



What Causes the Positive Price-Turnover Correlation in European Housing Markets?

Martijn I. Dröes^{1,2,3} · Marc K. Francke^{1,4}

Published online: 1 March 2017

© The Author(s) 2017. This article is published with open access at Springerlink.com

Abstract This paper examines what determines the correlation between prices and turnover in European housing markets. Using a panel vector autoregressive model, we find that there is a particularly strong feedback mechanism between prices and turnover. Momentum effects are another important reason why prices and turnover are correlated. Common underlying factors, such as GDP and interest rates, also explain part of the price-turnover correlation. The results in this paper imply that, to understand price and turnover dynamics, it is important to model prices and turnover as two interdependent processes. There is a considerable bias in the coefficient estimates of standard house price models if this dependency is not explicitly taken into account.

Keywords Price-turnover relationship · Feedback · Momentum effects · Credit constraints · Nominal loss aversion

JEL Classification E02 · R31 · O18

Introduction

It is a well-established empirical fact that prices and turnover in housing markets are positively correlated. There are several explanations for this correlation ranging from

✉ Martijn I. Dröes
m.i.droes@uva.nl

¹ Amsterdam Business School, Faculty of Economics and Business, University of Amsterdam, Plantage Muidergracht 12, 1018 TV Amsterdam, The Netherlands

² Amsterdam School of Real Estate, Jollemanhof 5, 1019 GW Amsterdam, The Netherlands

³ Tinbergen Institute, Gustav Mahlerplein 117, 1082 MS Amsterdam, The Netherlands

⁴ Ortec Finance, Naritaweg 51, 1043 BP Amsterdam, The Netherlands

credit constraints (Genesove and Mayer 1997; Stein 1995) and nominal loss aversion (Genesove and Mayer 2001) to hedging incentives (Sinai and Souleles 2005, 2009; Han 2008, 2010). Most previous literature on this topic has focused on the US (see Clayton et al. 2010). Although there have been several European-based studies on price-turnover dynamics, such as for Sweden (Hort 2000), the UK (Andrew and Meen 2003), and the Netherlands (De Wit et al. 2013), there has not yet been a cross-country European study on this topic. This paper aims to fill this gap.

There are several key reasons why prices and turnover are positively correlated. First, there may be momentum in both prices and turnover. A market that is on the rise has a tendency to keep rising. There is quite some literature on such momentum effects in house prices (see Case and Shiller 1989, or more recently Lai and Van Order 2010; Beracha and Skiba 2011; Head et al. 2014; Kuang 2014). A common explanation is that housing market frictions (i.e. search frictions, transaction costs) results in a sluggish adjustment of housing markets (see Díaz and Jerez 2013; Merlo et al. 2015). Alternatively, there is also quite some literature that focusses on price expectations and speculative behavior (bubbles) in housing markets (e.g. Case and Shiller 2003; Himmelberg et al. 2005; Glaeser et al. 2008; Han and Strange 2014; Ling et al. 2015). There is, unfortunately, much less known about momentum in housing market turnover. Some notable exceptions are Piazzesi and Schneider (2009), who focus on households beliefs and momentum traders, Krainer (2001), who provides a model of hot and cold housing markets and explains liquidity, amongst others, by the functioning of rental markets, and Anenberg and Bayer (2013) who argue that the cost of simultaneously holding two homes results in a strongly procyclical pattern of residential mobility within the Los Angeles metropolitan area.

A second reason that prices and turnover are correlated is because of a lagged feedback mechanism between prices and turnover. A good example of such a feedback mechanism is given by Ortalo-Magné and Rady (2006) (also see Ortalo-Magné and Rady 1999). They show in a life-cycle model setup that increases in income (especially of starter households) can result in price increases and subsequent increases in transaction volume. This effect propagates through the housing market, strengthening itself across the property ladder, and resulting in a positive correlation between prices and transaction volume. The positive correlation in this type of model is typically the result of financial constraints. Other models along this line are those of Wheaton (1990), Stein (1995), Goetzmann and Peng (2006), and Bajari et al. (2013). A related strand of literature also adds behavioral considerations, such as nominal loss aversion, to explain the price-turnover relationship (i.e. Genesove and Mayer 2001; Engelhardt 2003).

