The nexus between stock market index and apartment and villa prices

Granger causality test of Swedish data

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Abstract

Purpose – The purpose of this study is to investigate the Granger causal link between the stock market index and housing prices in terms of apartment and villa prices.

Design/methodology/approach – Monthly data from September 2005 to October 2013 on apartment prices, villa prices, the stock market index, mortgage rates and the consumer price index were used. Statistical methods were applied to explore the long-run co-integration and Granger causal link between the stock market index and apartment and villa prices in Sweden.

Findings – The results indicate that the stock market index and housing prices are co-integrated and that a long-run equilibrium relationship exists between them. According to the Granger causality tests, bidirectional relationships exist between the stock market index and apartment and villa prices, respectively, supporting the wealth and credit-price effects. Moreover, variations in apartment and villa prices are primarily caused by endogenous shocks.

Originality/value – To the authors' best knowledge, this study represents a first analysis of the causal nexus between the stock market and the housing market in terms of apartment and villa prices in the Swedish context using a vector error-correction model to analyze monthly data.

Keywords Housing prices, Granger causality tests, Prices of apartments, Prices of villas, Stock market index, Vector error-correction model

Paper type Research paper

1. Introduction

The world economy witnessed a financial crisis in 2007-2009 that significantly affected various actors, not least investors and policymakers. The global financial crisis originated from the subprime segment of the US housing market, which quickly cast its shadow over other markets, particularly the stock markets (Demyanyk and Van Hemert, 2011). Fluctuations in housing market values dramatically changed the economic conditions not only of companies but also of households, and the world economy is still fighting a considerable degree of residual uncertainty. It seems as though the links between the housing market and the whole property market and the financial markets, the stock market in particular, are crucial. Risk management and diversification rely on knowledge of the links between the housing and stock markets (Shiller, 2010). Studies of the relationship between the housing and financial markets may also enable policymakers to develop regulations aimed at preventing future financial crises (Claussen *et al.*, 2011).

Because of Sweden's past experience of a financial crisis, the Swedish housing market has attracted attention internationally (Yang and Turner, 2004). In the early 1990s, Sweden experienced a domestic financial crisis originating from deregulated lending in the housing

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market (Wohlin, 1998; Englund, 1999). As a result, Swedish housing prices declined to very low levels in the mid-1990s. Swedish housing market prices have increased for the past two decades, repeatedly hitting new highs (Claussen, 2013). In fact, prices in the Swedish housing market showed no significant signs of slowing down during the global financial crisis of 2007-2009 (Nordlund and Lundström, 2011).

Nordlund and Lundström (2011) have reported that most of the increasing value of Swedish properties can be explained by economic growth. Growth in various sectors increases the demand for properties, including houses, pushing up their prices (Lind and Lindqvist, 2005). Several variables, in particular easy access to bank loans, low interest rates and a low housing supply, are supposed to have increased the prices in the Swedish housing market (Englund, 2011). Similarly, Claussen *et al.* (2011) have explained the increasing housing prices in Sweden by citing higher incomes, low interest rates and an increased preference for home consumption.

It is no understatement to say that the housing market has become an increasingly important factor in the Swedish economy (Yang and Turner, 2004). The housing market has also become the subject of an increasing number of studies (Claussen *et al.*, 2011). For example, Yang (2005) provided evidence of the existence of a long-term association between the property market, the property stock market and bond market. Stock holdings and properties are the two most important components of wealth in the Swedish economy, as in most developed economies. Approximately, 75 per cent of the population in Sweden between the ages of 18 and 76 invest money in stock funds (Fondbolagens Förening, 2014), and Swedish households usually prefer to purchase housing before other types of consumption. Housing in Sweden is categorized in three dwelling forms: apartments and villas, rental apartments and cooperatives (Lind and Lundström, 2007). By the end of 2015, the number of housing units was approximately 4.7 million (Statistics Sweden, 2015a), mostly classified as apartments and villas. In larger cities, apartments are more common than villas, whereas villas dominate in smaller cities.

As demonstrated by Su (2011), the relationships between stock and housing prices are context dependent and vary across countries. Several country-level variables such as institutional factors, legal and regulatory systems and taxation may influence the relationship between the stock and housing markets. The present study uses Swedish data, and Sweden can be seen as a good empirical case because of its experience of a domestic financial crisis in the 1990s and the limited impact of the global financial crisis in the 2000s on its housing market (Nordlund and Lundström, 2011). The Swedish housing market is also characterized as relatively transparent, having public registers of individual data and Sweden has consistently applied laws and regulations and upheld private housing rights (Bellman and Öhman, 2016).

By using various econometric techniques, including the Granger causality test based on a vector error-correction model (VECM), the present study tests the relationship between the stock market index and housing prices. To the authors' best knowledge, this study represents a first attempt to examine the causal nexus between stocks and apartment and villa prices, respectively.

The present study differs from a previous study of the co-integration of housing prices and property stock prices in the Swedish context. The previous study, by Yang (2005), applied the portfolio perspective and tested the efficient market hypothesis. We use the Granger causality method to analyze the relationship between the stock market index and housing prices in terms of apartment prices and villa prices. Furthermore, while Yang (2005) used quarterly data covering the 1980-1998 period, our study is based on monthly data for the 2005-2013 period, i.e. before, during and after the financial crisis, and it includes control variables in terms of the mortgage rate (MR) and consumer price index (CPI).

The reminder of the paper is structured as follows. The next section presents the conceptual framework, a review of previous research and the null hypotheses. This is followed by the data and model specification section. The empirical results are then presented, and the paper ends with a concluding discussion.

