Spatial and temporal diffusion of house prices in Sweden

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Abstract

In Sweden, both house prices and household debt have more than doubled over the last two decades. This rapid surge has generated concerns about a housing bubble and the economic consequences that may follow, resulting in a considerable body of research analysing the fundamentals of Swedish house prices. To assess how a bubble or a crisis would ripple over the housing market, it is key to also understand the dynamics of house prices.

This paper examines the spatial and temporal diffusion of house prices in Sweden. The first aim is to empirically determine if regional house prices respond to a change in Stockholm house prices. The second aim is to establish which measure of proximity that gives the most accurate representation for the cross sectional dependence between regions. The purpose is to assess how a change in Stockholm house prices could ripple over Sweden in the event of a bubble or a crisis.

The analysis is performed by estimating two price diffusion models with OLS, using monthly regional real house price data over the period 2005m1 to 2018m12. The results suggest that Stockholm affects house prices in more than half of the other regions contemporaneously, and that regions that are economically or geographically close to Stockholm are more affected than regions far away. Further, the results suggest that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions, resulting in a more reliable analysis of the spatial and temporal diffusion of house prices. Together these results provide important insights for how a change in Stockholm house prices could ripple over Sweden in the event of a bubble or a crisis.

Keywords: house prices, ripple effect, spatial and temporal diffusion, proximity

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1 Introduction

In Sweden, both house prices[1] and household debt have more than doubled over the last two decades. This rapid surge has generated concerns about a housing bubble and the economic consequences that may follow, resulting in a considerable body of research analysing the fundamentals of Swedish house prices (see e.g. Yang, Wang and Campbell, 2010, Bergman and Sørensen, 2012 and Gustafsson, Stockhammar and Österholm, 2015). To assess how a bubble or a crisis would ripple over the housing market, it is key to also understand the dynamics of house prices. Nonetheless, there still appears to be a relatively small body of literature on the spatial and temporal diffusion of house prices in Sweden.

Previous research have investigated the spatial and temporal diffusion of house price movements. It is through cross sectional dependence, house price movements diffuse from one region to another. How fast and to what extent a change in house prices ripples over the housing market depends on structural differences, economic interdependence and information asymmetry (Grossman and Stiglitz, 1976 and Case, Quigley and Shiller, 2001). In the literature of cross sectional dependence, a common approach is to explain the relationship through contemporaneous dependence across space (Whittle, 1954) and thereby relating each cross section unit to its neighbour(s). It is not necessary for proximity to be limited in space, it can also be estimates of economic (Conley, 1999, Pesaran, Schuermann and Weiner, 2004) or social distance[2]. However, few attempts have been made to establish which measure of proximity that gives the most accurate representation for the cross sectional dependence between regions.

The conventional way to analyse dynamics in house prices is by including a dominant region, usually the main economic centre, from where house price movements diffuse (Grossman and Stiglitz, 1976, Case, Quigley and Shiller, 2001, Oikarinen, 2005 and Holly, Pesaran and Yamagata, 2011). The reasoning behind this approach is the assumption that the effects of the business cycle hit the economic centre first and more peripheral areas second[3].

This paper examines the spatial and temporal diffusion of house prices in Sweden. The first aim is to empirically determine if regional house prices respond to a change in Stockholm house prices. The second aim is to establish which measure of proximity that gives the most accurate representation for the cross sectional dependence between regions. The purpose is to assess how a change in Stockholm house prices could ripple over Sweden in the event of a bubble or a crisis. The first hypothesis states three things; (i) Stockholm is the dominant region; (ii) a change in Stockholm house prices affects house prices in the other regions and; (iii) regions that are economically or geographically close to Stockholm are more affected than regions far away. The second hypothesis states that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions.

The method used in this paper is build on the approach developed by Holly, Pesaran and Yamagata (2011). The analysis is performed by estimating two price diffusion models with ordinary least squares (OLS), using monthly seasonally adjusted regional real house

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[1] Henceforth, house prices are referred to as tenant owned apartment and villa prices.

[2] See, for example, Conley and Topa (2002) and Helgers and Buyst (2016).

[3] As macroeconomic shocks cause changes in the level of disposable income, the housing market reacts accordingly.

price data over the period 2005m1 to 2018m12. To establish which measure of proximity that is most accurate, a spatial variable that is dependent either on an economic or geographical measure is included in the second model. Due to different characteristics of tenant owned apartment and villa prices, there is a distinction used between the two types of housing for a more thorough analysis.

The results from the first model suggest that Stockholm is the dominant region and that its prices are long-run forcing all other regions. It is further suggested that Stockholm has a contemporaneous effect on house prices in more than half of the other regions, and that economic and geographical closeness to Stockholm affect how regional house prices respond to a shock to Stockholm house prices. For the second model, the results suggest that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions, resulting in a more reliable analysis of the spatial and temporal diffusion of house prices.

The remainder of this paper is set out as follows: In Section 2, a literature review is given. In Section 3, the method used in this paper is described, after which the data is presented in Section 4. In Section 5, the empirical results are reported which are further discussed in Section 6. Lastly, in Section 7 some conclusions are drawn.

2 Literature review

Previous research have investigated the spatial diffusion of house price movements through cross sectional dependence. In the literature of cross sectional dependence, a common approach is to explain the relationship through contemporaneous dependence across space (Whittle, 1954) and thereby relating each cross section unit to its neighbour(s). The idea of a spatial relationship between regional house prices may originate from Tobler's (1970) First Law of Geography: "everything is related to everything else, but near things are more related than distant things". One of the first analysis of the spatial diffusion of house prices was by Can (1990). Can introduced a precise geographic perspective when modelling the determination process of house prices by extending the price regression to incorporate spatial neighbourhood dynamics. As a result, Can was able to mirror the housing market more precisely.

It is not necessary that proximity is limited to proximity in space. There exists numerous different estimates of proximity such as economic (Conley, 1999, Pesaran, Schuermann and Weiner, 2004) or social distance[4]. In an intranational context, the proximity between one region and another can be measured in terms of available transport infrastructure. Hence, the possibility to commute easily between two regions may be a better indicator of economic proximity and interdependence rather than proximity in space[5]. The idea of a measurement accounting for both economic and geographical distance was first introduced by Isard (1954) with the Gravity Theory. Isard argued that if one account for both the economic potential and geographic distance between two regions, or countries, one could predict economic flows and trade patterns. One limitation of the Gravity Theory, which was also pointed out by Isard himself, is that it do not account for barriers of trade[6].

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[4] See, for example, Conley and Topa (2002) and Helgers and Buyst (2016).

[5] See, for example, Holly and Petrella (2008) and Horvath (1998, 2000).

[6] A trade barrier can be anything ranging from a geographical hinder to traditional tariffs. For example, in a regional context, it can be transportation costs or lack of infrastructure.

More recently, research have examined both the spatial and temporal diffusion of house prices. Studies that consider both dimensions are for example those by van Dijk, Franses, Paap and van Dijk (2007) and Holly, Pesaran and Yamagata (2010, 2011). These studies developed models that allow for stochastic trends, cointegration, cross-equation correlations and latent-class clustering of regions. Van Dijk et al. (2007) applied their panel model on quarterly data comprising 76 regions for the Netherlands. Through their research, van Dijk et al. found evidence for the existence of two cluster of regions; the first containing mainly rural regions close to the major cities and the second containing both larger cities and more remote rural regions. These clusters had in turn different house price dynamics, where a price change in the capital - Amsterdam - first disseminated to cluster one and then to cluster two. As such, van Dijk et al. were able to capture the ripple effect in Dutch house prices. Holly, Pesaran and Yamagata (2010) considered to which extent changes in real house prices in the U.S. are driven by real per capita disposable income by using State level data. Through their research they found support for the hypothesis that real house prices have been rising in line with real income as well as evidence for spatial effects in the U.S. house prices. Later, Holly, Pesaran and Yamagata (2011) provided a method to analyse the spatial and temporal diffusion of shocks in the UK, with London as the dominant region. Their results suggest that house prices within each region respond directly to a shock to London house prices and that the shock is magnified both by the inner dynamics of each region and by the synergy with neighbouring regions.

The conventional way to analyse dynamics in house prices is by including a dominant region towards which house prices tend to gravitate. There are different approaches for selecting the dominant region, where the easiest way is to simply assume which region that is dominant (Giussani and Hadjimatheou, 1991, MacDonald and Taylor, 1993 and Meen, 1996), but it can also be proven by using different statistical methods (Berg, 2002, Oikarinen, 2005 and Holly, Pesaran and Yamagata, 2011). Through a statistical approach, Berg (2002) proved that a change in the real house prices in Stockholm will ripple over Sweden. Similarly, Holly, Pesaran and Yamagata (2011) established that London is the dominant region within the UK and that its prices are long-run forcing all other regions. A common method when motivating a dominant region is to establish cointegration- and cotrending relationships. Two of the earliest and best known studies that examined the cointegrating relationship of house prices between regions were by MacDonald and Taylor (1993) and Alexander and Barrow (1994). MacDonald and Taylor examined the short-term dynamics and the long-run equilibrium of British house prices and found numerous cointegrating relationships as well as evidence for the ripple effect. Similarly, Alexander and Barrow found support, albeit weaker, for the existence of long-run relationships between regional house prices in the UK. In contrast, Abbot and De Vita (2011) found no evidence of a long-run convergence among regional house prices or of an equilibrium relationship towards which British house prices tend to gravitate.

Even if evidence is found for a region to be dominant, it do not necessarily imply that it is uniquely so. For instance, Yang and Turner (2016) suggest that it is possible to observe both a dominant region and sub-dominant regions simultaneously. Another difficulty is that the chosen dominant region might be dominated by a region outside the sample. As revealed by Holly, Pesaran and Yamagata (2011), New York house prices are significant drivers of house prices in the UK through London. Thus, London is the only dominant region as far as UK house prices are concerned.

House prices are commonly not uniformly distributed across regions within a country. As such, the housing market should not be viewed as a single national market but rather as multiple regional ones. Still, regional house prices are likely to correlate with that of changes in the dominant region with a lead-lag relationship. This as the housing market is characterised by large transaction costs, narrow markets and high costs for obtaining information, causing lag relationships in house price movements. In this paper the relationship between house price movements in Stockholm and the ripple effect that follows is of interest. There are several reasons for why this ripple effect would affect regions differently, including structural differences, economic interdependence and information asymmetry.

The first possible explanation to the lead-lag relationship between Stockholm and other Swedish regions is the difference in timing of the business cycle. Usually, the main economic centre(s) has a high concentration of financial services. Thus, these regions reacts first to a shock and the remaining regions second[7]. (Oikarinen, 2005)

The second explanation to the lead-lag relationship is that of Grossman and Stiglitz (1976) who assumed that the housing market has two types of actors; the informed and the uniformed. The informed actor is, in opposite to the uninformed, assumed to be well acquainted with the functioning of the housing market. Hence, if there exist a high concentration of informed actors in a certain region there will be a higher responsiveness to changes in house prices in the centre. An additional assumption is that the share of informed actors is greater in the central areas than the more peripheral ones, implying that changes in house prices will ripple from the largest region to the smallest. The idea of informational asymmetries is further supported by Clapp, Dolde and Tirtiroglu (1995). Their research suggest that information gathering is subject to economics of scale, implying that more densely populated regions would acquire information faster and of higher quality than that of sparsely populated ones. From this, it is expected that changes in house prices in the centre will ripple from the densely populated regions to the sparsely populated ones.

Taken together, the first and second explanation are based on regional differences in economic structure and information accessibility. As such, it is reasonable to assume that the causal relationship is more clear for neighbouring regions, as their housing markets can be seen as substitutes. It is also possible that house price changes in one region cause changes in a region geographically far away. This in accordance with the so called "wealth effect", i.e. change in consumption behaviour that accompanies a change in perceived wealth. Both Case, Quigley and Shiller (2001) and Benjamin, Chinloy and Jud (2004) found support for the wealth effect of housing; higher house prices cause higher levels of consumption. Higher consumption in one region leads to higher demand for products and services in another. Consequently, employment and income rises in the other regions which increase the demand for housing. Thus, a rise in house prices in one region can cause house prices to rise in other regions. Noteworthy, as demand increases it may not spread evenly, factors such as production capabilities, infrastructure and know-how are crucial for how regional trade patterns develop.

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[7] As macroeconomic shocks cause changes in the level of disposable income, the housing market reacts accordingly.

In view of all that has been mentioned, there are reasons to believe that Stockholm is the dominant region in Sweden and that a shock to Stockholm house prices should affect house prices in the other regions. The reviewed papers further support the notion that regions that are economically or geographically close to Stockholm are more affected than regions far away. The papers reviewed makes no distinction between tenant owned apartment and villa prices. As such, none of them accounts for their different characteristics in the housing market[8]. For that reason, this paper choose to separate the two types of housing to further investigate their spatial and temporal diffusion properties.

In the literature, the measure of proximity is of importance to accurately describe the interrelationship between regions. Despite its importance, none of the papers reviewed goes beyond discussing which proximity to use. Thus, this paper examines which measure of proximity[9] that gives the most accurate representation for the cross sectional dependence between regions. As suggested by Grossman and Stiglitz (1976) and Case, Quigley and Shiller (2001), structural differences, economic interdependence and information asymmetry can explain the interrelationship between regions and how house prices diffuse from one region to another. This implies that a measure of economic proximity should be better than geographical closeness at explaining the cross sectional dependence between regions.

3 Methodology

The two price diffusion models in this paper are based on the model developed by Holly, Pesaran and Yamagata (2011). The first model is calibrated to empirically determine if regional house prices respond to a shock to Stockholm house prices. The second model is developed to include a spatial variable that is dependent either on an economic or geographical measure. The aim is to establish which measure of proximity that gives the most accurate representation for the cross sectional dependence between regions.

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[8] For example, in turnover and price volatility.

[9] Either an economic or geographical measure.