A third reason for the price-turnover correlation is that there are common (macro-economic) factors that determine both prices and turnover. De Wit et al. (2013), for example, find that especially the mortgage rate explains the price-turnover relationship in the Netherlands. Clayton et al. (2010) argue that also labor market conditions and stock markets are important determinants in the US and that their impact depends on the supply elasticity of housing markets. Andrew and Meen (2003) document a change in the price-turnover relationship in the UK in the early 1990s. They argue that this change is, at least in part, the result of a change in the behavior of first-time buyers. Hort (2000) actually finds a negative contemporaneous correlation in Sweden. Buyers respond to demand shocks while the reservation prices of sellers remain the same. As a result, transaction volume declines but the prices of successful transactions increases.

Follain and Velz (1995) also find a negative correlation due to a decrease in the importance of downpayment constraints in the US in the 1990s.

Finally, there may be fixed institutional differences across countries that can explain the heterogeneity in price-turnover correlations. In the US, for example, down-payment constraints play an important role in the transaction process. By contrast, there are no such formal down-payment constraints in many European countries, although loan-to-value (LTV) ratios can still be interpreted as a measure of informal constraints imposed by banks (see Chiuri and Jappelli 2003). Other institutional differences across countries include the tax treatment of owner-occupied housing, whether mortgage loans are recourse or non-recourse loans, and the extent to which there are zoning regulations. Although it is out of the scope of this text to provide a full overview of such differences, the fact that we will use cross-country (panel) data at least allows us to control for ‘fixed’ institutional factors that determine prices and turnover.

A specific contribution of our paper is that we examine all of the aforementioned determinants of the price-turnover relationship for a set of European countries within a single estimation framework. In particular, we use data on prices and turnover of 16 European countries over the period 1999–2013. The dataset is based on several statistical publications of the European Mortgage Federation and on Eurostat data. The dataset contains information about some key macro-economic and housing market indicators, such as the amount of outstanding mortgage balance to GDP, the interest rates on new mortgage loans, and the housing stock. More importantly, besides data on house prices, the dataset contains information about the number of transactions. Although there have been several OECD/IMF studies examining price dynamics (e.g. Hilbers et al. 2011; André 2010; Andrews 2010; Andrews et al. 2011; Sánchez and Johansson 2011), to the best of our knowledge there is no such study examining the relation between prices and turnover across European countries. A further interesting aspect of the dataset is that it contains data on both the pre-crisis and crisis period. This allows us to examine nominal loss aversion, especially since the timing of the financial crisis, and the extent to which prices declined, has been considerably different across European countries.

We simultaneously model prices and turnover as two interdependent endogenous processes. We use an unrestricted panel VAR approach. Since we have 15 years of data we have to pool the data to estimate the VAR parameters. Since including lagged dependent variables in a panel data setup results in biased coefficient estimates (see Nickell 1981), we use an instrumental variable approach along the lines of Arellano and Bond (1991). A further complication is that some of the variables, including prices and turnover, appear to be non-stationary. We examine whether there is cointegration between those variables. We discuss what are the key determinants of prices and turnover for the European countries as a whole (on average) and we will highlight some key differences across countries (decomposition of house price dynamics).

The results in this paper show that there is a considerable degree of lagged feedback between prices and turnover. A 1% increase in (real) house prices decreases turnover (normalized by the housing stock) by 0.74%, while a 1% increase in the turnover rate increases prices by 0.24%. There are also strong momentum effects in prices and turnover. Price increases in one year have an effect of 34% on house prices the next year. For turnover this autoregressive effect is even 60%. Jointly with GDP and (real) interest rates, momentum and lagged feedback are key in explaining the price-turnover

relationship. In this respect, it is important to note that (lagged) price shocks have an opposite sign in the price and turnover equations and, thus, such shocks act to weaken the positive price-turnover correlation. Other factors, like the loan-to-GDP ratio, population growth, and inflation, do not seem to directly affect prices and turnover. However, a high loan-to-GDP ratio does seem to increase the effect of GDP and interest rates on prices and turnover, although the effects of GDP and interest rates mainly go through turnover. In addition, we do not find evidence for nominal loss aversion or cointegration. Further results based on a historical decomposition of house price changes in Europe show that especially shocks in turnover (contribution of 12.4%) and real house prices (contribution of 6.7%) explain house price dynamics.