2. Frame of reference

2.1 Causal relationship between the stock and housing markets

Theoretically, the relationship between wealth and consumption is very broad. Friedman (1957a, 1957b) and Ando and Modigliani (1963) have highlighted the effects of changes in household wealth on private consumption. The link between wealth and consumption can be explained by the permanent income model or the lifecycle model, both of which suggest a linear association between aggregate consumption and income. As households are expected to smooth their consumption expenditures over time, increases in stock prices – one source of wealth – are therefore linked to increased current and future consumption.

Houses have been described as a dual commodity because they are not only a consumption good but also an investment (Brueckner, 1997; Dusansky and Koc, 2007). This dual characteristic plays an important role in the analysis of the housing market. Hypotheses explaining the relationship between the stock and housing markets can be classified in three categories, concerning the wealth effect, the credit-price effect and bidirectional causality, as described below.

The wealth effect hypothesis is based on the assumption that houses are consumption goods. Changes in stock prices influence the net wealth of households and therefore their current consumption (Case *et al.*, 2012; Lean, 2012). This hypothesis assumes, in agreement with the lifecycle proposition, that households regulate their lifetime consumption plan. A change in the value of a house, or of any other asset, tends to affect the household consumption pattern (Campbell and Cocco, 2007). Theoretically, an increase in wealth in terms of capital gains and/or dividends can increase household consumption (Case *et al.*, 2012). The wealth effect hypothesis predicts a unidirectional causality effect running from the stock market to the housing market. The existence of well-developed financial markets is regarded as a precondition for the wealth effect (Muellbauer and Murphy, 1997).

The credit-price effect hypothesis suggests a reversed unidirectional relationship instead running from the housing market to the stock market (Ibrahim, 2010; Lean, 2012), possibly because a large share of household assets often consists of the housing itself. As a result, an increase in the value of its housing may improve the household's creditworthiness. In this situation, household collateral increases, creating opportunities for borrowing, consumption and investment. Similarly, Kapopoulos and Siokis (2005) argue that an increase in housing prices can stimulate financial activity at the macro level and create opportunities for future profitability at the firm level, which in turn can lead to increased stock prices.

A third hypothesis suggests bidirectional causality between stock and housing prices (Liu and Su, 2010; Lean and Smyth, 2014). In this case, stock prices and housing prices are expected to be closely interconnected. According to the wealth effect, stock prices influence the net wealth of households and, hence, their current consumption in terms of housing purchases, thereby stimulating demand for houses (Case *et al.*, 2012; Lean, 2012). In accordance with the credit-price effect, an increase in household value may improve the household's creditworthiness and collateral level, which may generate opportunities for investments in the stock market (Kapopoulos and Siokis, 2005). Stock prices will thereby be affected by the change in housing prices to the degree that home equity and/or loans are used to acquire stocks. The feedback effect can be interpreted as the presence of both mechanisms, i.e. wealth and credit-price effects, indicating a spiraling interaction (Ibrahim, 2010).

2.2 Previous empirical studies

Existing empirical research falls into two main strands. The first is based on portfolio management approaches focusing on the long-term link between the stock and property markets (Ibbotson and Siegel, 1984; Eichholtz and Hartzell, 1996; Quan and Titman, 1999; Yang, 2005). Studies included in this strand often ignore the question of whether the stock market affects the housing market or vice versa. However, the second strand of literature focuses on the causal link between these markets (Gyourko and Keim, 1992; Green, 2002; Kakes and Van Den End, 2004; Ibrahim, 2010) and mostly examines the long-term link between the stock and property markets. These studies have primarily covered the USA although several recent studies have been conducted in Asian countries.

The pioneering study of Ibbotson and Siegel (1984) investigated the long-term association between returns on property in the USA and returns on the stock market (i.e. S&P 500) from a portfolio management perspective using annual data for the 1947-1982 period. The study was based on cross and serial correlation of methods, and the results indicated a negative and weak correlation between stock and property returns. Covering the 1972-1998 period, Okunev *et al.* (2000) adopted Granger co-integration and vector autoregression (VAR) methods to analyze the causal relationship between the USA property and stock markets (i.e. S&P 500). The results indicated, in agreement with the wealth effect hypothesis, unidirectional causality running from the stock to the property markets. Similarly, using the VAR and Granger methods, Chen (2001) analyzed quarterly data on Taiwan's property and stock markets for the 1973-1992 period. The results confirmed a strong causal relationship between stock and property prices, supporting unidirectional causation running from the stock to the property market, i.e. the existence of the wealth effect.

Several other studies based on data from the USA and/or Europe have partly confirmed the wealth effect hypothesis. Using the Granger method, Green (2002) investigated the relationship between the stock and housing markets in California for the 1989-1998 period. The overall results suggested a causal and unidirectional relationship between stock and housing prices. However, the wealth effect was not supported in the southern part of the state. Adopting Granger causality to analyze quarterly Greek data for the 1993 Q1-2003 Q2 period, Kapopoulos and Siokis (2005) reported the existence of a unidirectional causal relationship between stock and housing prices. The results confirmed a wealth effect for housing prices in Athens but not in other urban regions in Greece. Kakes and Van Den End (2004) used a number of statistical techniques, including VAR and generalized impulse response function models to examine the relationship between stock prices (measured by the AEX index) and housing prices in The Netherlands. The analysis of quarterly observations for the 1985-2002 period demonstrated that the relationship between the stock and housing markets was strongest in the most expensive segments of the Dutch housing market. The finding also indicated that the stock market's impact on the housing market through the wealth effect was greater than previously understood. Moreover, Berg and Lyhagen (1998) used the Granger causality test based on the VAR structure, both bivariate and multivariate, to investigate housing price determinants in various areas of Sweden between 1981 and 1997. Their analysis of monthly data demonstrated a positive unidirectional causal relationship from the stock market to housing prices in the capital, Stockholm, but not in Sweden as a whole.

The results of more recent studies are more mixed. Su (2011) applied a nonlinear causality test based on threshold autoregressive and threshold error-correction models to analyze a sample consisting of monthly observations of the natural logarithm of the property price indices and the natural logarithm of the stock price sample for the 2000-2007 period. The results confirmed the existence of long-run unidirectional and bidirectional causality between the markets in European regions both above and below the threshold level. The findings supported the wealth effect in Belgium and Italy, the credit-price effect in Germany, The Netherlands, and the UK, and both effects in France, Spain and Switzerland.

McMillan (2012) examined the causality between the stock and housing markets in the USA and the UK using ESTR and error-correction models to analyze a sample comprising quarterly stock market and housing price data for the 1974-2009 period. The results suggested, in accordance with the credit-price effect hypothesis, a unidirectional causality running from the housing market to the stock market in both the USA and the UK. Tsai *et al.* (2012) studied the long-term relationship between the US stock and housing markets using the threshold co-integration model analyzing quarterly data from 1970 Q1 to 2009 Q3. The results suggested an asymmetric wealth effect, creating the possibility of portfolio diversification. Moreover, Aye *et al.* (2013) performed linear and nonparametric co-integration and Granger causality tests to identify a long-term causal relationship between stock and housing prices in South Africa using a sample of monthly data over a 45-year period. The results of the nonparametric co-integration test confirmed the existence of a long-run association between the variables, whereas the findings of the nonparametric Granger causality test indicated a bi-directional causal relationship.

In addition, studies based on Asian data indicate the applicability of the wealth effect hypothesis and/or the credit-price effect hypothesis. Sim and Chang (2006) used VAR to study the relationship between stock and property prices in the Korean market over a 19-year period (from 1986 Q1 to 2005 Q1). The findings were in agreement with the credit-price effect hypothesis that the stock market would react immediately to shocks in housing and land prices. Ibrahim (2010) empirically tested the wealth effect and credit-price effect hypotheses for Thailand using quarterly data from 1995 to 2006. The author applied various econometric techniques, for example, VAR, Granger causality tests and impulse-response functions. Consistent with the wealth effect hypothesis, the results indicated unidirectional causality running from stock prices to housing prices. Liu and Su (2010) used asymmetrical threshold co-integration tests to study the relationship between the stock and property markets in China for the 1996-2008 period. The results supported the wealth effect hypothesis in the short run and the credit-price effect hypothesis in the long run.

Lin and Lin (2011) used the Johansen co-integration and Granger causality econometric techniques to test the relationship between the stock and property markets in six Asian countries (i.e. China, Hong Kong, Japan, Singapore, South Korea and Taiwan) during the 1995-2010 period. The results, based on an analysis of quarterly data, indicated various interrelationships between the markets. The authors observed segmentation between the stock and property markets in South Korea and Singapore, fractional integration in China, Hong Kong and Taiwan and integration in Japan. In addition, they found evidence of a Granger causal relationship running from the property to the stock market in Singapore and Taiwan. Hui and Ng (2012) used various econometric methods, such as Granger causality and variance decomposition tests, to study the interaction between the stock and housing markets in Hong Kong. The sample consisted of quarterly data covering the 1990-2006 period. Although the authors identified two structural breaks, indicating changes in the causal relationship between the two markets, they found some support for the credit-price effect hypothesis. Lean and Smyth (2014) carried out co-integration and Granger tests on a quarterly data sample covering Malaysian stock and housing prices over the 2000 Q1-2010

Q3 period. The results indicated a wealth effect in Malaysia as a whole and a credit-price effect in Kuala Lumpur.

2.3 Null hypotheses

According to previous studies, the causal link between the stock and housing markets can mainly be explained by two mechanisms: the wealth effect and the credit-price effect. While the wealth effect mechanism suggests a unidirectional causality running from the stock to the housing market, the credit-price effect predicts an opposite unidirectional effect. A third possibility is that housing and stock prices affect each other.

As the literature review indicates, previous empirical findings regarding the link between stock and housing prices are mixed and sometimes contradictory, possibly because different socio-economic contexts, samples and time periods have been investigated. The quality of data and the methods used may also have affected the empirical findings. Moreover, both Su (2011) and Lean and Smyth (2014) obtained different results for different countries included in their samples.

Based on previous studies, the use of bivariate analysis may not be adequate (Quan and Titman, 1999; Ibrahim, 2010). Two control variables, interest rate (i.e. MR) and CPI, are therefore used in the present study (Quan and Titman, 1999; Chen, 2001; Ibrahim, 2010; Claussen *et al.*, 2011; Claussen, 2013). In previous research, the arguments and findings are also mixed. MR may affect household wealth and decisions regarding consumption, saving and investment. At the same time, a bidirectional link between MR and housing prices has been identified (Brissimis and Vlassopoulos, 2009). Previous studies also suggest that housing price variation is closely linked to CPI and inflation (Goodhart, 2001; Kontonikas and Montagnoli, 2004). Naji Meidani *et al.* (2011) found a bidirectional relationship between housing prices and CPI.

In line with Berg and Lyhagen (1998) and Ibrahim (2010), and based on assumptions regarding the Granger causality model, four null hypotheses are formulated. Because of the focus on housing prices in terms of apartment and villa prices, the two main hypotheses are numbered *H1a* and *H1b*.

H1a. There is no Granger causal relationship between stock market and housing prices in terms of apartment prices.

H1b. There is no Granger causal relationship between stock market and housing prices in terms of villa prices

H2. There is no Granger causal relationship between the MR and housing prices in terms of apartment and villa prices.

H3. There is no Granger causal relationship between the CPI and housing prices in terms of apartment and villa prices.

3. Data and model specification

3.1 Data

The time series included in the empirical analysis are average Swedish housing prices for apartments and villas, respectively (SEK per square meter, real terms), monthly average Stockholm all-share stock index (nominal terms), monthly average MR (real terms in per cent) and monthly CPI (nominal terms). The preliminary dataset consists of 98 monthly observations (from September 2005 to October 2013) obtained from Swedish Property Broker Statistics (2015) and Statistics Sweden (2015b). Before analyzing the variables, they were all transformed by taking their natural logarithms. Figure 1 illustrates the development of apartment prices, villa prices, stock market prices, MR and CPI over the 2005-2013 period.

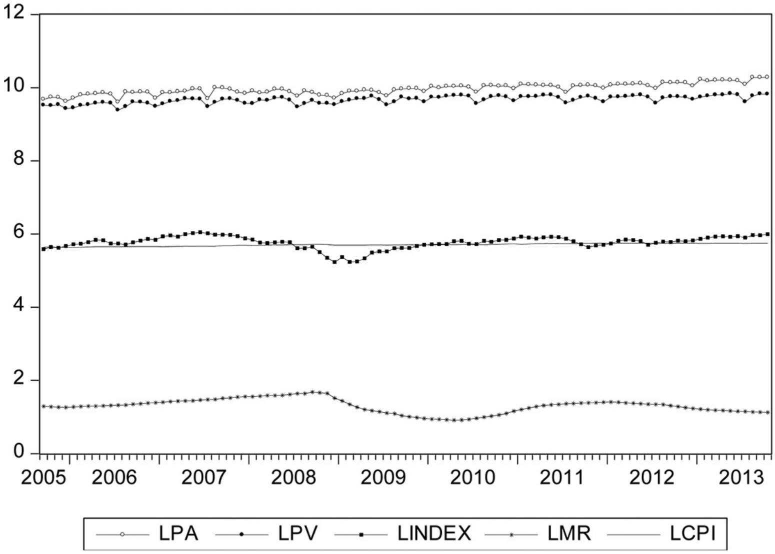

Figure 1.
The natural logarithms of prices of apartments (LPA), prices of villas (LPV), stock market prices (LINDEX), MR (LMR) and CPI (LCPI) in Sweden for the 2005-2013 period

The figure confirms that the Swedish housing market was not significantly affected by the global financial crisis.

3.2 Model specification

The dependent variable, housing prices, is in each case regressed against past values of itself and past values of other variables in the models. In line with Granger causality, X causes Y if the past values of X explain the changes in Y, whereas Y causes X if the past values of Y explain the changes in X. For this purpose, the VAR model can be implemented. However, if the series are co-integrated, the VAR model is no longer the most appropriate model with which to investigate Granger causality between the variables because it fails to account for the underlying long-run relationship among the co-integrated series. To overcome this problem, the long-run stationary component of the data should be incorporated into the VECM as follows:

$$\Delta HP_t = \alpha_0 + \alpha_1 e_{t-1} + \sum_{i=1}^{n} \alpha_2 \Delta HP_{t-i} + \sum_{i=1}^{n} \alpha_3 \Delta index_{t-j} + \sum_{i=1}^{n} \alpha_4 \Delta MR_{t-j} + \sum_{i=1}^{n} \alpha_5 \Delta CPI_{t-j} + \varepsilon_t$$

$$\Delta Index_t = \beta_0 + \beta_1 u_{t-1} + \sum_{i=1}^{n} \beta_2 \Delta index_{t-i} + \sum_{i=1}^{n} \beta_3 \Delta HP_{t-i} + \sum_{i=1}^{n} \beta_4 \Delta MR_{t-j} + \sum_{i=1}^{n} \beta_5 \Delta CPI_{t-j} + v_{t1}$$

As four covariates are included in the model, similar equations can be applied to the two control variables, MR and CPI:

$$\Delta MR_t = \gamma_0 + \gamma_1 \pi_{t-1} + \sum_{i=1}^{n} \gamma_2 \Delta MR_{t-j} + \sum_{i=1}^{n} \gamma_3 \Delta index_{t-i} + \sum_{i=1}^{n} \gamma_4 \Delta HP_{t-i} + \sum_{i=1}^{n} \gamma_5 \Delta CPI_{t-j} + v_{t2}$$

$$\Delta CPI_t = \delta_0 + \delta_1 \tau_{t-1} + \sum_{i=1}^{n} \delta_2 \Delta CPI_{t-j} + \sum_{i=1}^{n} \delta_3 \Delta index_{t-i} + \sum_{i=1}^{n} \delta_4 \Delta HP_{t-i} + \sum_{i=1}^{n} \delta_5 \Delta MR_{t-j} + v_{t3}$$

where α_0 , β_0 , γ_0 , and δ_0 are constants, $e_{t-1,}$ μ_{t-1} , π_{t-1} , and τ_{t-1} refer to the error-correction terms and Δ represents the first difference. Moreover, HP_t and $Index_t$ denote the natural logarithms of the two main variables, i.e. housing prices in terms of apartments and villas and the stock index, respectively. MR_t and CPI_t denote the natural logarithms of the two control variables, i.e. MR and CPI. The residuals ε_t ,v_{t1} , v_{t2} and v_{t3} are error terms assumed to be normally distributed and white noise.

4. Results

4.1 Descriptive statistics

Table I presents the descriptive statistics of the sampled time series, including sample means, medians, maximums, minimums, standard deviations, skewness, kurtosis and the Jarque–Bera tests. As mentioned, the preliminary dataset consists of 98 observations.

Jarque–Bera tests were performed to test for the normality of observations. Table I shows that the null hypothesis for the observations that are normally distributed cannot be rejected at the 5 per cent significance level, as the *p*-values for PA (0.439), PV (0.097) and MR (0.383) are all above the significance level. However, the two time series of the stock index (0.041) and CPI (0.029) are characterized by non-normality. In addition, the standard deviations of the house variables, i.e. apartments and villas, are high, implying that the volatility of the time series is high.

Descriptive statistics	PA	PV	Index	MR	CPI
Mean	21467.64	15872.65	324.2289	3.737551	301.1870
Median	21294.74	16054.57	328.7650	3.720000	302.0100
Minimum	14815.08	11898.70	187.2500	2.500000	279.5900
Maximum	29130.95	18693.62	423.5900	5.380000	315.4900
SD	3178.079	1610.410	51.61021	0.714426	11.03120
Skewness	0.283423	−0.323415	−0.610214	0.255981	−0.351915
Kurtosis	2.714130	2.149666	3.279308	2.544341	1.890449
Jarque–Bera	1.645728	4.660948	6.400453	1.918064	7.049799
p-value	0.439172	0.097250	0.040753	0.383264	0.029455
n	98	98	98	98	98

Notes: PA = Price, apartments (SEK per square meter, real terms); PV = Price, villas (SEK per square meter, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms)

Table I. Descriptive statistics (monthly data from September 2005 to October 2013)

4.2 Phillips–Perron tests

To assess the stationarity and integration orders of the time series, Phillips–Perron (PP) tests were performed. The advantage of PP tests compared with the augmented Dickey–Fuller test is that the former addresses potential serial correlation and heteroscedasticity in the errors. The null hypothesis of the PP unit root tests is that all variables contain a unit root, against the alternative that all these series are stationary. The null hypothesis must be accepted if the absolute value of the test statistics is smaller than the absolute value of the corresponding critical significance value, otherwise it must be rejected. An intercept and linear time trend were included in the tests at both level and first differences. The results of the PP tests reported in Table II indicate that the null hypothesis could be rejected for a number of dependent and independent variables at level. However, the null hypothesis was rejected for the first difference, suggesting that these variables are integrated at the first order or [*1* ~ *I(1)*].

The most important criterion for carrying out the Granger causality model is that the variables included in the model must be stationary variables. Therefore, the first differences of the variables were used in the Granger causality models.

4.3 Lag order selection

Before carrying out the estimation of the co-integration test, the optimal lag order length was established. Various information criteria were estimated for various lag lengths. The results of testing the lag order selection criteria, at the 5 per cent level, are summarized in Table III.

The sequential modified LR test statistic (LR), the final prediction error (FPE), the Akaike information criterion (AIC) and the Hannan–Quinn information criterion (HQ) indicate that the optimal lag length is 7 for the apartment time series. Similarly, the LR, FPE, AIC and HQ indicate that the optimal lag length is 7 for the villa time series. The results of the majority of the tests indicate that [lag length = 1 – 7] is the most appropriate lag length for apartments and villas, respectively, so the study follows the indications of these tests.

4.4 The co-integration analysis

Based on the results of previous selection criteria, the Johansen co-integration test was implemented to determine whether there is a long-run relationship between the time series. If two non-stationary variables are not co-integrated, the VAR model in first differences is applicable for investigating the long-run effects of a common trend; otherwise, VECM will be appropriate. The results of the Johansen co-integration test are summarized in Table IV.

As λ_{trace} statistics for apartments (52.33204) and villas (64.70310) exceed the 5 per cent critical values, it is possible to reject the null hypothesis of no co-integrating vectors. The

PP tests	Intercept (level)	Trend and intercept (level)	Intercept (first differences)	Trend and intercept (first differences)
PA	−2.5655 (0.104)	−34.119 (0.000)***	−7.2338 (0.000)***	−35.740 (0.000)***
PV	−4.4013 (0.001)***	−6.3356 (0.000)***	−31.649 (0.000)***	−31.578 (0.000)***
Index	−1.9301 (0.317)	−1.9648 (0.613)	−8.3389 (0.000)***	−8.3000 (0.000)***
MR	−12.014 (0.000)***	−1.6062 (0.786)	−4.1039 (0.015)**	−8.3535 (0.000)***
CI	−1.3704 (0.594)	−1.7109 (0.739)	−8.7838 (0.000)***	−8.8328 (0.000)***

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; PA = Price, apartments (SEK per square meter, real terms); PV = Price, villas (SEK per square meter, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms)

Table II.
Results of Phillips–Perron (PP) tests

Lag	LogL	LR	FPE	AIC	SC	HQ
Apartment						
0	340.8875	NA	6.59e-09	−7.486388	−7.375286	−7.441585
1	857.5344	975.8886	9.71e-14	−18.61188	−18.05636	−18.38786
2	901.5777	79.27800	5.22e-14	−19.23506	−18.23514*	−18.83183
3	923.2123	37.01922	4.63e-14	−19.36027	−17.91594	−18.77783
4	941.3887	29.48611	4.46e-14	−19.40864	−17.51989	−18.64698
5	970.3850	44.46103	3.39e-14	−19.69744	−17.36429	−18.75658
6	997.5855	39.28954	2.71e-14	−19.94634	−17.16878	−18.82627
7	1045.528	64.98844*	1.38e-14*	−20.65617*	−17.43420	−19.35688*
8	1061.161	19.80237	1.46e-14	−20.64803	−16.98164	−19.16952
Villa						
0	344.8339	NA	6.04e-09	−7.574088	−7.462985	−7.529285
1	854.7604	963.1944	1.03e-13	−18.55023	−17.99472	−18.32622
2	914.4599	107.4590	3.92e-14	−19.52133	−18.52141*	−19.11810
3	933.3808	32.37585	3.69e-14	−19.58624	−18.14191	−19.00380
4	946.8318	21.82044	3.95e-14	−19.52960	−17.64085	−18.76794
5	976.2763	45.14833	2.98e-14	−19.82836	−17.49521	−18.88750
6	1016.514	58.12153	1.78e-14	−20.36699	−17.58942	−19.24691
7	1058.017	56.25885*	1.05e-14*	−20.93371*	−17.71173	−19.63442*
8	1069.769	14.88568	1.21e-14	−20.83930	−17.17292	−19.36080

Notes: *Indicates lag order selected by the criterion, natural logarithm of lagged variable; LR = sequential modified LR test statistic; FPE = Final prediction error; AIC = Akaike information criterion; SC = Schwarz information criterion and HQ = Hannan-Quinn information criterion

Table III. VAR lag order selection criteria for the apartment and the villa time series

H_0	λ_{trace} statistic	5% critical value	*p*-value	H_0	Max-Eigen statistic	5% critical value	*p*-value
Apartment							
$r = 0$	52.33204	47.85613	0.0179**	$r = 0$	29.53520	27.58434	0.0277**
$r = 1$	22.79684	29.79707	0.2562	$r = 1$	18.33774	21.13162	0.1177
$r = 2$	4.459101	15.49471	0.8632	$r = 2$	3.985467	14.26460	0.8609
$r =3$	0.473635	3.841466	0.4913	$r = 3$	0.473635	3.841466	0.4913
Villa							
$r = 0$	64.70310	47.85613	0.0006***	$r = 0$	37.45828	27.58434	0.0020***
$r = 1$	27.24482	29.79707	0.0958	$r = 1$	19.78744	21.13162	0.0762
$r = 2$	7.457380	15.49471	0.5251	$r = 2$	5.934316	14.26460	0.6217
$r = 3$	1.523064	3.841466	0.2172	$r = 3$	1.523064	3.841466	0.2172

Notes: $*p < 0.1$; $**p < 0.05$; $***p < 0.01$

Table IV. Johansen co-integration results: a four-variable, seven-lag system for apartment time series and villa time series, respectively

maximum eigenvalue tests are also below the 10 per cent critical value, further indicating that the null hypothesis can be rejected. In other words, the results confirm that all the series are co-integrated in the long run.

4.5 The vector error-correction model

The VECM results are reported in Table V, indicating that the first, second, third and sixth lagged prices of apartments have a negative and significant effect on current apartment

Table V.
Vector error correction estimates

Apartment	PA	Sig.	Index	Sig.	MR	Sig.	CPI	Sig	Villa	PV	Sig.	Index	Sig.	MR	Sig.	CPI	Sig.
Lag1	−0.51675	0.000***	0.26704	0.0556*	−1.19604	0.006***	1.23953	0.5608	Lag1	−0.25984	0.0773*	−0.01162	0.9297	−1.07121	0.0250**	2.645639	0.2591
Lag2	−0.45398	0.003***	−0.12081	0.3744	0.12549	0.7776	2.73191	0.1734	Lag2	−0.19105	0.1798	−0.00122	0.9923	−0.15616	0.7399	2.912876	0.2063
Lag3	−0.45372	0.008***	−0.17915	0.1329	1.09450	0.0255	−5.21942	0.0051	Lag3	−0.16199	0.2776	−0.11190	0.3646	1.10123	0.0290**	−4.193162	0.0550*
Lag4	−0.46519	0.010**	0.19365	0.1106	−0.92353	0.0619	−4.56723	0.0210**	Lag4	−0.12707	0.4181	0.05843	0.6283	0.24616	0.6297	−5.710438	0.0105**
Lag5	−0.09076	0.590	0.03048	0.8034	−0.55920	0.2738	4.70982	0.0258**	Lag5	0.03835	0.7982	0.11549	0.3354	−1.39756	0.0075***	3.467503	0.1300
Lag6	−0.45154	0.001***	−0.23179	0.0537*	0.32534	0.5227	5.35624	0.0142**	Lag6	−0.31654	0.0267**	−0.23078	0.0522*	−0.46719	0.3895	11.97845	0.0000***
Lag7	−0.06295	0.6213	0.01058	0.9328	0.57461	0.1858	−6.10667	0.0039**	Lag7	−0.22690	0.1155	−0.30744	0.0141**	1.23223	0.0097***	−1.380743	0.5013
$\alpha1$	−0.0629	0.6213							$\alpha1$	−0.00407	0.7144						

Notes: $*p < 0.1$; $**p < 0.05$; $***p < 0.01$; PA = Price, apartments (SEK per square meter, real terms); PV = Price, villas (SEK per square meter, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms) prices at the 1 per cent level, whereas the fourth lagged apartment prices have a negative effect at the 5 per cent significance level. The coefficient of the first lagged stock index is positive at the 10 per cent significance level, indicating a positive shock from stock index to apartment prices, whereas the coefficient of the sixth lagged stock index is negative at the same level. The coefficient of the first lagged MR is negative and significant at the 1 per cent level. The coefficients of four of the lagged values of the CPI on apartment prices are significant at the 5 per cent level.

Table V also shows that the coefficients of the first and sixth lagged villa prices are significantly negative at the 10 and 5 per cent levels, respectively. The associations between the sixth and seventh lagged stock index and villa prices are negative at the 10 and the 5 per cent levels, respectively. The coefficients of the first and fifth lagged MR are significantly negative, whereas the coefficients of the third and seventh lagged MR are significantly positive. Finally, the third and fourth lagged CPI have negative signs, whereas the sixth lagged CPI has a positive sign.

4.6 Results of the granger causality tests

Granger causality analyses based on the VECM with seven lags were conducted between the stock market index and apartment and villa prices, respectively. MR and CPI were used as control variables. The results of the first Granger causality test for monthly data presented in Tables VI suggests bidirectional causality between the stock market index and apartment prices. The results also indicate bidirectional causality between MR and CPI, respectively, and apartment prices.

According to the results reported in Table VII for villa prices, there is a bidirectional relationship between the stock market index and villa prices. The results of the Granger causality test further indicate bidirectional causality between MR and villa prices, as well as between CPI and villa prices.

Tables VI and VII also report the diagnostic tests of heteroscedasticity, residuals, serial autocorrelation, and normality. This supports the contention that the assumptions of the model as to homoscedasticity, the absence of serial autocorrelation of the majority of lags and normality (except for the residuals for apartment) are met at 5 or 10 per cent significance levels.

4.7 Variance decomposition results

To investigate the dynamic relationships between housing prices and the other variables and to evaluate whether the variations in apartment and villa prices can be attributed primarily

Apartment	Causality direction	Chi^2 (p-value)	df	Description	n
(Index, PA)	Index— causality direction—>PA	22.79 (0.001)***	7	Bidirectional	98
(PA, Index)	PA— causality direction—>Index	17.48 (0.0145)**	7	(feedback)	98
(MR,PA)	MR— causality direction—>PA	13.38 (0.063)*	7	Bidirectional	98
(PA, MR)	PA— causality direction—>MR	25.30 (0.000)***	7	(feedback)	98
(CPI, PA)	CPI— causality direction—>PA	55.87 (0.055)*	7	Bidirectional	98
(PA, CPI)	PA— causality direction—>CPI	40.32 (0.000)***	7	(feedback)	98

Notes: Heteroscedasticity test: (Chi^2: 609.98, P: 0.1880); Residual serial correlation tests: (lag1: P, 0.0117; lag2: P, 0.8068; lag3: P, 0.0226; lag4: P, 0.0204; lag5: P, 0.2440; lag6: P, 0.4472; lag7: P, 0.0933); J-B normality test: (Chi^2: 74.8, P: 0.04); $*p < 0.1$; $**p < 0.05$; $***p < 0.01$; PA = Price, apartments (SEK per square metre, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms)

Table VI. Results of granger causality tests based on VECM for apartments

Villa	Null hypothesis	Chi^2 (p-value)	df	Description	n
(Index, PV)	Index— causality direction—>PV	18.24(0.019)**	7	Bidirectional	98
(PV, Index)	PV— causality direction—>Index	12.58(0.082)*	7	(feedback)	98
(MR,PV)	MR— causality direction—>PV	16.11(0.024)**	7	Bidirectional	98
(PV,MR)	PV— causality direction—>MR	18.50(0.058)*	7	(feedback)	98
(CPI, PV)	CPI— causality direction—>PV	65.96(0.000)***	7	Bidirectional	98
(PV, CPI)	PA— causality direction—>CPI	27.65(0.000)***	7	(feedback)	98

Notes: Heteroscedasticity test: (Chi^2: 585.13, P: 0.4325); Residual serial correlation tests: (lag1: P, 0.2684; lag2: P, 0.5639; lag3: P, 0.1229; lag4: P, 0.1345; lag5: P, 0.4509; lag6: P, 0.2025; lag7: P, 0.0508); J-B normality test: (Chi^2: 15.17, P: 0.06); $*p < 0.1$; $**p < 0.05$; $***p < 0.01$; PV = Price, villas (SEK per square metre, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms)

Table VII. Results of granger causality tests based on VECM for villas

to their own shocks or to shocks from other variables, the variance decomposition of the housing price return was used. The results for a seven-month time horizon are reported in Table VIII.

Variance decomposition estimation measures the percentage of the variation in housing prices caused by shocks originating from the dependent variable itself and from the independent variables. As illustrated by Table VIII, past shocks originating from housing prices themselves account for the greatest variation in future prices (on average 68 per cent for apartments and 78 per cent for villas). The results also indicate that the stock market index, MR and CPI explain the rest of the housing price variability. While the stock market index accounts for around 9 per cent of the variation in apartment prices, MR and CPI explain around 13 and 10 per cent, respectively. A similar pattern can be observed concerning the variation in villa prices: the variation caused by shocks from the stock market index is smaller than that caused by shocks from MR and CPI, respectively.