3.1 A price diffusion model

The price diffusion model developed by Holly, Pesaran and Yamagata (2011) is extended to include several control variables (oil price = OP, real mortgage rate = RR and gross regional product = GRP_i) and to distinguish between tenant owned apartment, a, and villa, v, prices. The spatial variable for region i is further developed by introducing an economic weighting perspective. The diffusion of (log) house prices, p_{ijt}, are indexed by house type $j = a, v$, time $t = 1, 2, ..., T$ and region $i = 0, 1, ..., N$. There is *a priori* reason to believe that Stockholm ($i = 0$) is the dominant region in the sense that a change in its house prices affects the other regions both contemporaneously and over time, but a change in the other regions have no effect on region 0. However, the lag effect of a shock to neighbouring regions are allowed to affect the dominant region. The price equation is given by:

$$\begin{aligned}\Delta p_{0jt} &= \phi_{0js}(p_{0j,t-1} - \bar{p}^s_{0j,t-1}) + \alpha_{0j} + \beta_{0j1}\Delta p_{0j,t-1} + \beta_{0j2}\Delta\bar{p}^s_{0j,t-1} \\ &\quad + \beta_{0j3}\Delta OP_{t-1} + \beta_{0j4}\Delta RR_{t-1} + \beta_{0j5}\Delta GRP_{0,t-1} + \varepsilon_{0jt}\end{aligned} \tag{1}$$

and for the remaining regions:

$$\begin{aligned}\Delta p_{ijt} &= \phi_{ij0}(p_{ij,t-1} - p_{0j,t-1}) + \phi_{ijs}(p_{ij,t-1} - \bar{p}^s_{ij,t-1}) + \alpha_{ij} \\ &\quad + \beta_{ij1}\Delta p_{0jt} + \beta_{ij2}\Delta p_{0j,t-1} + \beta_{ij3}\Delta p_{ij,t-1} + \beta_{ij4}\Delta\bar{p}^s_{ij,t-1} \\ &\quad + \beta_{ij5}\Delta OP_{t-1} + \beta_{ij6}\Delta RR_{t-1} + \beta_{ij7}\Delta GRP_{i,t-1} + \varepsilon_{ijt}\end{aligned} \tag{2}$$

for $i = 1, 2, ..., N$. $\bar{p}^s_{ijt}$ denotes the spatial variable for region i and is given by:

$$\bar{p}^s_{ijt} = \sum_{k=0}^{N} s_{ik}p_{kjt}, \text{ with } \sum_{k=0}^{N} s_{ik} = 1, \text{ for } i = 0, 1, ..., N. \tag{3}$$

The weights, s_{ik}, are developed by using both a contiguity and an economic measure. If region i shares a border with another region, k, they are considered neighbours. The weights, s_{ik}, are equal to each neighbour's GRP divided by the total sum of the neighbours' GRP[10]. Hence, $\bar{p}^s_{ijt}$ can be viewed as a weighted neighbourhood average price for region i, where the weights are proportional to the economic size of each neighbour. The weights, s_{ik}, are arranged in the form of a spatial matrix, S.

The model allows for the price equations to be error correcting, even though the empirical validity of this specification needs to be further investigated. By assuming Stockholm to be the dominant region, its house prices are allowed to be cointegrated with the weighted average in the neighbourhood of Stockholm, $\bar{p}^s_{0jt}$, while the other regions are allowed to be cointegrated both with Stockholm and with their neighbours. The error correcting coefficients, ϕ_{ij0} and ϕ_{ijs}, are assumed to be significant if a long-run interrelationship is present. To test the validity of such a modelling, a pair-wise cointegration test between Stockholm and region i following the method of Johansen (1991) is applied below. Also, instead of just carry out the empirical analysis on the maintained assumption that Stockholm is the dominant region it will be tested by estimating the error correction coefficients for each price pair that includes Stockholm.

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[10] $GRP_k/\sum_{k=0}^{N} GRP_k$

The above specification of the price equation for the i^{th} region implies that when conditional on the dominant region's price variable and lag effect, the shock, ε_{ijt}, is generally independently distributed across all regions. To ensure that Δp_{0jt} is weakly exogenous in the price equations for the other regions, the method proposed by Wu (1973)[11] is applied to test for exogeneity. Following Wu's method, denote the OLS residual from equation (1) by:

$$\begin{aligned}\hat{\varepsilon}_{0jt} &= \Delta p_{0jt} - \hat{\phi}_{0js}(p_{0j,t-1} - \bar{p}^s_{0j,t-1}) - \hat{\alpha}_{0j} - \hat{\beta}_{0j1}\Delta p_{0j,t-1} - \hat{\beta}_{0j2}\Delta\bar{p}^s_{0j,t-1} \\ &\quad - \hat{\beta}_{0j3}\Delta OP_{t-1} - \hat{\beta}_{0j4}\Delta RR_{t-1} - \hat{\beta}_{0j5}\Delta GRP_{0,t-1}\end{aligned} \tag{4}$$

and run the augmented regression:

$$\begin{aligned}\Delta p_{ijt} &= \phi_{ij0}(p_{ij,t-1} - p_{0j,t-1}) + \phi_{ijs}(p_{ij,t-1} - \bar{p}^s_{ij,t-1}) + \alpha_{ij} \\ &\quad + \beta_{ij1}\Delta p_{0jt} + \beta_{ij2}\Delta p_{0j,t-1} + \beta_{ij3}\Delta p_{ij,t-1} + \beta_{ij4}\Delta\bar{p}^s_{ij,t-1} \\ &\quad + \beta_{ij5}\Delta OP_{t-1} + \beta_{ij6}\Delta RR_{t-1} + \beta_{ij7}\Delta GRP_{i,t-1} + \lambda_{ij}\hat{\varepsilon}_{0jt} + \varepsilon_{ijt}\end{aligned} \tag{5}$$

and then apply a simple Wald-test to test the hypothesis that $\lambda_{ij} = 0$ for each i separately.

A set of tests and methods are applied to investigate the presence of non-stationarity, serial correlation, heteroscedasticity, multicollinearity and outliers. First, a simple Dickey-Fuller test is applied on the logarithm of the price series in first difference to establish the absence of trend components[12]. Secondly, as the model only allows for the first order lag, there is a possibility of dynamics in the error term. As Newey-West standard errors can solve both possible serial correlation and heteroscedasticity, they are applied to all regressions[13]. Thirdly, with the purpose of ruling out multicollinearity a Variance Inflation Factor (VIF) test is applied on each model as well as a simple correlation test for the control variables.[14] Lastly, as the dataset covers the period of the Great Recession, the likeliness of outliers is fairly high. As such, correction dummies will be included if outliers exists.

3.2 A price diffusion model; economic and geographical proximity

This price diffusion model is a further extended version of the model in Subsection 3.1. The focus of the model is changed to solely examine which measure of proximity that gives the most accurate representation for cross sectional dependence between regions. This is done by including a spatial variable that is dependent either on an economic, e, or geographical, g, measure. The shock does not originate from any assumed dominant region but rather from a weighted nation-wide change in house prices. For consistency, the two error correction coefficients, ϕ_{ij0} and ϕ_{ijs}, are included as in the previous model, but now also indexed by $q = e, g$. The diffusion of (log) prices, p_{ijt}, are indexed by house type $j = a, v$, time $t = 1, 2, ..., T$ and region $i = 0, 1, ..., N$. The price equation is given by:

$$\begin{aligned}\Delta p_{ijt} &= \phi_{ijq0}(p_{ij,t-1} - p_{0j,t-1}) + \phi_{ijqs}(p_{ij,t-1} - \bar{p}^s_{ij,t-1}) \\ &\quad + \alpha_{ijq} + \beta_{ijq1}\Delta\bar{p}^q_{ij,t-1} + \beta_{ijq2}\Delta p_{ij,t-1} \\ &\quad + \beta_{ijq3}\Delta OP_{t-1} + \beta_{ijq4}\Delta RR_{t-1} + \beta_{ijq5}\Delta GRP_{i,t-1} + \varepsilon_{ijqt}\end{aligned} \tag{6}$$

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[11] This test is asymptotically equivalent to using Hausman's (1978) procedure.

[12] These are available from the authors on request.

[13] A Breusch–Godfrey test is presented in Table 7a and 7b in Appendices, where it is shown that serial correlation is absent for almost all price equations.

[14] These are available from the authors on request.

where $\bar{p}^q_{ijt}$ denotes the spatial variable for region i (the other spatial variable $\bar{p}^s_{ijt}$ is calculated according to equation (3)). The variable is dependent either on an economic or a geographical measure, $q = e, g$, and is given by:

$$\bar{p}^q_{ijt} = \sum_{i=0}^{N} w_{iq} p_{ijt}, \text{ with } \sum_{i=0}^{N} w_{iq} = 1, \text{ for } i = 0, 1, ..., N. \tag{7}$$

The economic weights, w_{ie}, are constructed by taking the average $G\bar{R}P_i$ over the sample period for region i and divide it by an adjusted average $G\bar{D}P_i$[15]. As such, the size of region i affects the weights assigned to the other regions. To calculate the geographical weights, w_{ig}, the distances from each region to all other regions are retrieved via Beräkna Avstånd (n.d)[16]. For measurement purpose, all distances from region i are adjusted by taking 1 over each distance. The geographical weights are then calculated by dividing each adjusted distance for region i by the sum of the adjusted distances. The weights, w_{iq}, are arranged in the form of two separate spatial matrices, W_e and W_g. The tests and methods used in Subsection 3.1 are applied to this model as well.

4 Data

The Swedish agency Svensk Mäklarstatistik AB publishes both national and regional nominal house price statistics for Sweden. The published data are collected on a monthly basis from Swedish real estate agencies where more than 95 percent of all transactions are reported[17]. The dataset in this study covers both tenant owned apartment and villa prices over the sample period 2005m1 to 2018m12 ($T = 168$ months)[18] for $N = 21$ Swedish regions[19]. Hence, the panel database includes both a fairly large cross section dimension N and time dimension T.

The models presented in Section 3 includes the control variables: oil price (Federal Reserv Bank of St. Louis, 2019), real mortgage rate[20] (OECD, 2019 and SCB, 2019) and gross regional product[21] (GRP) (SCB, 2018). The oil price is included as it mirrors the market, and the real mortgage rate as it indicates how households allocate their resources. Following Helgers and Buyst (2016), the GRP is included as regional house prices follow macroeconomic developments. Also, the GRP can function as a proxy of disposable income which in turn can be translated to purchasing power. Additionally, to steer out possible noise from neighbouring regions, a weighted variable for house prices in the neighbourhood is included. Real prices are obtained by deflating all nominal data with the consumer price index with a fixed interest rate (CPIF) (SCB, 2019). All data are seasonally adjusted using the Census X-12 algorithm[22], with the exception of the real mortgage rate as there is no clear seasonal pattern in this variable. To get stationary

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[15] The adjusted $G\bar{D}P_i$ is defined by: $G\bar{D}P_i = G\bar{D}P - G\bar{R}P_i$

[16] The distances are measured from one regional capital to another. See Table 4 in Appendices.

[17] Svensk Mäklarstatistik AB process the data together with SCB to ensure credibility and high quality statistics.

[18] The latest available period for regional monthly data.

[19] The country is divided into 21 regions following Sweden's administrative division "län".

[20] Calculated by using Fisher's hypothesis: $r = n - i$, where r is the real mortgage rate, n is the nominal mortgage rate and i is inflation (CPI).

[21] As there is only quarterly data available, the data have been interpolated using STATA 15.

[22] Available in EViews 7.1.

variables, both the natural logarithm and the first difference have been applied when needed.

As suggested by the literature, economic centre(s) and population density are significant factors in the diffusion of house prices. To illustrate where the major economic centres (regions) are located in Sweden, each region's average GRP for the period is visualised in Figure 4 (a) in Appendices. The population density is portrayed in Figure 4 (b) in Appendices. Taken together, these figures show that the three largest regions, both economically and population wise, are Stockholm, Västra Götaland and Skåne. Each of these regions can be expected to act as a local dominant region for its surrounding regions[23].

Table 5 in Appendices presents the descriptive statistics for the monthly change of real house prices for each region. Interestingly, there is a clear difference between the volatility of real house price changes across regions, where the three largest regions have a lower volatility and a lower average growth rate than the other regions. Also, when comparing the descriptive statistics for price changes between the two types of housing, there are clear differences. Tenant owned apartment prices have a higher volatility on average than villa prices. However, in the three largest regions, the volatility in villa prices are higher than for tenant owned apartment prices. This is also true for Uppsala and Gotland. Another observation is that the average growth rate of tenant owned apartment prices is much higher than the average of villa prices across all regions, with the exception of Jämtland and Norrbotten. Surprisingly, changes in tenant owned apartment prices have a negative growth rate in Jämtland. The difference in volatility between regions and house type might be explained by the difference in data quality. Larger regions with a relatively balanced share of tenant owned apartments and villas (see Table 6 in Appendices) will generate less volatile data as their monthly sample size is greater.

The logarithm of real house prices in SEK are shown in Figure 5a and 5b in Appendices. These figures suggest an upward trend in real house prices over the sample period, with tenant owned apartment prices rising faster than villa prices for all regions. Non-surprisingly, real villa prices are higher in levels than real tenant owned apartment prices. The figures further suggest that the regional house price series could be cointegrated.

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[23] See Table 4 in Appendices for each regions' neighbourhood.

5 Empirical results

5.1 Cointegrating properties of Swedish house prices

To confirm the assumption that Stockholm is the dominant region, two things needs to be established; (i) a cointegrated relationship between Stockholm and region i house prices and; (ii) prices in Stockholm are long-run forcing all other regions[24].

The trace statistics for cointegration between Stockholm and region i house prices are presented in Table 7 in Appendices. The pair-wise cointegration test is computed based on a bivariate VAR specification in p_{0jt} and p_{ijt} for $j = a, v$ and $i = 1, 2, ..., N$. The null hypothesis is rejected at the 1 % significance level in all cases, for both tenant owned apartment and villa prices. Hence, these results support the notion that Stockholm house prices are cointegrated with house prices in all other regions. The results further motivate the error correction specification in equation (1) and (2). Overall, the cointegrated relationship between Stockholm and region i house prices suggests that at least one of the error correction coefficients should be statistically significant in at least one of the price equations.

The estimates of the error correction coefficients for each price pair are reported in Table 1 below (see Table 8a and 8b in Appendices for complete tables). Column 2 and 4 provide the estimates of $\hat{\phi}_{0ji}$ which captures the effect of deviations of Stockholm house prices from region i, while Column 3 and 5 provide estimates of $\hat{\phi}_{ij0}$ which captures the effect of deviations of region i house prices from Stockholm. Column 3 and 5 are highlighted as these coefficients address the hypothesis.

As shown in Column 2, none of the error corrections terms are significant in the Stockholm equation, with the exception of Västra Götaland and Gävleborg. Similar results are shown in Column 4, where none of the error corrections terms are significant in the Stockholm equation, with the exception of Södermanland, Gävleborg and Jämtland. In Column 3 and 5, all the error correction terms are significant in the equations for all other regions at the 10 % significance level or less. These results are consistent with the view of Stockholm as the dominant region and that its prices are long-run forcing all other regions. Noteworthy, the long-run forcing effect of Stockholm is greater than that of all exceptions in Column 2 and 4, supporting Stockholm's dominant position.

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[24] For long-run convergence, both cointegration and cotrending is necessary. For simplicity, cotrending is assumed based on that Sweden is a small country with the same underlying fundamentals for all regions.

Table 1: Error correction coefficients in cointegrating bivariate VAR model

	Tenant owned apartment		Villa	
Region (i)	EC Coeff. for Sthlm Equation ($\hat{\phi}_{0ai}$)	EC Coeff. for region i Equation ($\hat{\phi}_{ia0}$)	EC Coeff. for Sthlm Equation ($\hat{\phi}_{0vi}$)	EC Coeff. for region i Equation ($\hat{\phi}_{iv0}$)
Uppsala	$-.02$	$-.17^{***}$	$-.03$	$-.98^{***}$
Södermanland	$.01$	$-.34^{***}$	$-.10^{**}$	$-.57^{***}$
Östergötland	$-.00$	$-.16^{***}$	$-.05$	$-.62^{***}$
Jönköping	$.01$	$-.20^{***}$	$-.01$	$-.65^{***}$
Kronoberg	$-.01$	$-.31^{***}$	$-.02$	$-.74^{***}$
Kalmar	$.00$	$-.45^{***}$	$.02$	$-.32^{***}$
Gotland	$.03$	$-.57^{***}$	$-.00$	$-.93^{***}$
Blekinge	$-.02$	$-.86^{***}$	$-.02$	$-.43^{***}$
Skåne	$-.02$	$-.09^{**}$	$-.02$	$-.15^{**}$
Halland	$-.00$	$-.57^{***}$	$-.06$	$-.64^{***}$
Västra Götaland	$-.10^{***}$	$-.48^{***}$	$-.01$	$-.63^{***}$
Värmland	$.00$	$-.20^{***}$	$-.01$	$-.50^{***}$
Örebro	$-.02$	$-.23^{***}$	$.01$	$-.71^{***}$
Västmanland	$.01$	$-.56^{***}$	$-.02$	$-.30^{***}$
Dalarna	$.00$	$-.18^{***}$	$-.03$	$-.40^{***}$
Gävleborg	$-.14^{***}$	$-.63^{***}$	$-.10^{*}$	$-.92^{***}$
Västernorrland	$.01$	$-.56^{***}$	$.02$	$-.59^{***}$
Jämtland	$.01$	$-.84^{***}$	$-.04^{*}$	$-.94^{***}$
Västerbotten	$-.02$	$-.10^{*}$	$-.01$	$-.58^{***}$
Norrbotten	$-.01$	$-.15^{***}$	$-.04$	$-.50^{***}$

Notes: For the Stockholm equation "EC Coeff." is the estimate of ϕ_{0ji}, in equation $\Delta p_{0jt} = \phi_{0ji}(p_{0j,t-1} - p_{ij,t-1}) + \beta_{0j1}\Delta p_{0j,t-1} + \beta_{0j2}\Delta p_{ij,t-1} + \beta_{0j3}\Delta OP_{t-1} + \beta_{0j4}\Delta RR_{t-1} + \beta_{0j5}\Delta GRP_{0,t-1} + \varepsilon_{0ijt}$. For the other regions it is given by the estimate of ϕ_{ij0} in equation $\Delta p_{ijt} = \phi_{ij0}(p_{ij,t-1} - p_{0j,t-1}) + \beta_{ij1}\Delta p_{0j,t-1} + \beta_{ij2}\Delta p_{ij,t-1} + \beta_{ij3}\Delta OP_{t-1} + \beta_{ij4}\Delta RR_{t-1} + \beta_{ij5}\Delta GRP_{i,t-1} + \varepsilon_{i0jt}$. Intercepts are included in all the regressions. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. See Table 8a and 8b in Appendices for complete tables.

5.2 Estimates of regional house price equations

The estimates of a change in regional house prices are presented in Table 2a and 2b below (see Table 9a and 9b in Appendices for complete tables). Column 4 and 5 are highlighted as their coefficients address the hypothesis.

The reported results give little evidence for the hypothesis that Stockholm affects house prices in the other regions. Nevertheless, if the reported results in Table 2a and 2b are combined, the contemporaneous effect of Stockholm is statistically significant in more than half of the regions and is thereby partially in line with the first hypothesis. As such, the contemporaneous effect of a shock to Stockholm on the other regions is further visualised in Figure 1.

Table 2a: Estimation results of price equations; tenant owned apartment

Region (i)	EC1 ($\hat{\phi}_{ia0}$)	EC2 ($\hat{\phi}_{ias}$)	Sthlm Cont. Effect ($\hat{\beta}_{ia1}$)	Sthlm Lag Effect ($\hat{\beta}_{ia2}$)	Own Lag Effect ($\hat{\beta}_{ia3}$)	Neighb. Lag Effect ($\hat{\beta}_{ia4}$)
Stockholm		$-.01$			$-.31^{***}$	.02
		(.02)			(.11)	(.03)
Uppsala	$-.44^{***}$	$.28^{***}$	.12	.07	$-.29^{***}$	$.20^{***}$
	(.07)	(.06)	(.23)	(.16)	(.07)	(.05)
Södermanland	$-.67^{***}$	$.30^{**}$	$.79^{**}$	$-.27$	$-.35^{***}$	$.30^{**}$
	(.17)	(.12)	(.34)	(.34)	(.10)	(.15)
Östergötland	$-.36^{***}$	$.17^{*}$	$-.48$	.03	$-.42^{***}$	$.31^{***}$
	(.12)	(.09)	(.42)	(.36)	(.11)	(.11)
Jönköping	$-.36^{***}$	$.17^{**}$	.35	$-.08$	$-.34^{***}$	$.20^{**}$
	(.09)	(.07)	(.40)	(.27)	(.07)	(.07)
Kronoberg	$-.93^{***}$	$.43^{***}$	.12	.24	$-.24^{***}$	$.19^{**}$
	(.16)	(.10)	(.54)	(.39)	(.09)	(.09)
Kalmar	$-.57^{***}$	.10	$.86^{*}$	$-.17$	$-.29^{***}$	$.45^{**}$
	(.14)	(.10)	(.50)	(.54)	(.09)	(.17)
Gotland	$-.59^{***}$	.05	.38	$-.26$	$-.10$	$-.03$
	(.10)	(.10)	(.35)	(.38)	(.09)	(.07)
Blekinge	$-.93^{***}$	.05	.90	.37	.03	.06
	(.12)	(.10)	(.55)	(.49)	(.09)	(.11)
Skåne	$-.15^{***}$	$-.13^{**}$	$.51^{***}$	.03	$-.27^{***}$	.07
	(.04)	(.06)	(.13)	(.14)	(.08)	(.07)
Halland	$-.63^{***}$	.05	.25	$-.24$	$-.14^{*}$	.12
	(.13)	(.08)	(.27)	(.30)	(.09)	(.08)
Västra Götaland	$-.53^{***}$	.03	.40	.22	.04	.07
	(.08)	(.07)	(.25)	(.14)	(.10)	(.08)
Värmland	$-.41^{***}$	$.18^{*}$	.02	$-.63^{*}$	$-.35^{***}$	.13
	(.12)	(.09)	(.39)	(.36)	(.07)	(.10)
Örebro	$-.41^{***}$	.14	$.74^{**}$	$-.33$	$-.32^{***}$	.10
	(.13)	(.10)	(.33)	(.31)	(.08)	(.09)
Västmanland	$-.53^{***}$	$-.02$	.36	$-.20$	$-.19^{**}$	$.23^{***}$
	(.11)	(.05)	(.31)	(.41)	(.07)	(.08)
Dalarna	$-.32^{**}$	.14	.03	$-.70^{*}$	$-.34^{***}$	.13
	(.13)	(.12)	(.42)	(.40)	(.09)	(.15)
Gävleborg	$-.65^{***}$	.00	.16	$-.16$	$-.04$	.02
	(.11)	(.05)	(.19)	(.16)	(.09)	(.08)
Västernorrland	$-.81^{***}$	$.27^{**}$	$-.01$	.58	$-.19$	$.32^{***}$
	(.13)	(.12)	(.50)	(.38)	(.06)	(.10)
Jämtland	$-.82^{***}$	$-.03$	.14	$-.16$	$-.03$	$-.11$
	(.20)	(.14)	(.69)	(.73)	(.10)	(.10)
Västerbotten	$-.22^{**}$	.10	.36	.11	$-.28^{***}$	.05
	(.09)	(.06)	(.36)	(.29)	(.08)	(.07)
Norrbotten	$-.26$	.11	$.80^{*}$	.59	$-.40^{***}$	$-.00$
	(.16)	(.15)	(.44)	(.46)	(.08)	(.12)

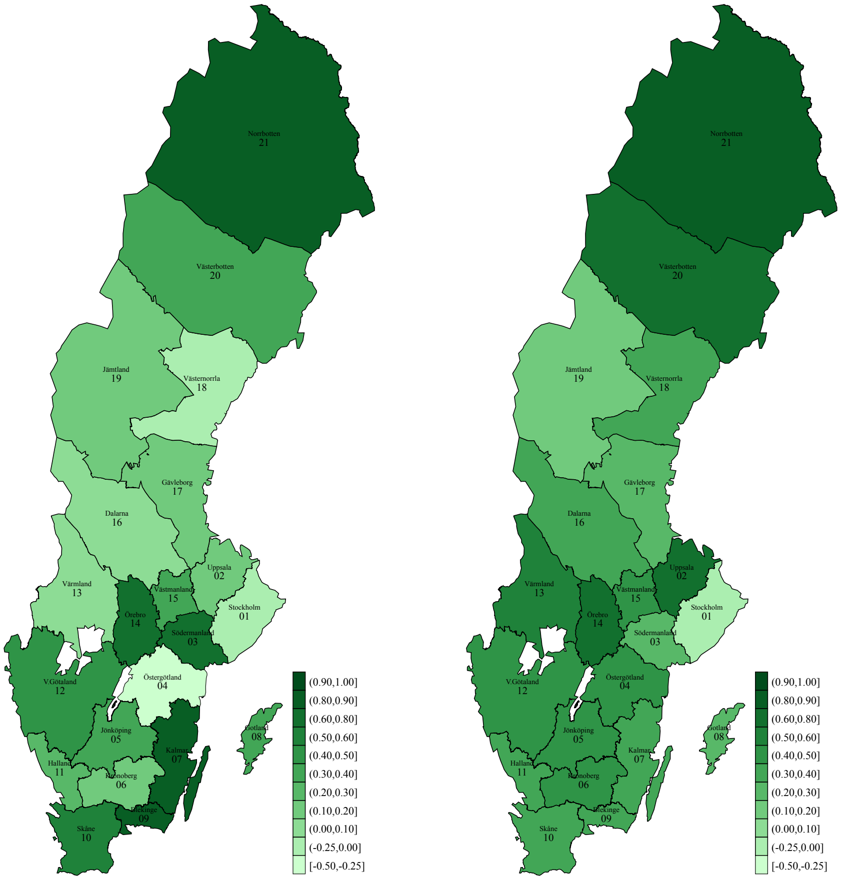
Notes: This table reports estimates based on equation (2) for $j = a$ and $i = 1, 2, ..., N$. For $i = 0$, denoting the Stockholm equation, there is an additional *a priori* restrictions, $\phi_{0a0} = \beta_{0a1} = 0$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. See Table 9a in Appendices for complete table.

Table 2b: Estimation results of price equations; villa

Region (i)	EC1 ($\hat{\phi}_{iv0}$)	EC2 ($\hat{\phi}_{ivs}$)	Sthlm Cont. Effect ($\hat{\beta}_{iv1}$)	Sthlm Lag Effect ($\hat{\beta}_{iv2}$)	Own Lag Effect ($\hat{\beta}_{iv3}$)	Neighb. Lag Effect ($\hat{\beta}_{iv4}$)
Stockholm		$-.24^{***}$			$-.24^{***}$	$-.05$
		(.07)			(.08)	(.05)
Uppsala	-1.2^{***}	.08	$.72^{***}$	$-.22$	$.14^{*}$	.14
	(.15)	(.15)	(.26)	(.30)	(.08)	(.13)
Södermanland	$.46^{***}$	$-.21^{**}$	.26	.18	$-.21^{***}$	$-.01$
	(.11)	(.09)	(.16)	(.17)	(.08)	(.07)
Östergötland	$-.65^{***}$	$-.03$	$.46^{**}$	$-.13$	$-.03$	.23
	(.10)	(.13)	(.20)	(.21)	(.10)	(.10)
Jönköping	$-.47^{***}$	$-.43^{**}$	.40	$-.15$	.04	.01
	(.13)	(.17)	(.25)	(.26)	(.11)	(.16)
Kronoberg	$-.15$	$-.74^{***}$	.41	$-.02$	.02	$.44^{***}$
	(.14)	(.17)	(.27)	(.02)	(.08)	(.17)
Kalmar	$-.18$	$-.20$	.32	.37	$-.18^{*}$	$-.08$
	(.12)	(.16)	(.26)	(.28)	(.09)	(.15)
Gotland	$-.70^{***}$	$-.30^{***}$	.22	$-.08$	$-.02$	$-.08$
	(.14)	(.11)	(.43)	(.41)	(.07)	(.11)
Blekinge	$-.07$	$-.64^{***}$	.39	$-.04$	$-.09$	$-.08$
	(.12)	(.17)	(.26)	(.26)	(.08)	(.18)
Skåne	$-.16^{***}$	.00	$.35^{**}$	$.34^{**}$	$-.41^{***}$	.06
	(.06)	(.09)	(.16)	(.14)	(.08)	(.07)
Halland	$-.54^{***}$	$-.29^{*}$	.36	$-.15$	.00	$-.12$
	(.11)	(.17)	(.29)	(.23)	(.10)	(.15)
Västra Götaland	$-.66^{***}$	.04	$.50^{***}$	$-.13$	.00	.14
	(.09)	(.17)	(.18)	(.20)	(.12)	(.11)
Värmland	$-.33^{***}$	$-.25^{*}$	$.53^{**}$	.11	$-.18^{**}$	.20
	(.11)	(.15)	(.25)	(.23)	(.07)	(.15)
Örebro	$-.64^{***}$	$-.12$	$.63^{**}$	.11	$-.13$	$.28^{*}$
	(.12)	(.18)	(.26)	(.24)	(.09)	(.15)
Västmanland	$-.92^{***}$	$.73^{***}$	$.46^{**}$	$-.19$	$-.37^{***}$	$.59^{***}$
	(.16)	(.17)	(.22)	(.22)	(.09)	(.15)
Dalarna	$-.36^{***}$	$-.03$	.33	.06	$-.32^{***}$	$.16^{*}$
	(.12)	(.10)	(.21)	(.21)	(.08)	(.09)
Gävleborg	$-.77^{***}$	$-.23$	.22	$-.45^{***}$	.02	.24
	(.15)	(.18)	(.14)	(.16)	(.09)	(.15)
Västernorrland	$-.56^{***}$	$-.04$	.31	.30	$-.22^{***}$	$-.03$
	(.16)	(.13)	(.27)	(.30)	(.08)	(.11)
Jämtland	$-.83^{***}$	$-.11$	.14	$-.75$	$-.05$	$.46^{**}$
	(.25)	(.26)	(.51)	(.48)	(.08)	(.22)
Västerbotten	$-.62^{***}$	.02	$.65^{*}$	$-.02$	$-.07$	$.25^{*}$
	(.14)	(.16)	(.34)	(.27)	(.08)	(.14)
Norrbotten	$-.40^{***}$	$-.26^{***}$	$.86^{***}$	.29	$-.08$	$-.07$
	(.09)	(.08)	(.23)	(.25)	(.08)	(.06)

Notes: This table reports estimates based on equation (2) for $j = v$ and $i = 1, 2, ..., N$. For $i = 0$, denoting the Stockholm equation, there is an additional *a priori* restrictions, $\phi_{0v0} = \beta_{0v1} = 0$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. See Table 9b in Appendices for complete table.

Figure 1: The contemporaneous effect on regional house prices



(a) Tenant owned apartment (b) Villa

It is apparent from Figure 1 that the contemporaneous effect of Stockholm differs within the country and between the two types of housing. For tenant owned apartments in (a) it is clear that Stockholm has a greater impact on the larger regions and in the South of Sweden, particularly on the South East Coast. The effect is less apparent north of Stockholm, with the exception of Norrbotten which deviates from this geographical pattern. Nonetheless, this result is expected as Norrbotten is an economically strong region. In contrast to (a), the contemporaneous effect of Stockholm is more significant and smooth across the regions for villa prices in (b). This might be explained by the large share of villas in all regions, resulting in better data quality.

The Stockholm lag effect on changes in regional house prices is insignificant for all regions, with the exception of Skåne, Värmland, Dalarna and Gävleborg. Interestingly, the sum of the coefficients for the contemporaneous and lag effect of Stockholm on Skåne is equal to the contemporaneous effect on Uppsala. This implies that the economic size of Skåne compensates for its geographical distance with one lag. The negative lag coefficients for the three northern regions implies a revers causality, which might be explained by the distance to Stockholm and the depopulation in these regions.

The estimates of the error correction coefficients, $\hat{\phi}_{ij0}$ and $\hat{\phi}_{ijs}$, are reported in Column 2 and 3. The first coefficient captures the effect of a deviation of region i house prices from Stockholm, while the second coefficient captures the deviation from neighbouring house prices. The error correction coefficients in Column 2 are statistically significant for most regions. Unsurprisingly, the coefficients in Column 3 are less significant.

The own lag effect is statistically significant for most regions, with more significance for tenant owned apartments. The neighbourhood lag effect is strong if the two types of housing are assessed together, indicating the importance of dynamic spill-overs from neighbouring regions. Noteworthy, in Table 2a there is a clear pattern for regions near Stockholm of similar estimates with high level of significance in the second error correction coefficient, the own and neighbourhood lag effect, indicating strong cross sectional dependence between these regions.

Together these results provide important insights into the spatial and temporal diffusion of house prices in Sweden. To ensure that the results are not subject to endogeneity, a Wu-Hausman statistic is used to test the null hypothesis that changes in Stockholm house prices are exogeneously given. The test statistic reported in the 11^{th} column of Table 9a and 9b in Appendices, suggests that a small number of regions might suffer of simultaneity bias, with slightly more evidence in the price equations for tenant owned apartments.

5.3 Estimates with economic and geographical proximity

The estimates of a change in regional house prices are presented in Table 3 below (see Table 10a to 10d in Appendices for complete tables). Column 2 and 4 present the lag effect of house prices with economic proximity, while Column 3 and 5 present the lag effect of house prices with geographical proximity. The presented coefficients are further visualised in Figure 2 and 3. Noteworthy, each column in Table 3 reports coefficients from different regressions following the procedure of equation (6) in subsection 3.2. Column 2 and 4 are highlighted as these coefficients address the hypothesis.

As shown, the lag effect of house prices with economic proximity is both greater and more statistically significant than its geographical counterpart for almost all regions. This result clearly supports the hypothesis that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions. Surprisingly, Blekinge reports a coefficient over one in Column 2. The size of the coefficient might be explained by the region's low share of tenant owned apartments[25] and the size of the region, indicating a low monthly turnover in the housing market resulting in less accurate data. Hence, this coefficient should be approached with caution.

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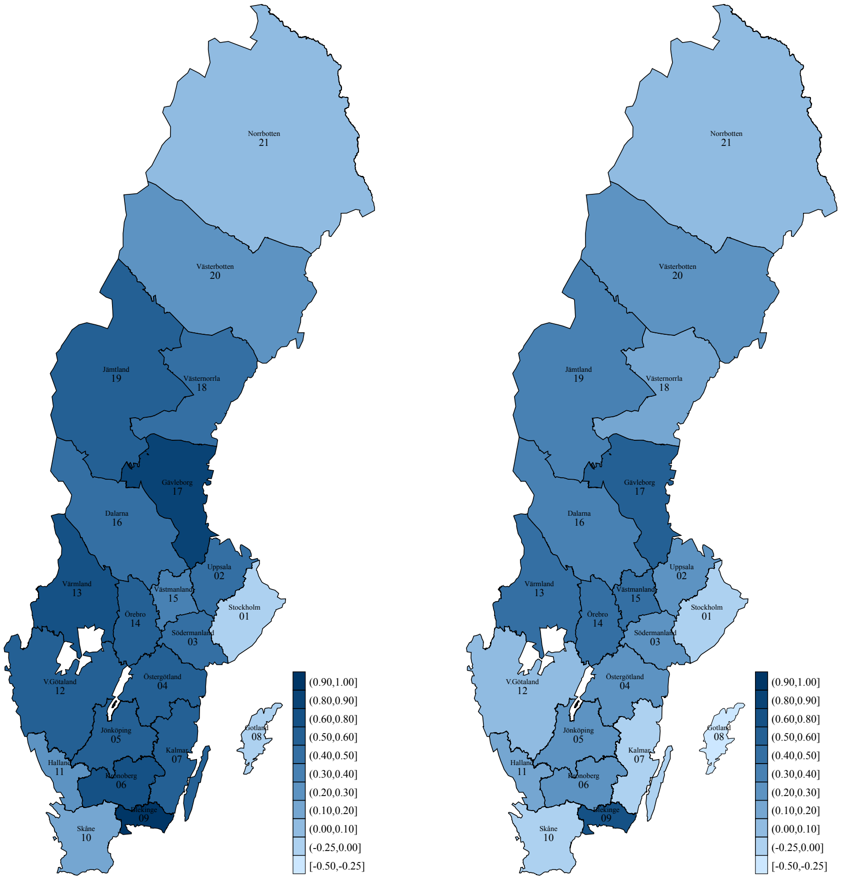
[25] See Table 5 in Appendices.

Table 3: Estimation results of price equations with economic and geographical proximity

	Tenant owned apartment		Villa	
Region (i)	Economic Prox. Lag Effect ($\hat{\beta}_{iae1}$)	Geographical Prox. Lag Effect ($\hat{\beta}_{iag1}$)	Economic Prox. Lag Effect ($\hat{\beta}_{ive1}$)	Geographical Prox. Lag Effect ($\hat{\beta}_{ivg1}$)
Stockholm	$-.05$	$-.06$	$-.32^{*}$	$-.35^{**}$
	(.17)	(.11)	(.16)	(.15)
Uppsala	$.45^{***}$	$.22^{*}$	$.54^{***}$	$.34^{***}$
	(.15)	(.11)	(.18)	(.17)
Södermanland	$.46^{**}$	.27	.06	$-.05$
	(.22)	(.21)	(.11)	(.11)
Östergötland	$.54^{**}$	.25	$-.16$	.03
	(.25)	(.20)	(.15)	(.14)
Jönköping	$.57^{***}$	.25	.20	$-.08$
	(.17)	(.15)	(.21)	(.19)
Kronoberg	$.61^{**}$	.25	$.63^{***}$	$.54^{***}$
	(.24)	(.17)	(.19)	(.20)
Kalmar	$.58^{**}$	$-.02$	.20	$-.16$
	(.24)	(.22)	(.15)	(.16)
Gotland	$-.20$	$-.34^{*}$	.25	$.39^{*}$
	(.25)	(.17)	(.21)	(.22)
Blekinge	1.9^{***}	$.70^{***}$	$.40^{**}$	.21
	(.34)	(.22)	(.19)	(.21)
Skåne	$.15^{*}$	.00	$.29^{***}$	$.21^{**}$
	(.08)	(.07)	(.08)	(.09)
Halland	.21	.16	$-.01$	.02
	(.17)	(.14)	(.14)	(.14)
Västra Götaland	$.52^{***}$	.06	$.34^{**}$	.09
	(.19)	(.12)	(.15)	(.15)
Värmland	$.60^{***}$	$.41^{*}$	$.40^{**}$	$.29^{*}$
	(.23)	(.23)	(.17)	(.16)
Örebro	$.56^{***}$	$.49^{***}$	$.39^{*}$	.23
	(.19)	(.15)	(.16)	(.16)
Västmanland	$.38^{*}$	.45	$.71^{***}$	$.75^{***}$
	(.23)	(.26)	(.18)	(.19)
Dalarna	.40	.35	$.33^{***}$	$.29^{***}$
	(.27)	(.25)	(.11)	(.11)
Gävleborg	$.90^{***}$	$.52^{***}$	$.34^{**}$	.16
	(.18)	(.16)	(.16)	(.17)
Västernorrland	$.46^{*}$	.10	$.40^{**}$	.26
	(.24)	(.20)	(.18)	(.18)
Jämtland	.58	.39	$.58^{**}$	$.62^{**}$
	(.46)	(.30)	(.23)	(.24)
Västerbotten	.21	$.24^{*}$	.24	.19
	(.18)	(.14)	(.18)	(.20)
Norrbotten	.07	.01	.19	.03
	(.23)	(.20)	(.15)	(.14)

Notes: This table reports estimates based on equation (6) for $j = a, v$, $q = e, g$ and $i = 0, 1, 2, \ldots, N$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. See Table 10a to 10d in Appendices for complete tables.

Figure 2: The lag effect on tenant owned apartment prices with economic and geographical proximity



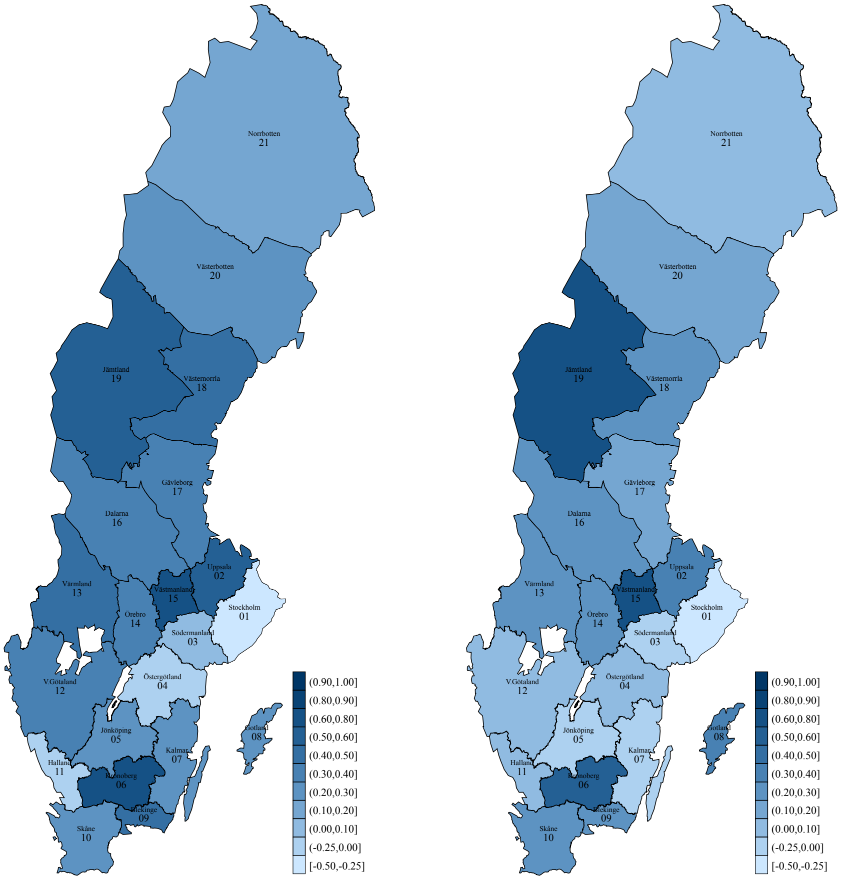
(a) Economic proximity (b) Geographical proximity

Figure 2 (a) clearly shows that the lag effect of tenant owned apartment prices with economic proximity is stronger in the southern regions and in those regions located in the middle of Sweden. Perhaps not surprisingly, Stockholm deviates from this pattern and shows little signs of being affected by the rest of the country. The more surprising deviation is that of Skåne, which might be explained by its economic and geographical proximity to Copenhagen, Denmark.

As can be seen in Figure 2 (b), the lag effect of tenant owned apartment prices with geographical proximity is relatively weak in all regions and especially in the three largest ones. This outcome is not unexpected as these regions can be viewed as local dominant regions. As such, these regions affect their surroundings but is not in turn affected by it.

When comparing (a) and (b) it becomes clear that geographical proximity has less impact on the spatial and temporal diffusion of tenant owned apartment prices.

Figure 3: The lag effect on villa prices with economic and geographical proximity



(a) Economic proximity (b) Geographical proximity

The lag effect of villa prices with the two proximities are shown in Figure 3. Neither (a) nor (b) show any general pattern for how the regions are affected. Interestingly, Stockholm is the only region that reports negative coefficients with significance for both (a) and (b). The two other larger regions, Skåne and Västra Götaland, demonstrate a similar outcome as in Figure 2.

From Figure 2 and 3 it becomes evident that tenant owned apartment prices with economic proximity have a stronger spatial component than their villa counterpart. In general, economic proximity has a greater impact when analysing the spatial and temporal diffusion of regional house prices.