The key message of this paper is that it is essential to model the interdependency between prices and turnover when examining price (or turnover) dynamics. Our results indicate that there is considerable bias if this interdependency is not explicitly taken into account. In particular, the autoregressive coefficient on house prices is about 14% higher and the autoregressive coefficient on turnover 43% lower if the feedback between prices and turnover is not correctly specified. This is an important result because it implies that part of the (house price) momentum that is typically found in housing markets (i.e. Case and Shiller 1989; Lai and Van Order 2010) can be explained by the feedback between prices and turnover.

Further results indicate that the bias in the real GDP coefficient ranges from 21% in the price equation to 3% in the turnover equation. The effect of real interest rates is severely overestimated in the price equation (although its effect is statistically insignificant) and it is underestimated by 21% in the turnover equation. In both equations the year-specific time trends are also underestimated. There is a growing literature suggesting that it is important to account for liquidity when calculating housing returns (Cheng et al. 2013) or property price indices (Fisher et al. 2003; Goetzmann and Peng 2006). We argue that this line of reasoning should be extended to include regression models that aim to explain house price dynamics. It is, therefore, essential that information on housing transactions is publically available. Although most national statistical institutes (besides house price indices) publish such information, the overarching European statistical institute (Eurostat) currently does not. It explains why many cross-country studies (i.e. OECD/IMF) have focused solely on price dynamics. Our results suggest that a proper cross-country comparison should also look at differences in housing market liquidity.

This paper is not the first to examine the price-turnover relation in a panel data setup. A closely related paper is the paper by Clayton et al. (2010). Using a similar panel VAR setup, they examine the price-turnover correlation based on data from 114 metropolitan statistical areas in the US between 1990 and 2002. They find that house prices affect turnover, but that the effect is asymmetric. Only price decreases seem to have a (decreasing) effect on turnover. Turnover also has a positive effect on house prices, but only if supply is inelastic. Hence, they conclude that the price-turnover correlation is mainly the result of common factors (e.g. mortgage rate, income) that affect both prices and turnover. Although our results, to some extent, corroborate the findings by Clayton et al. (2010), albeit for a set of European countries, we also show some important new insights.

First, we find that although common factors play a role in explaining the price-turnover correlation, the feedback between prices and turnover and the autoregressive component in prices and turnover are more important determinants of the price-

turnover correlation in European countries. In part this reflect that the effect of GDP and interest rates, also from a dynamic point of view, goes through turnover and, to a lesser extent, through prices. We further contribute to the existing literature by showing the bias in case the interdependency between prices and turnover is not explicitly taken into account and, as mentioned, relating that bias to explain part of the momentum effect typically found in housing markets (i.e. Case and Shiller 1989; Lai and Van Order 2010).

Second, we do not find much evidence for an asymmetric effect. Price decreases, *ceteris paribus*, seem to increase turnover, which is in line with classical demand theory and stands in contrast to the results of Clayton et al. (2010). Hence, it seems that in European markets the demand effect, at least on average, outweighs the potential negative effects due to nominal loss aversion (Genesove and Mayer 2001). We find this also using data from the crisis period, which was characterized by substantial price declines (Clayton et al. 2010, only use pre-crisis data). By contrast, we do find that the loan-to-GDP ratio acts to strengthen the price-turnover relationship by increasing the effect of GDP and interest rates on prices and turnover (also see Genesove and Mayer 1997).

A third contribution is that we use the regression results (impulse response functions) to decompose house price dynamics in several European countries, showing some remarkable differences regarding the role of momentum and turnover in explaining house price dynamics. We focus the discussion on price dynamics, because housing is typically a considerable part of household wealth. So, variations in prices link to variations in wealth. