector. The REIT structure would enhance the development of the real estate markets because the tax legislation and dividend payout policies arguably make them closer representatives of the underlying direct markets.

The results also show that a long-run linkage between securitized and direct real estate exists and it is led by the securitized market. The cointegrating relationship between the Finnish all-sectors securitized real estate and the housing indices implies that even the listed real estate companies investing in other sectors than residential, such as in offices or retail properties, do not enjoy diversification benefits for a portfolio with housing assets in the long-run. In addition, let us consider a retail investor who wishes to participate in the real estate markets to diversify stock investments. While the direct housing and listed real estate sectors do co-move in the long-run, it is not advisable to invest only in the securitized real estate in a hope to avoid a housing constraint in the portfolio due to the capital intensiveness of the direct asset investment. It was established that the housing and stock markets do not have a cointegrating relationship, whereas the listed real estate sector follows the overall stock market in the long-run.

The short-run dynamics between the listed real estate and housing markets indicate that the housing market is largely segmented from the listed market. The housing market does not react strongly to shocks in the listed market. In addition, the forecast error variance of housing returns is not substantially affected by the shocks in listed real estate returns. Moreover, in the short- and long-run, the listed real estate and housing return responses to shocks in macroeconomic factors have not been similar. Thus, it is concluded that the listed real estate sector did not depict the Finnish housing market during the sample period. This means that the two markets were not good substitutes in a mixed-asset portfolio, and similar diversification benefits were not available from housing and securitized real estate markets during the sample period.

Further research on the topic could include other asset types, such as bonds and commodities. This would widen the implications of asset allocation and portfolio construction. Moreover, the effect of other macroeconomic fundamentals could be studied. For example, the inflation hedging properties of real estate have been studied on some previous articles. In addition, it would be interesting to further inspect the sector level dynamics between listed and direct real estate in economies such as Finland, where the listed real estate sector is less matured than in the US. However, at least in the case of Finland, the lack of public sector-level data on commercial direct real estate limits this kind of research design.

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Appendices

Appendix 1. Johansen test results with asset variables *H* and *EREIT*

Hypothesis			r = 0	r ≤ 1	r ≤ 2
Variables	**EREIT, H**	(ML=1)			
Trace test	(p-value)		**15,9 (0,49)**		
Variables	**EREIT, H, IR**	(ML=1)			
Trace test	(p-value)		58,3 (0,00)	**14,4 (0,63)**	
P-value for weak exogeneity of EREIT=0,65					
Long-run relation		H= 0,16*FRE - 0,21*IR			
(Standard error)		(0,05) (0,03)			
Adjustment speed*			H= -0,005		
(Standard error)			(0,001)		
Variables	**EREIT, H, GDP**	(ML=1)			
Trace test	(p-value)		**39,5 (0,11)**		
Variables	**EREIT, H, M1**	(ML=1)			
Trace test	(p-value)		50,2 (0,00)	**15,4 (0,54)**	
Joint test for weak exogeneity of *EREIT* and *H*=0,73					

* Adjustment speed after setting *EREIT* weakly exogenous

Appendix 2. Impulse responses of asset variables to shocks in control variables, based on long-run VECM models

*Right axis for *H*