6 Discussion

This paper examines the spatial and temporal diffusion of house prices in Sweden. The first aim is to empirically determine if regional house prices respond to a change in Stockholm house prices. The second aim is to establish which measure of proximity that gives the most accurate representation for cross sectional dependence between regions. The first hypothesis states three things; (i) Stockholm is the dominant region; (ii) a change in Stockholm house prices affects house prices in the other regions and; (iii) regions that are economically or geographically close to Stockholm are more affected than regions far away. The second hypothesis states that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions.

There are five main findings in this paper. The first finding is that Stockholm is the dominant region in Sweden and that its prices are long-run forcing all other regions. The second finding is that Stockholm has a contemporaneous effect on house prices in more than half of the regions, but has less effect with one lag. The third finding is that economic and geographical closeness to Stockholm affects the degree of how regional house prices respond to a shock to Stockholm house prices. The fourth finding is that economic proximity gives a more accurate representation for cross sectional dependence between regions. The fifth finding is that tenant owned apartment prices have a stronger spatial and temporal component than villa prices.

The first, second and third finding support the first hypothesis, and are broadly consistent with the literature. Previous research on the choice of dominant region suggest that a country's economic centre tend to be dominant causing house price movements in all other regions (Berg, 2002, Oikarinen, 2005 and Holly, Pesaran and Yamagata, 2011). Research has also shown that a dominant region is not necessary uniquely so (Holly, Pesaran and Yamagata, 2011 and Yang and Turner, 2016) which is further supported by this paper. This as both Västra Götaland and Skåne are suggested to be sub-dominant regions for their surrounding regions. The finding that Stockholm affects regional house prices contemporaneously is coherent with that of Holly, Pesaran and Yamagata (2011), who established that house prices within the UK respond directly to a shock to London house price. The findings further suggest that Stockholm has a greater impact on regions that are economically and geographically close. This pattern may partly be explained by regional similarities in economic structure and information accessibility as suggested by Grossman and Stiglitz (1976) and Case, Quigley and Shiller (2001) which leads to stronger interdependence. However, this paper has been unable to demonstrate the same robustness. The presented results should therefore be considered as an indication, rather than a confirmation.

The fourth and fifth finding contribute to the existing literature by shading light on both the choice of proximity and on the different properties of tenant owned apartment and villa prices. The fourth finding suggests that the lag effect of house prices with economic proximity is both greater and more statistically significant than its geographical counterpart for almost all regions. This result may be explained by the fact that economic size can compensate for the lack of geographical closeness when analysing interdependence between two (or more) parts. The result can be generalisable to other economic areas, for example the diffusion of technological innovations.

The fifth finding suggests that there is a difference in the spatial and temporal diffusion properties of the two types of housing. Tenant owned apartment prices have a stronger spatial and temporal component than villa prices, however less statistically significant. The reason for this can originate from the higher turnover and price volatility of tenant owned apartments compared to villas. This as the housing market for villas are characterised by long-term ownership (Svensk Mäklarstatistik, 2019). Thus, it is not necessarily the case that the two types of housing follow the same trend. This particular finding can contribute to the understanding of how house price changes spread differently, and thereby to the analysis of the spatial and temporal diffusion of house prices. One unanticipated observation is that the lag effect of villa prices with both economic and geographical proximity affects changes in Stockholm villa prices negatively. The most likely explanation for the negative relationship is one type of crowding out effect. Higher growth rates in house prices often indicate strong macroeconomic developments, resulting in less economic incentives to move to Stockholm, which in turn lowers the demand for housing in Stockholm.

7 Conclusions

The purpose of this study was to assess how a change in Stockholm house prices could ripple over Sweden in the event of a bubble or a crisis. Due to different characteristics of tenant owned apartment and villa prices, there was a distinction used between the two types housing for a more thorough analysis. The analysis was performed by estimating two price diffusion models with OLS, using monthly seasonally adjusted regional real house price data over the period 2005m1 to 2018m12.

The two models used are extended versions of the model presented by Holly, Pesaran and Yamagata (2011). The first model was calibrated to empirically determine if regional house prices respond to a shock to Stockholm house prices. The second model was calibrated to examine which measure of proximity that gives the most accurate representation of the cross sectional dependence between regions.

The results suggest that Stockholm is the dominant region in the sense of Berg (2002), causing direct house price movements for a weak majority of the other regions. In accordance with the expectations of Grossman and Stiglitz (1976) and Case, Quigley and Shiller (2001), the results suggest that regions that are economically or geographically close to Stockholm are more affected than regions far away. Similarly, the results from the second model support the expectations of Grossman and Stiglitz and Case, Quigley and Shiller by suggesting that economic proximity is better than geographical closeness at explaining the cross sectional dependence between regions, resulting in a more reliable analysis of the spatial and temporal diffusion of house prices. By separating the two types of housing, it was revealed that there is a difference in their diffusion properties. Tenant owned apartment prices have a stronger spatial and temporal component than villa prices, which may originate from the higher turnover and price volatility[26].

To conclude, the findings of this study provide important insights for the cross sectional dependence between regions and how a change in Stockholm house prices could ripple over Sweden in the event of a bubble or a crisis. Due to different spatial properties of the two types of housing, the results are of direct practical relevance in terms of policy making.

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[26] See Table 5 in Appendices for descriptive statistics.

One policy suggestion is to demand higher collateral on loans for tenant owned apartments than on loans for villas. Another suggestion is to increase the required amortisation on loans for tenant owned apartments. Both policies aim at lowering the risk associated with the high spatial dependence of tenant owned apartments in case of a bubble or a crisis. As the two policy suggestions affect economic groups differently and have different implications for the liquidity on the market, a combination of the two suggestions could be favoured.

The study has a number of possible limitations and the presented results should therefore be considered as an indication, rather than a confirmation. Future research are encouraged to increase the lag-length to further improve the understanding for the temporal diffusion of a shock to house prices in Sweden.

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Appendices

Table 4: Region, code, regional capital and neighbour(s)

Region	Code	Regional capital	Neighbour(s)
Stockholm	01	Stockholm	03, 04, 09
Uppsala	03	Uppsala	01, 04, 19, 21
Södermanland	04	Nyköping	01, 03, 05, 18, 21
Östergötland	05	Linköping	04, 06, 08, 18
Jönköping	06	Jönköping	05, 07, 08, 14
Kronoberg	07	Växjö	06, 08, 10, 12, 13, 14
Kalmar	08	Kalmar	05, 06, 07, 09, 10
Gotland	09	Visby	01, 08
Blekinge	10	Karlskrona	07, 08 12
Skåne	12	Malmö	07, 10, 13
Halland	13	Halmstad	07, 12, 14
Västra Götaland	14	Göteborg	06, 07, 13, 17, 18
Värmland	17	Karlstad	14, 18, 20
Örebro	18	Örebro	04, 05, 14, 17, 19, 20
Västmanland	19	Västerås	03, 04, 18, 20, 21
Dalarna	20	Falun	17, 18, 19, 21, 23
Gävleborg	21	Gävle	03, 17, 20, 22, 23
Västernorrland	22	Härnösand	21, 23, 24
Jämtland	23	Östersund	20, 21, 22, 24
Västerbotten	24	Umeå	22, 23, 25
Norrbotten	25	Luleå	24

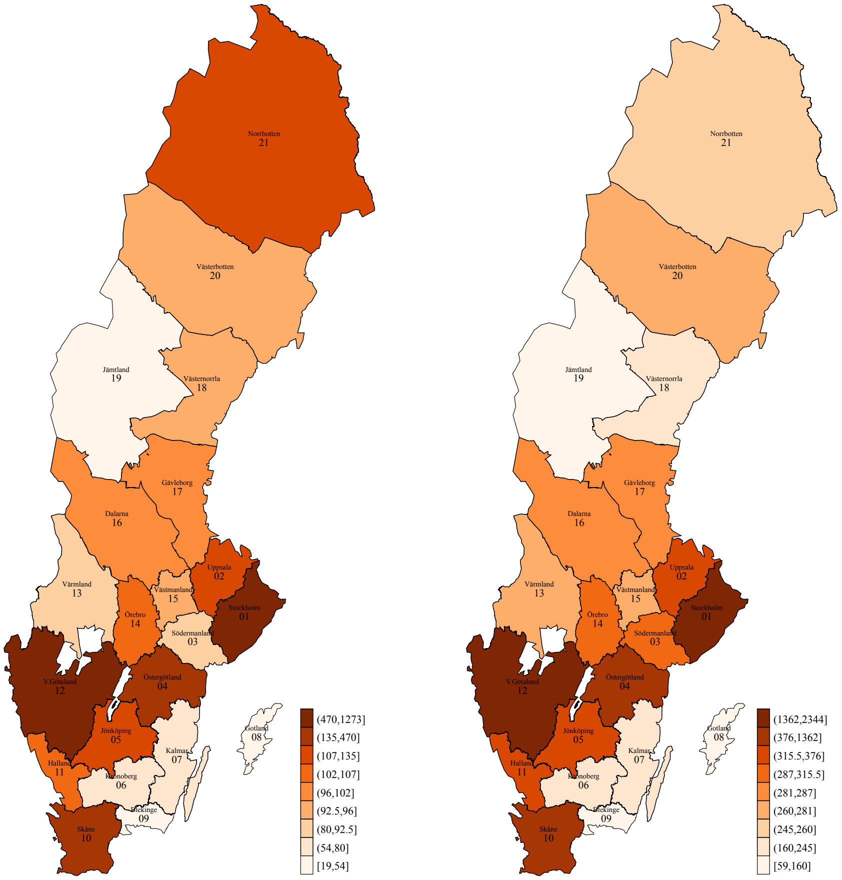
Notes: The regional code follows the standard Swedish notation.

Table 5: Descriptive statistics

	Tenant owned apartment				Villa			
Region (i)	Mean	SE	Min	Max	Mean	SE	Min	Max
Stockholm	.0047	.0293	-.1005	.1222	.0030	.0304	-.0887	.1021
Uppsala	.0045	.0552	-.1996	.1762	.0028	.0732	-.2275	.1872
Södermanland	.0070	.1470	-.7304	.5324	.0037	.0671	-.2298	.2212
Östergötland	.0087	.1131	-.6969	.6689	.0038	.0598	-.1453	.1994
Jönköping	.0053	.0982	-.3352	.3516	.0039	.0786	-.2396	.3130
Kronoberg	.0072	.1599	-.6275	.6639	.0018	.1041	-.2396	.4123
Kalmar	.0074	.2042	-.8444	.6225	.0037	.0854	-.3327	.2919
Gotland	.0052	.1391	-.5446	.4325	.0058	.1833	-.4313	.4680
Blekinge	.0054	.1784	-.4849	.6508	.0032	.1137	-.3456	.4119
Skåne	.0043	.0399	-.1929	.1283	.0032	.0477	-.1637	.1704
Halland	.0066	.1036	-.3784	.3015	.0044	.0741	-.2094	.3520
Västra Götaland	.0044	.0389	-.1083	.1502	.0036	.0407	-.0964	.1300
Värmland	.0069	.1202	-.3380	.3572	.0032	.0801	-.2264	.2181
Örebro	.0044	.1154	-.4074	.4462	.0036	.0807	-.2290	.2475
Västermanland	.0040	.1125	-.4487	.4002	.0028	.0651	-.2032	.1698
Dalarna	.0075	.1301	-.5232	.3386	.0040	.0652	-.1807	.1955
Gävleborg	.0090	.1082	-.4265	.3733	.0036	.0745	-.2234	.1896
Västernorrland	.0063	.1576	-.6400	.4621	.0052	.1098	-.4221	.3262
Jämtland	-.0028	.2035	-.9823	.7059	.0017	.1739	-.4933	.6152
Västerbotten	.0049	.1085	-.3337	.3922	.0018	.1052	-.2597	.2847
Norrbotten	.0026	.1395	-.5183	.3813	.0029	.0870	-.2898	.2252
For all regions	.0054	.1307	-.9823	.7059	.0034	.0930	-.4933	.6152

Notes: The descriptive statistics are based on the monthly change of the logarithm of real house prices across regions containing 168 observations.

Figure 4: Gross regional product in thousands of SEK and the regional population in thousands of people



(a) Gross regional product
Source: SCB (2018), "Regionalräkenskaper".

(b) Population
Source: SCB (2018), "Folkmängd i riket".

Table 6: Share of tenant owned apartments and villas by region

Region	% of Tenant owned apartments	% of Villas
Stockholm	63 %	37 %
Uppsala	45 %	55 %
Södermanland	31 %	69 %
Östergötland	32 %	68 %
Jönköping	21 %	79 %
Kronoberg	17 %	83 %
Kalmar	19 %	81 %
Gotland	26 %	74 %
Blekinge	17 %	83 %
Skåne	37 %	63 %
Halland	17 %	83 %
Västra Götaland	33 %	67 %
Värmland	24 %	76 %
Örebro	26 %	74 %
Västmanland	39 %	61 %
Dalarna	20 %	80 %
Gävleborg	25 %	75 %
Västernorrland	29 %	71 %
Jämtland	27 %	73 %
Västerbotten	28 %	72 %
Norrbotten	21 %	79 %

Source: SCB (2019), ”Antal lägenheter efter region, hustyp och upplåtelseform (inklusive specialbostäder)”.

Figure 5a: The logarithm of real tenant owned apartment prices by region (in SEK)

Figure 5b: The logarithm of real villa prices (in SEK)

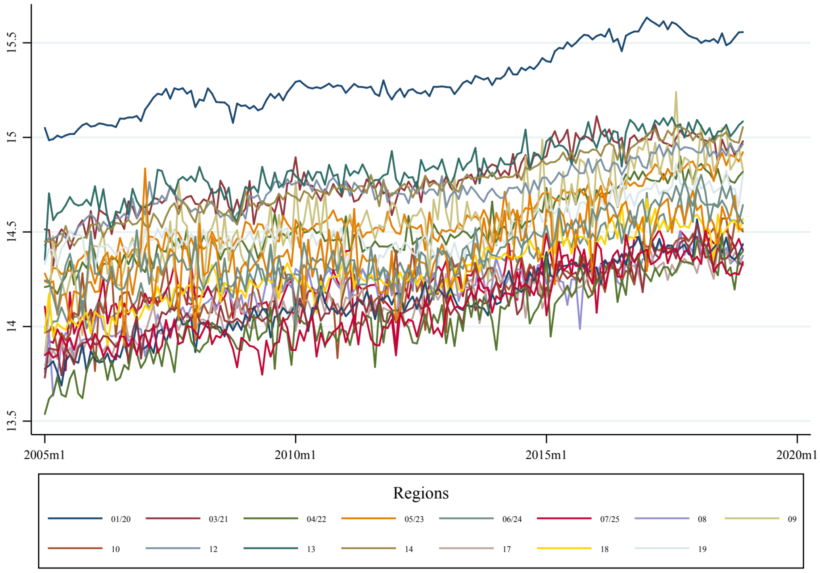


Table 7: The results of trace cointegration tests

	Tenant owned apartment		Villa	
Region	$H_0 : r = 0$ $H_1 : r \geq 1$	$H_0 : r \leq 1$ $H_1 : r = 2$	$H_0 : r = 0$ $H_1 : r \geq 1$	$H_0 : r \leq 1$ $H_1 : r = 2$
Uppsala	31.9	6.09***	91.6	5.93***
Södermanland	68.0	6.24***	49.9	5.74***
Östergötland	62.9	6.28***	63.0	5.88***
Jönköping	61.0	6.21***	83.9	5.92***
Kronoberg	81.4	5.79***	90.7	5.81***
Kalmar	61.0	6.15***	45.3	5.95***
Gotland	50.8	6.89***	78.1	5.95***
Blekinge	72.3	6.12***	53.8	5.93***
Skåne	20.6***	6.30	33.4	5.96***
Halland	58.5	6.11***	78.1	5.79***
Västra Götaland	55.6	5.95***	84.0	5.94***
Värmland	64.4	6.11***	71.1	5.91***
Örebro	50.7	5.97***	63.6	5.95***
Västmanland	37.3	5.93***	43.9	5.65***
Dalarna	48.0	5.85***	52.2	5.91***
Gävleborg	69.6	15.5***	97.7	9.99***
Västernorrland	61.5	6.06***	55.6	5.92***
Jämtland	55.5	6.39***	83.8	5.47***
Västerbotten	41.4	5.27***	54.4	5.68***
Norrbotten	22.5***	4.91	40.7	5.92***

Notes: The trace statistics reported are based on the bivariate VAR specification of log of real house prices of Stockholm and other regions, with unrestricted intercepts and restricted trend coefficients. The cointegration test follows the method of Johansen (1991). ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 8a: Error correction coefficients in cointegrating bivariate VAR model; tenant owned apartment

	EC Equation for Stockholm (p_{0at})				EC Equation for other Regions (p_{iat})			
Region (i)	EC Coeff. ($\hat{\phi}_{0ai}$)	t-ratio	$\bar{R}^2$	Serial Corr.	EC Coeff. ($\hat{\phi}_{ia0}$)	t-ratio	$\bar{R}^2$	Serial Corr.
Uppsala	−.02	−.74	.08	1.8	$-.17^{***}$	−3.4	.20	1.3
Södermanland	.01	.87	.08	1.4	$-.34^{***}$	−4.4	.35	1.4
Östergötland	−.00	−.33	.08	1.3	$-.16^{***}$	−3.3	.29	1.7
Jönköping	.01	.90	.10	.72	$-.20^{***}$	−3.6	.22	4.0^{**}
Kronoberg	−.01	−.56	.08	4.3^{**}	$-.31^{***}$	−4.3	.33	13^{***}
Kalmar	.00	.15	.12	2.1	$-.45^{***}$	−5.3	.36	2.3
Gotland	.03	1.3	.09	1.6	$-.57^{***}$	−6.5	.31	2.2
Blekinge	−.02	−.99	.08	2.1	$-.86^{***}$	−7.9	.51	4.8^{**}
Skåne	−.02	−.55	.08	1.4	$-.09^{**}$	−2.1	.23	1.4
Halland	−.00	−.14	.07	1.9	$-.57^{***}$	−6.3	.33	7.6^{***}
Västra Götaland	$-.10^{***}$	−2.8	.12	.72	$-.48^{***}$	−5.8	.20	.23
Värmland	.00	.31	.07	1.8	$-.20^{***}$	−3.6	.25	11^{***}
Örebro	−.02	−.89	.12	.44	$-.23^{***}$	−3.5	.34	3.2^{*}
Västmanland	.01	.53	.09	2.7	$-.56^{***}$	−6.4	.40	1.2
Dalarna	.00	.09	.07	1.8	$-.18^{***}$	−3.5	.34	.62
Gävleborg	$-.14^{***}$	−3.3	.28	5.9^{**}	$-.63^{***}$	−7.3	.38	2.9^{*}
Västernorrland	.01	.75	.10	1.9	$-.56^{***}$	−7.2	.44	2.7^{*}
Jämtland	.01	.40	.09	2.0	$-.84^{***}$	−7.3	.46	.49
Västerbotten	−.02	−1.0	.08	1.4	$-.10^{*}$	−1.9	.21	.98
Norrbotten	−.01	−.66	.08	1.7	$-.15^{***}$	−3.1	.27	9.7^{***}

Notes: Notes: For the Stockholm equation "EC Coeff." is the estimate of ϕ_{0ci}, in equation $\Delta p_{0at} = \phi_{0ai}(p_{0a,t-1} - p_{ia,t-1}) + \beta_{0a1}\Delta p_{0a,t-1} + \beta_{0a2}\Delta p_{ia,t-1} + \beta_{0a3}\Delta OP_{t-1} + \beta_{0a4}\Delta RR_{t-1} + \beta_{0a5}\Delta GRP_{0,t-1} + \varepsilon_{0iat}$. For the other regions it is given by the estimate of ϕ_{ia0} in equation $\Delta p_{iat} = \phi_{ia0}(p_{ia,t-1} - p_{0a,t-1}) + \beta_{ia1}\Delta p_{0a,t-1} + \beta_{ia2}\Delta p_{ia,t-1} + \beta_{ia3}\Delta OP_{t-1} + \beta_{ia4}\Delta RR_{t-1} + \beta_{ia5}\Delta GRP_{i,t-1} + \varepsilon_{i0at}$. Intercepts are included in all the regressions. The $\bar{R}^2$ is the adjusted R^2. The column "Serial Corr." reports the Breusch-Godfrey serial correlation test statistic which is distributed as χ^2 under the null of no residual serial correlation. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 8b: Error correction coefficients in cointegrating bivariate VAR model; villa

	EC Equation for Stockholm (p_{0vt})				EC Equation for other Regions (p_{ivt})			
Region (i)	EC Coeff. ($\hat{\phi}_{iv0}$)	t-ratio	$\bar{R}^2$	Serial Corr.	EC Coeff. ($\hat{\phi}_{iv0}$)	t-ratio	$\bar{R}^2$	Serial Corr.
Uppsala	−.03	−.88	.16	.00	−.98***	−9.6	.47	2.3
Södermanland	−.10**	−2.4	.18	.00	−.57***	−5.7	.41	.48
Östergötland	−.05	−1.3	.09	2.0	−.62***	−6.5	.28	.59
Jönköping	−.01	−.36	.09	2.1	−.65***	−6.8	.35	11***
Kronoberg	−.02	−.78	.09	2.4	−.74***	−7.2	.32	1.8
Kalmar	.02	.85	.08	3.5*	−.32***	−4.4	.22	1.6
Gotland	−.00	−.08	.11	2.4	−.93***	−8.7	.47	6.3**
Blekinge	−.02	−1.0	.09	2.8*	−.43***	−5.0	.29	1.2
Skåne	−.02	−.65	.15	.00	−.15**	−2.5	.26	4.5**
Halland	−.06	−1.6	.09	2.3	−.64***	−6.5	.42	1.2
Västra Götaland	−.01	−.27	.08	2.9*	−.63***	−6.8	.27	.40
Värmland	−.01	−.37	.09	2.3	−.50***	−5.4	.28	.01
Örebro	.01	.18	.08	2.8*	−.71***	−6.8	.34	.08
Västmanland	−.02	−1.0	.09	2.8*	−.30***	−4.3	.25	1.1
Dalarna	−.03	−.74	.09	3.0*	−.40***	−4.9	.34	1.4
Gävleborg	−.10*	−1.9	.31	8.7***	−.92***	−9.1	.45	.88
Västernorrland	.02	.81	.09	3.2*	−.59***	−6.0	.39	.94
Jämtland	−.04*	−2.0	.11	1.9	−.94***	−8.8	.49	3.2*
Västerbotten	−.01	−.37	.09	4.3**	−.58***	−6.2	.29	2.0
Norrbotten	−.04	−1.2	.09	4.5***	−.50***	−5.4	.27	7.1***

Notes: For the Stockholm equation "EC Coeff." is the estimate of ϕ_{0vi}, in equation $\Delta p_{0vt} = \phi_{0vi}(p_{0v,t-1} - p_{iv,t-1}) + \beta_{0v1}\Delta p_{0v,t-1} + \beta_{0v2}\Delta p_{iv,t-1} + \beta_{0v3}\Delta OP_{t-1} + \beta_{0v4}\Delta RR_{t-1} + \beta_{0v5}\Delta GRP_{0,t-1} + \varepsilon_{0ivt}$. For the other regions it is given by the estimate of ϕ_{iv0} in equation $\Delta p_{ivt} = \phi_{iv0}(p_{iv,t-1} - p_{0v,t-1}) + \beta_{iv1}\Delta p_{0v,t-1} + \beta_{iv2}\Delta p_{iv,t-1} + \beta_{iv3}\Delta OP_{t-1} + \beta_{iv4}\Delta RR_{t-1} + \beta_{iv5}\Delta GRP_{i,t-1} + \varepsilon_{i0vt}$. Intercepts are included in all the regressions. The $\bar{R}^2$ is the adjusted R^2. The column "Serial Corr." reports the Breusch-Godfrey serial correlation test statistic which is distributed as χ^2 under the null of no residual serial correlation. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 9a: Estimation results of price diffusion equation; tenant owned apartment

Region (i)	EC1 ($\hat{\phi}_{ia0}$)	EC2 ($\hat{\phi}_{ias}$)	Sthlm Cont. Effect ($\hat{\beta}_{ia1}$)	Sthlm Lag Effect ($\hat{\beta}_{ia2}$)	Own Lag Effect ($\hat{\beta}_{ia3}$)	Neighb. Lag Effect ($\hat{\beta}_{ia4}$)	Oil Lag Effect ($\hat{\beta}_{ia5}$)	RR Lag Effect ($\hat{\beta}_{ia6}$)	GRP Lag Effect ($\hat{\beta}_{ia7}$)	Wu-Hausman Statistic
Stockholm		$-.01$			$-.31^{***}$	$.02$	$-.04$	$-.00$	$-.36$	
		(.02)			(.11)	(.03)	(.04)	(.00)	(.81)	
Uppsala	$-.44^{***}$	$.28^{***}$	$.12$	$.07$	$-.29^{***}$	$.20^{***}$	$-.05$	$.01^{**}$	-1.5	.00
	(.07)	(.06)	(.23)	(.16)	(.07)	(.05)	(.08)	(.01)	(2.0)	
Södermanland	$-.67^{***}$	$.30^{**}$	$.79^{**}$	$-.27$	$-.35^{***}$	$.30^{**}$	$.08$	$.03$	-1.3	61^{***}
	(.17)	(.12)	(.34)	(.34)	(.10)	(.15)	(.14)	(.03)	(3.7)	
Östergötland	$-.36^{***}$	$.17^{*}$	$-.48$	$.03$	$-.42^{***}$	$.31^{***}$	$-.13$	$-.02$	-2.1	.81
	(.12)	(.09)	(.42)	(.36)	(.11)	(.11)	(.12)	(.01)	(3.8)	
Jönköping	$-.36^{***}$	$.17^{**}$	$.35$	$-.08$	$-.34^{***}$	$.20^{**}$	$-.15$	$-.01$	-1.2	5.8^{**}
	(.09)	(.07)	(.40)	(.27)	(.07)	(.07)	(.11)	(.01)	(3.1)	
Kronoberg	$-.93^{***}$	$.43^{***}$	$.12$	$.24$	$-.24^{***}$	$.19^{**}$	$.03$	$-.02$	4.2	1.6
	(.16)	(.10)	(.54)	(.39)	(.09)	(.09)	(.15)	(.02)	(5.3)	
Kalmar	$-.57^{***}$	$.10$	$.86^{*}$	$-.17$	$-.29^{***}$	$.45^{**}$	$.09$	$.02$	9.9^{*}	8.3^{***}
	(.14)	(.10)	(.50)	(.54)	(.09)	(.17)	(.20)	(.02)	(5.3)	
Gotland	$-.59^{***}$	$.05$	$.38$	$-.26$	$-.10$	$-.03$	$.28^{*}$	$.00$	$.63$	.18
	(.10)	(.10)	(.35)	(.38)	(.09)	(.07)	(.15)	(.02)	(3.9)	
Blekinge	$-.93^{***}$	$.05$	$.90$	$.37$	$.03$	$.06$	$-.07$	$-.00$	-5.9	1.3
	(.12)	(.10)	(.55)	(.49)	(.09)	(.11)	(.19)	(.04)	(5.2)	
Skåne	$-.15^{***}$	$-.13^{**}$	$.51^{***}$	$.03$	$-.27^{***}$	$.07$	$.02$	$.01$	$-.17$	2.0
	(.04)	(.06)	(.13)	(.14)	(.08)	(.07)	(.05)	(.01)	(1.4)	
Halland	$-.63^{***}$	$.05$	$.25$	$-.24$	$-.14^{*}$	$.12$	$.00$	$.00$	-4.4	4.3^{**}
	(.13)	(.08)	(.27)	(.30)	(.09)	(.08)	(.15)	(.01)	(3.3)	
Västra Götaland	$-.53^{***}$	$.03$	$.40$	$.22$	$.04$	$.07$	$.02$	$.01$	1.2	3.3^{*}
	(.08)	(.07)	(.25)	(.14)	(.10)	(.08)	(.08)	(.01)	(1.8)	
Värmland	$-.41^{***}$	$.18^{*}$	$.02$	$-.63^{*}$	$-.35^{***}$	$.13$	$-.16$	$-.00$	-5.1	1.9
	(.12)	(.09)	(.39)	(.36)	(.07)	(.10)	(.16)	(.01)	(4.3)	
Örebro	$-.41^{***}$	$.14$	$.74^{**}$	$-.33$	$-.32^{***}$	9.9	$-.15$	$.01$	3.8	2.3
	(.13)	(.10)	(.33)	(.31)	(.08)	(.09)	(.11)	(.01)	(2.9)	
Västmanland	$-.53^{***}$	$-.02$	$.36$	$-.20$	$-.19^{**}$	$.23^{***}$	$-.14$	$.01$	-9.9^{***}	.02
	(.11)	(.05)	(.31)	(.41)	(.07)	(.08)	(.12)	(.02)	(3.4)	
Dalarna	$-.32^{**}$	$.14$	$.03$	$-.70^{*}$	$-.34^{***}$	$.13$	$.18$	$-.02^{*}$	-2.7	$.94^{***}$
	(.13)	(.12)	(.42)	(.40)	(.09)	(.15)	(.15)	(.01)	(3.6)	
Gävleborg	$-.65^{***}$	$.00$	$.16$	$-.16$	$-.04$	$.02$	$.01$	1.6	$-$	1.3
	(.11)	(.05)	(.19)	(.16)	(.09)	(.08)	(.01)	(2.9)		
Västernorrland	$-.81^{***}$	$.27^{**}$	$-.01$	$.58$	$-.19$	$.32^{***}$	$.17$	$-.00$	-2.8	.28
	(.13)	(.12)	(.50)	(.38)	(.06)	(.10)	(.15)	(.03)	(3.9)	
Jämtland	$-.82^{***}$	$-.03$	$.14$	$-.16$	$-.03$	$-.11$	$-.01$	$-.01$	3.4	3.5^{*}
	(.20)	(.14)	(.69)	(.73)	(.10)	(.10)	(.25)	(.02)	(5.6)	
Västerbotten	$-.22^{**}$	$.10$	$.36$	$.11$	$-.28^{***}$	$.05$	$-.10$	$.03^{*}$	$.07$	.75
	(.09)	(.06)	(.36)	(.29)	(.08)	(.07)	(.15)	(.02)	(2.9)	
Norrbotten	$-.26$	$.11$	$.80^{*}$	$.59$	$-.40^{***}$	$-.00$	$.37^{**}$	$-.01$	9.1	.30
	(.16)	(.15)	(.44)	(.46)	(.08)	(.12)	(.16)	(.01)	(4.8)	

Notes: This table reports estimates based on equation (2) for $j = a$ and $i = 1, 2, ..., N$. For $i = 0$, denoting the Stockholm equation, there is an additional *a priori* restrictions, $\phi_{0a0} = \beta_{0a1} = 0$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. Wu-Hausman is the F-ratio for testing $H_0 : \lambda_i = 0$ in the augmented equation 5, where $\hat{\epsilon}_{0t}$ is the residual of the Stockholm equation.

Table 9b: Estimation results of price diffusion equation; villa

Region (i)	EC1 ($\hat{\phi}_{iv0}$)	EC2 ($\hat{\phi}_{ivs}$)	Sthlm Cont. Effect ($\hat{\beta}_{iv1}$)	Sthlm Lag Effect ($\hat{\beta}_{iv2}$)	Own Lag Effect ($\hat{\beta}_{iv3}$)	Neighb. Lag Effect ($\hat{\beta}_{iv4}$)	Oil Lag Effect ($\hat{\beta}_{iv5}$)	RR Lag Effect ($\hat{\beta}_{iv6}$)	GRP Lag Effect ($\hat{\beta}_{iv7}$)	Wu-Hausman Statistic
Stockholm		$-.24^{***}$			$-.24^{***}$	−.05	.01	−.00	−.64	
		(.07)			(.08)	(.05)	(.03)	(.00)	(.67)	
Uppsala	-1.2^{***}	.08	$.72^{***}$	−.22	$.14^{*}$	.14	−.17	−.00	−.21	4.6^{**}
	(.15)	(.15)	(.26)	(.30)	(.08)	(.13)	(.12)	(.01)	(3.2)	
Södermanland	$.46^{***}$	$-.21^{**}$	.26	.18	$-.21^{***}$	−.01	$-.13^{*}$	.00	−1.8	.02
	(.11)	(.09)	(.16)	(.17)	(.08)	(.07)	(.07)	(.01)	(2.0)	
Östergötland	$-.65^{***}$	−.03	$.46^{**}$	−.13	−.03	.23	−.11	.00	−1.3	.00
	(.10)	(.13)	(.20)	(.21)	(.10)	(.10)	(.09)	(.01)	(2.3)	
Jönköping	$-.47^{***}$	$-.43^{**}$	.40	−.15	.04	.01	.01	.01	−2.8	3.1^{*}
	(.13)	(.17)	(.25)	(.26)	(.11)	(.16)	(.10)	(.02)	(2.8)	
Kronoberg	−.15	$-.74^{***}$	.41	−.02	.02	$.44^{***}$	−.02	−.00	1.5	2.8^{*}
	(.14)	(.17)	(.27)	(−.02)	(.08)	(.17)	(.14)	(.01)	(3.1)	
Kalmar	−.18	−.20	.32	.37	$-.18^{*}$	−.08	.03	.01	−1.5	.35
	(.12)	(.16)	(.26)	(.28)	(.09)	(.15)	(.09)	(.01)	(2.4)	
Gotland	$-.70^{***}$	$-.30^{***}$	.22	−.08	−.02	−.08	.04	−.02	6.2	5.0^{**}
	(.14)	(.11)	(.43)	(.41)	(.07)	(.11)	(.17)	(.02)	(3.8)	
Blekinge	−.07	$-.64^{***}$	.39	−.04	−.09	−.08	.04	.01	−.63	.10
	(.12)	(.17)	(.26)	(.26)	(.08)	(.18)	(.10)	(.01)	(3.0)	
Skåne	$-.16^{***}$	.00	$.35^{**}$	$.34^{**}$	$-.41^{***}$	.06	$-.10^{**}$	$.01^{**}$	−2.1	.15
	(.06)	(.09)	(.16)	(.14)	(.08)	(.07)	(.05)	(.00)	(1.6)	
Halland	$-.54^{***}$	$-.29^{*}$	.36	−.15	.00	−.12	−.15	−.00	−1.9	16^{***}
	(.11)	(.17)	(.29)	(.23)	(.10)	(.15)	(.10)	(.01)	(2.2)	
Västra Götaland	$-.66^{***}$	.04	$.50^{***}$	−.13	.00	.14	−.08	.00	1.2	.03
	(.09)	(.17)	(.18)	(.20)	(.12)	(.11)	(.09)	(.01)	(2.3)	
Värmland	$-.33^{***}$	$-.25^{*}$	$.53^{**}$	.11	$-.18^{**}$	.20	.04	.00	.10	.97
	(.11)	(.15)	(.25)	(.23)	(.07)	(.15)	(.10)	(.01)	(2.8)	
Örebro	$-.64^{***}$	−.12	$.63^{**}$	.11	−.13	$.28^{*}$	.00	$-.01^{*}$	−.61	2.7
	(.12)	(.18)	(.26)	(.24)	(.09)	(.15)	(.08)	(.01)	(2.6)	
Västmanland	$-.92^{***}$	$.73^{***}$	$.46^{**}$	−.19	$-.37^{***}$	$.59^{***}$	−.07	−.00	−.97	.75
	(.16)	(.17)	(.22)	(.22)	(.09)	(.15)	(.09)	(.01)	(2.4)	
Dalarna	$-.36^{***}$	−.03	.33	.06	$-.32^{***}$	$.16^{*}$	−.06	$.02^{*}$	−.60	.22
	(.12)	(.10)	(.21)	(.21)	(.08)	(.09)	(.07)	(.01)	(2.0)	
Gävleborg	$-.77^{***}$	−.23	.22	$-.45^{***}$	.02	.24	.00	−1.4	.06	.27
	(.15)	(.18)	(.14)	(.16)	(.09)	(.15)	(.01)	(1.7)	(.05)	
Västernorrland	$-.56^{***}$	−.04	.31	.30	$-.22^{***}$	−.03	.03	.01	−.00	2.7
	(.16)	(.13)	(.27)	(.30)	(.08)	(.11)	(.13)	(.02)	(3.3)	
Jämtland	$-.83^{***}$	−.11	.14	−.75	−.05	$.46^{**}$	$-.26^{*}$	−.01	−3.5	.00
	(.25)	(.26)	(.51)	(.48)	(.08)	(.22)	(.15)	(.01)	(3.9)	
Västerbotten	$-.62^{***}$	.02	$.65^{*}$	−.02	−.07	$.25^{*}$	.05	$.02^{*}$	3.6	1.1
	(.14)	(.16)	(.34)	(.27)	(.08)	(.14)	(.11)	(.01)	(3.4)	
Norrbotten	$-.40^{***}$	$-.26^{***}$	$.86^{***}$	.29	−.08	−.07	.03	−.01	5.2^{**}	.96
	(.09)	(.08)	(.23)	(.25)	(.08)	(.06)	(.10)	(.10)	(2.6)	

Notes: This table reports estimates based on equation (2) for $j = v$ and $i = 1, 2, ..., N$. For $i = 0$, denoting the Stockholm equation, there is an additional *a priori* restrictions, $\phi_{0v0} = \beta_{0v1} = 0$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively. Wu-Hausman is the F-ratio for testing $H_0 : \lambda_i = 0$ in the augmented equation 5, where $\hat{\epsilon}_{0jt}$ is the residual of the Stockholm equation.

Table 10a: Estimation results of price diffusion equation with economic proximity; tenant owned apartment

Region (i)	EC1 ($\hat{\phi}_{ia0}$)	EC2 ($\hat{\phi}_{ias}$)	Economic Prox. Lag Effect ($\hat{\beta}_{iae1}$)	Own Lag Effect ($\hat{\beta}_{iae2}$)	Oil Lag Effect ($\hat{\beta}_{iae3}$)	RR Lag Effect ($\hat{\beta}_{iae4}$)	GRP Lag Effect ($\hat{\beta}_{iae5}$)
Stockholm		$-.07$	$-.05$	$-.11$	$-.08$	$.00$	$-.05$
		(.09)	(.17)	(.17)	(.07)	(.00)	(2.0)
Uppsala	$-.34^{***}$	$.20^{***}$	$.45^{***}$	$-.33^{***}$	$-.08$	$.01$	$-.91$
	(.05)	(.05)	(.15)	(.09)	(.07)	(.00)	(2.1)
Södermanland	$-.43^{***}$	$.11$	$.46^{**}$	$-.40^{***}$	$.06$	$.02$	-1.4
	(.15)	(.11)	(.22)	(.10)	(.13)	(.02)	(3.9)
Östergötland	$-.32^{***}$	$.13$	$.54^{**}$	$-.45^{***}$	$-.14$	$-.02$	-1.4
	(.12)	(.09)	(.25)	(.13)	(.12)	(.01)	(3.8)
Jönköping	$-.27^{***}$	$.10$	$.57^{***}$	$-.39^{***}$	$-.15$	$-.01$	$-.81$
	(.09)	(.07)	(.17)	(.07)	(.11)	(.01)	(3.0)
Kronoberg	$-.74^{***}$	$.30^{***}$	$.61^{**}$	$-.29^{***}$	$-.02$	$-.02$	4.5
	(.14)	(.09)	(.24)	(.10)	(.16)	(.02)	(5.2)
Kalmar	$-.46^{***}$	$-.03$	$.58^{**}$	$-.31^{***}$	$.10$	$.01$	9.9^{*}
	(.13)	(.11)	(.24)	(.09)	(.19)	(.02)	(5.3)
Gotland	$-.59^{***}$	$.05$	$-.20$	$-.12$	$.27^{*}$	$-.00$	$.11$
	(.09)	(.07)	(.25)	(.08)	(.15)	(.02)	(3.9)
Blekinge	$-.73^{***}$	$-.01$	1.9^{***}	$-.12$	$-.15$	$-.01$	-5.2
	(.13)	(.08)	(.34)	(.07)	(.17)	(.04)	(4.8)
Skåne	$-.14^{***}$	$-.17^{***}$	$.15^{*}$	$-.29^{***}$	$-.01$	$.01$	-1.6
	(.04)	(.06)	(.08)	(.08)	(.05)	(.01)	(1.5)
Halland	$-.53^{***}$	$.00$	$.21$	$-.18^{**}$	$-.01$	$-.00$	-4.0
	(.12)	(.07)	(.17)	(.08)	(.15)	(.01)	(3.4)
Västra Götaland	$-.48^{***}$	$.03$	$.52^{***}$	$-.15$	$-.01$	$.01$	1.2
	(.08)	(.06)	(.19)	(.12)	(.07)	(.01)	(1.9)
Värmland	$-.30^{***}$	$.11$	$.60^{***}$	$-.40^{***}$	$-.16$	$-.01$	-4.5
	(.10)	(.08)	(.23)	(.07)	(.17)	(.01)	(4.1)
Örebro	$-.36^{***}$	$-.11$	$.56^{***}$	$-.32^{***}$	$-.17$	$.01$	3.5
	(.11)	(.08)	(.19)	(.08)	(.11)	(.01)	(2.9)
Västmanland	$-.47^{***}$	$-.05$	$.38^{*}$	$-.23^{***}$	$-.13$	$.01$	-9.9^{***}
	(.10)	(.05)	(.23)	(.08)	(.12)	(.01)	(3.4)
Dalarna	$-.20^{*}$	$.04$	$.40$	$-.37^{***}$	$.20$	$-.03^{**}$	-2.2
	(.11)	(.10)	(.27)	(.09)	(.13)	(.01)	(3.6)
Gävleborg	$-.51^{***}$	$-.02$	$.90^{***}$	$-.20^{**}$	$.00$	2.2	
	(.10)	(.05)	(.18)	(.08)	(.01)	(2.6)	
Västernorrland	$-.68^{***}$	$.05$	$.46^{*}$	$-.11$	$.05$	$.01$	$-.98$
	(.11)	(.10)	(.24)	(.08)	(.17)	(.03)	(4.1)
Jämtland	$-.76^{***}$	$-.08$	$.58$	$-.12$	$-.01$	$-.01$	4.0
	(.16)	(.10)	(.46)	(.11)	(.23)	(.02)	(5.7)
Västerbotten	$-.19^{**}$	$.08$	$.21$	$-.30^{***}$	$-.13$	$.03^{*}$	$.15$
	(.09)	(.06)	(.18)	(.08)	(.14)	(.02)	(2.9)
Norrbotten	$-.23^{**}$	$.08$	$.07$	$-.39^{***}$	$.32$	$-.01$	8.8
	(.12)	(.11)	(.23)	(.09)	(.15)	(.01)	(4.7)

Notes: This table reports estimates based on equation (6) for $j = a$, $q = e$ and $i = 0, 1, 2, \ldots, N$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 10b: Estimation results of price diffusion equation with geographical proximity; tenant owned apartment