4.8 Hypothesis test results

The results concerning the association between the stock market index and housing prices in terms of apartment and villa prices, respectively, are not in line with the null hypotheses (*H1a* and *H1b*). Instead, the results indicate bidirectional causality between the variables, in agreement with the wealth effect and credit-price effect hypotheses. As

Period	PA	Index	MR	CPI	Period	PV	Index	MR	CPI
1	100	NA	NA	NA	1	100	NA	NA	NA
2	78.63342	11.09006	9.644019	0.6325	2	92.02731	0.300435	5.829608	1.842645
3	75.27163	12.39806	11.72539	0.604922	3	87.72773	1.333466	8.861876	2.076927
4	66.53544	11.25667	10.03196	12.17593	4	80.92918	1.170873	11.37975	6.520194
5	52.51049	10.15393	17.455	19.88058	5	66.87115	0.97248	16.00525	16.15112
6	50.65314	10.42584	19.6125	19.30853	6	59.61341	1.319532	24.39464	14.67242
7	50.09552	10.4929	20.38939	19.02219	7	57.22085	1.385843	24.72528	16.66802
Mean	67.67138	9.402494	12.69404	10.23209	Mean	77.76995	0.92609	13.02806	8.275904

Notes: PA = Price, apartments (SEK per square meter, real terms); PV = Price, villas (SEK per square meter, real terms); Index = OMXPI Stockholm stock index all shares (nominal terms); MR = monthly average mortgage rates (real terms) and CPI = Consumer Price Index (nominal terms)

Table VIII. Results of estimates of variance decomposition for a seven-month period suggested by Liu and Su (2010), Su (2011), Aye *et al.* (2013) and Lean and Smyth (2014), this can be interpreted as a sign of spiraling movements between the prices. This also means that our findings differ from previous Swedish results (Berg and Lyhagen, 1998), suggesting unidirectional Granger causality running from stock prices to housing prices in the capital, Stockholm. The bidirectional relationship between MR and apartment and villa prices, respectively, is in contrast to *H2*, but in line with Brissimis and Vlassopoulos (2009). The bidirectional relationship between CPI and apartment and villa prices, respectively, is in contrast to *H3*, but in line with Naji Meidani *et al.* (2011).

5. Concluding discussion

This study examines the Granger causal link between the stock market index and housing prices in terms of apartment and villa prices, respectively, by applying a two-stage VECM estimation approach to Swedish data. Two control variables, MR and CPI, were included in our models.

Based on the results of Johansen co-integration tests, a co-integrated relationship was found between the stock market index and housing prices. The results further indicate that the long-run direction of causality between the stock market index and housing prices is bidirectional, indicating a spiraling movement between stock prices and apartment and villa prices, respectively. Dusansky and Koc (2007) have described houses as a dual commodity because they can be seen as both consumption goods and investments. According to the present results, both apartments and villas tend to be characterized as consumption goods as a result of the wealth effect and as investments as a result of the credit-price effect. Moreover, the bidirectional link indicates that financial integration not only increases market efficiency but also gives rise to spillover effects. In other words, the stock and housing markets in Sweden are integrated, indicating that disturbance in one market will be transmitted to the other. The results further indicate bidirectional causation running from MR and CPI, respectively, to housing prices. It should also be noted that the dynamic analysis (i.e. variance decomposition testing) demonstrates that apartment and villa prices respond mainly to themselves. This means that past shocks originating from housing prices themselves account for the greatest variation in future apartment and villa prices.

By focusing on housing prices in terms of apartment and villa prices, respectively, this study provides additional empirical evidence regarding the causal nexus between stock and housing prices. Previous studies, not comparing apartments and villas, have obtained different results for different countries and regions regarding how to classify the relationship between the stock and housing markets (Berg and Lyhagen, 1998; Green, 2002; Kapopoulos and Siokis, 2005; Liu and Su, 2010). Other studies have found a wealth effect in one country and a credit-price effect in a neighboring country (Su, 2011; Lean and Smyth, 2014). Although the main pattern seems to be similar for both apartment and villa prices, there are some differences at the more detailed level, for example, how much future price variation is explained by the stock market index.

The findings regarding the nature of the causality between the stock and housing markets can be useful for several parties. For example, the bidirectional link between the markets indicates that both markets can be exposed to similar economic shocks. As suggested by Chen (2001), Case *et al.* (2005), and Kapopoulos and Siokis (2005), various stakeholders can formulate a general strategy for addressing transmission mechanisms. From the perspective of investors, the notion of this dynamic bidirectional causal relationship is significant for portfolio diversification and can help in inter-market performance forecasting. Changes in the stock and housing markets affect household wealth and creditworthiness, so the present findings may be of interest to banks and other financial institutions in assessing mortgage applications. Banks can improve their household lending policies and, in that way, decrease their credit risks. From the household perspective, it is important to create instruments for hedging against housing price fluctuations originating from the stock market. The findings may also be useful for policymakers addressing market structure and regulatory impediments concerning capital movements among asset markets. Fluctuations in any of these markets can affect each other, possibly influencing household consumption and thereby the economy as a whole.

Admittedly, certain limitations have been identified concerning the data used here. Swedish Property Broker Statistics (2015) do not include apartment and villa transfers that take place without broker involvement, meaning that the statistics used are not comprehensive. Moreover, only monthly data from September 2005 to October 2013 were used for data accessibility reasons. Additional tests on data of different frequencies, such as yearly and/or quarterly, could be conducted in future studies. Another limitation related to data accessibility is that only two control variables, MR and CPI, were included. The use of other control variables with a possible effect on housing prices (i.e. apartment and villa prices) and stock prices, such as households' disposable income and expectations about future income, may improve future studies. In addition, the apartment and villa markets are geographically heterogeneous and spatially dispersed, and these issues could be considered in future studies. Like single measurements, the measurements used here, i.e. apartment and villa prices, entail disadvantages that may affect the results. To overcome this, future studies should preferably use multiple measurements of housing prices in terms of prices and indices (if both measurements are available).

To detect possible nonlinear co-integration between variables, the use of different linear and nonlinear models is also recommended. The volatility of assets and their correlations with other assets during global financial crises may differ from those in normal times, affecting their co-integration patterns as well. This may have an effect on the present results, meaning that they may not be applicable in time periods with different characteristics. The use of more longitudinal data is therefore recommended. Longitudinal studies should preferably be conducted in countries significantly affected by the global financial crisis.

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