Region (i)	EC1 ($\hat{\phi}_{ia0}$)	EC2 ($\hat{\phi}_{ias}$)	Geographical Prox. Lag Effect ($\hat{\beta}_{iag1}$)	Own Lag Effect ($\hat{\beta}_{iag2}$)	Oil Lag Effect ($\hat{\beta}_{iag3}$)	RR Lag Effect ($\hat{\beta}_{iag4}$)	GRP Lag Effect ($\hat{\beta}_{iag5}$)
Stockholm		−.07	−.06	−.11	−.08	.00	−.06
		(.09)	(.11)	(.14)	(.07)	(.00)	(2.0)
Uppsala	$-.31^{***}$	$.17^{***}$	$.22^{**}$	$-.25^{***}$	−.08	$.01^{**}$	−.93
	(.06)	(.05)	(.11)	(.08)	(.07)	(.00)	(2.1)
Södermanland	$-.44^{***}$	.11	.27	$-.38^{***}$	.06	.02	−1.6
	(.15)	(.11)	(.21)	(.10)	(.14)	(.02)	(4.0)
Östergötland	$-.29^{**}$	.10	.25	$-.44^{***}$	−.14	−.01	−1.4
	(.11)	(.08)	(.20)	(.13)	(.12)	(.01)	(3.9)
Jönköping	$-.27^{***}$	−.08	.25	$-.34^{***}$	−.15	−.01	−.81
	(.08)	(.07)	(.15)	(.07)	(.11)	(.01)	(3.0)
Kronoberg	$-.78^{***}$	$.33^{***}$	.25	$-.27^{***}$	−.01	−.02	4.6
	(.15)	(.09)	(.17)	(.09)	(.16)	(.02)	(5.2)
Kalmar	$-.48^{***}$	.04	−.02	$-.29^{***}$	.10	.01	9.8^{*}
	(.13)	(.10)	(.22)	(.09)	(.18)	(.02)	(5.4)
Gotland	$-.59^{***}$	.06	$-.34^{*}$	−.11	$.27^{*}$	−.00	−.26
	(.09)	(.07)	(.17)	(.08)	(.15)	(.02)	(3.9)
Blekinge	$-.85^{***}$	.02	$.70^{***}$	−.02	−.10	−.01	−5.1
	(.12)	(.08)	(.22)	(.08)	(.18)	(.04)	(5.1)
Skåne	$-.13^{***}$	−.15	.00	$-.24^{***}$	−.00	.01	−1.2
	(.04)	(.05)	(.07)	(.07)	(.05)	(.01)	(1.4)
Halland	$-.54^{***}$	−.00	.16	$-.18^{**}$	−.01	−.00	−4.0
	(.12)	(.07)	(.14)	(.08)	(.15)	(.01)	(3.4)
Västra Götaland	$-.47^{***}$	.01	.06	.04	−.00	.01	1.5
	(.08)	(.06)	(.12)	(.09)	(.07)	(.01)	(1.8)
Värmland	$-.32^{***}$	.12	$.41^{*}$	$-.39^{***}$	−.17	−.01	−4.7
	(.10)	(.08)	(.23)	(.06)	(.17)	(.01)	(4.2)
Örebro	$-.34^{***}$	.09	$.49^{***}$	$-.30^{***}$	−.18	.01	3.5
	(.11)	(.08)	(.15)	(.08)	(.11)	(.01)	(2.8)
Västmanland	$-.48^{***}$	−.06	.45	−.23	−.13	.01	-9.9^{***}
	(.10)	(.05)	(.26)	(.08)	(.12)	(.01)	(3.4)
Dalarna	$-.20^{*}$	.04	.35	$-.37^{***}$	.19	$-.03^{**}$	−2.2
	(.11)	(.10)	(.25)	(.09)	(.13)	(.01)	(3.6)
Gävleborg	$-.57^{***}$	−.02	$.52^{***}$	−.12	.00	2.2	
	(.10)	(.05)	(.16)	(.08)	(.01)	(2.7)	
Västernorrland	$-.69^{***}$	.05	.10	−.08	.04	.01	−1.2
	(.11)	(.10)	(.20)	(.08)	(.18)	(.03)	(4.1)
Jämtland	$-.77^{***}$	−.08	.39	−.11	−.02	−.01	4.0
	(.16)	(.10)	(.30)	(.11)	(.23)	(.02)	(5.7)
Västerbotten	$-.19^{**}$	.08	$.24^{*}$	$-.31^{***}$	−.14	$.03^{*}$	.23
	(.08)	(.06)	(.14)	(.08)	(.14)	(.02)	(2.8)
Norrbotten	$-.23^{**}$	.08	.01	$-.39^{***}$	.32	−.01	8.7
	(.11)	(.11)	(.20)	(.09)	(.16)	(.01)	(4.7)

Notes: This table reports estimates based on equation (6) for $j = a$, $q = g$ and $i = 0, 1, 2, \ldots, N$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 10c: Estimation results of price diffusion equation with economic proximity; villa

Region (i)	EC1 ($\hat{\phi}_{iv0}$)	EC2 ($\hat{\phi}_{ivs}$)	Economic Prox. Lag Effect ($\hat{\beta}_{ive1}$)	Own Lag Effect ($\hat{\beta}_{ive2}$)	Oil Lag Effect ($\hat{\beta}_{ive3}$)	RR Lag Effect ($\hat{\beta}_{ive4}$)	GRP Lag Effect ($\hat{\beta}_{ive5}$)
Stockholm		$-.19^{**}$	$-.32^{*}$	.10	−.00	.00	1.1
		(.10)	(.16)	(.14)	(.07)	(.00)	(2.3)
Uppsala	-1.0^{***}	−.00	$.54^{***}$	−.01	−.17	−.00	−.75
	(.15)	(.14)	(.18)	(.08)	(.13)	(.01)	(3.1)
Södermanland	$-.46^{***}$	$-.16^{**}$	.06	$-.23^{***}$	$-.12^{*}$	.00	−1.5
	(.10)	(.08)	(.11)	(.08)	(.07)	(.01)	(1.9)
Östergötland	$-.57^{***}$	−.07	−.16	−.08	−.11	.00	−1.4
	(.10)	(.12)	(.15)	(.10)	(.09)	(.01)	(2.3)
Jönköping	$-.45^{***}$	$-.38^{**}$	.20	−.06	.01	.01	−2.7
	(.14)	(.15)	(.21)	(.12)	(.10)	(.02)	(2.7)
Kronoberg	−.08	$-.76^{***}$	$.63^{***}$	−.05	−.01	−.00	1.5
	(.13)	(.16)	(.19)	(.08)	(.13)	(.01)	(3.2)
Kalmar	$-.26^{***}$	−.09	.20	$-.22^{**}$	.02	.01	−1.5
	(.09)	(.13)	(.15)	(.09)	(.10)	(.01)	(2.4)
Gotland	$-.67^{***}$	$-.19^{*}$	.25	−.07	.02	−.01	4.4
	(.12)	(.10)	(.21)	(.06)	(.17)	(.02)	(4.0)
Blekinge	−.07	$-.54^{***}$	$.40^{**}$	$-.18^{**}$	.04	.00	−.63
	(.11)	(.14)	(.19)	(.08)	(.11)	(.01)	(2.9)
Skåne	$-.14^{**}$	−.09	$.29^{***}$	$-.49^{***}$	$-.11^{**}$	$.01^{*}$	−2.0
	(.05)	(.07)	(.08)	(.08)	(.05)	(.00)	(1.5)
Halland	$-.51^{***}$	−.23	−.01	−.06	$-.17^{*}$	−.00	−2.0
	(.12)	(.16)	(.14)	(.09)	(.10)	(.01)	(2.2)
Västra Götaland	$-.59^{***}$	.02	$.34^{**}$	−.13	−.06	.00	1.1
	(.09)	(.15)	(.15)	(.12)	(.10)	(.01)	(2.3)
Värmland	$-.31^{***}$	−.23	$.40^{**}$	$-.24^{***}$	.05	.00	.02
	(.12)	(.15)	(.17)	(.07)	(.10)	(.01)	(2.8)
Örebro	$-.60^{***}$	−.17	$.39^{**}$	$-.16^{*}$	.01	−.01	−.92
	(.13)	(.17)	(.16)	(.08)	(.08)	(.01)	(2.6)
Västmanland	$-.66^{***}$	$.47^{***}$	$.71^{***}$	$-.44^{***}$	−.07	.00	−1.3
	(.13)	(.14)	(.18)	(.10)	(.09)	(.01)	(2.5)
Dalarna	$-.29^{***}$	−.07	$.33^{***}$	$-.37^{***}$	−.06	$.02^{**}$	−.50
	(.10)	(.08)	(.11)	(.07)	(.07)	(.01)	(1.9)
Gävleborg	$-.49^{***}$	$-.35^{**}$	$.34^{**}$	−.06	−.00	−.95	.02
	(.13)	(.15)	(.16)	(.09)	(.01)	(1.6)	(.06)
Västernorrland	$-.58^{***}$	−.02	$.40^{**}$	$-.26^{***}$	.03	.01	.37
	(.13)	(.11)	(.18)	(.08)	(.13)	(.01)	(3.0)
Jämtland	$-.50^{**}$	−.31	$.58^{**}$	−.11	−.23	−.00	−2.2
	(.25)	(.26)	(.23)	(.09)	(.14)	(.01)	(3.9)
Västerbotten	$-.47^{***}$	−.15	.24	−.10	.03	.01	2.9
	(.14)	(.15)	(.18)	(.09)	(.11)	(.01)	(3.4)
Norrbotten	$-.39^{***}$	−.16	.19	$-.16^{*}$	.04	−.01	4.3
	(.09)	(.07)	(.15)	(.09)	(.10)	(.01)	(2.4)

Notes: This table reports estimates based on equation (6) for $j = v$, $q = e$ and $i = 0, 1, 2, \ldots, N$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.

Table 10d: Estimation results of price diffusion equation with geographical proximity; villa

Region (i)	EC1 ($\hat{\phi}_{iv0}$)	EC2 ($\hat{\phi}_{ivs}$)	Geographical Prox. Lag Effect ($\hat{\beta}_{ivg1}$)	Own Lag Effect ($\hat{\beta}_{ivg2}$)	Oil Lag Effect ($\hat{\beta}_{ivg3}$)	RR Lag Effect ($\hat{\beta}_{ivg4}$)	GRP Lag Effect ($\hat{\beta}_{ivg5}$)
Stockholm		$-.26^{**}$	$-.35^{**}$	.13	−.00	.01	1.1
		(.10)	(.15)	(.14)	(.07)	(.00)	(2.3)
Uppsala	-1.1^{***}	.02	$.34^{**}$	.06	−.16	−.00	−.73
	(.15)	(.14)	(.17)	(.08)	(.13)	(.01)	(3.2)
Södermanland	$-.45^{***}$	$-.21^{**}$	−.05	$-.20^{***}$	$-.12^{*}$	.00	−1.5
	(.11)	(.09)	(.11)	(.07)	(.07)	(.01)	(1.9)
Östergötland	$-.57^{***}$	−.09	.03	−.03	−.10	.00	−1.4
	(.10)	(.13)	(.14)	(.10)	(.09)	(.01)	(2.3)
Jönköping	$-.45^{***}$	$-.42^{**}$	−.08	−.01	.01	.01	−2.9
	(.13)	(.16)	(.19)	(.11)	(.10)	(.02)	(2.8)
Kronoberg	−.12	$-.76^{***}$	$.54^{***}$	−.02	−.02	−.00	1.5
	(.13)	(.16)	(.20)	(.08)	(.14)	(.01)	(3.2)
Kalmar	$-.19^{*}$	−.23	−.16	−.15	−.02	.01	−2.0
	(.11)	(.15)	(.16)	(.09)	(.10)	(.01)	(2.4)
Gotland	$-.68^{***}$	$-.17^{*}$	$.39^{*}$	−.08	.02	−.01	4.5
	(.12)	(.10)	(.22)	(.06)	(.16)	(.02)	(4.0)
Blekinge	$-.09^{***}$	$-.55^{***}$	.21	$-.15^{*}$	.04	.00	−.91
	(.12)	(.16)	(.21)	(.08)	(.11)	(.01)	(2.9)
Skåne	$-.17^{***}$	.03	$.21^{**}$	$-.46^{***}$	$-.11^{**}$	$.01^{*}$	−2.1
	(.05)	(.08)	(.09)	(.08)	(.05)	(.00)	(1.5)
Halland	$-.51^{***}$	−.22	.02	−.07	$-.17^{*}$	−.00	−2.0
	(.12)	(.17)	(.14)	(.09)	(.10)	(.01)	(2.2)
Västra Götaland	$-.59^{***}$	−.03	.09	.00	−.08	.00	1.1
	(.09)	(.16)	(.15)	(.12)	(.09)	(.01)	(2.3)
Värmland	$-.32^{**}$	−.26	$.29^{*}$	$-.21^{***}$	.05	.00	−.05
	(.12)	(.16)	(.16)	(.07)	(.10)	(.01)	(2.8)
Örebro	$-.61^{***}$	−.22	.23	−.10	.01	$-.01^{*}$	−.95
	(.13)	(.17)	(.16)	(.08)	(.08)	(.01)	(2.6)
Västmanland	$-.79^{***}$	$-.61^{***}$	$.75^{***}$	$-.45^{***}$	−.06	−.00	−1.2
	(.14)	(.15)	(.19)	(.10)	(.09)	(.01)	(2.5)
Dalarna	$-.33^{***}$	−.03	$.29^{***}$	$-.36^{***}$	−.06	$.02^{*}$	−.60
	(.10)	(.08)	(.11)	(.07)	(.07)	(.01)	(1.7)
Gävleborg	$-.49^{***}$	$-.40^{**}$	.16	−.03	−.00	−.99	.04
	(.13)	(.17)	(.17)	(.10)	(.01)	(1.7)	(.06)
Västernorrland	$-.64^{***}$	−.06	.26	−.25	.04	.01	.28
	(.13)	(.12)	(.18)	(.08)	(.13)	(.02)	(3.2)
Jämtland	$-.61^{**}$	−.20	$.62^{**}$	−.11	−.22	−.00	−2.4
	(.24)	(.25)	(.24)	(.08)	(.14)	(.01)	(3.9)
Västerbotten	$-.51^{***}$	−.11	.19	−.09	.03	.01	2.9
	(.14)	(.16)	(.20)	(.09)	(.11)	(.01)	(3.5)
Norrbotten	$-.40^{***}$	$-.18^{**}$	.03	−.12	.04	−.01	4.3
	(.09)	(.08)	(.14)	(.09)	(.10)	(.01)	(2.5)

Notes: This table reports estimates based on equation (6) for $j = v$, $q = g$ and $i = 0, 1, 2, \ldots, N$. The standard errors are shown in the parenthesis. ***, ** and * denote for 1 %, 5 % and 10 % level of significance, respectively.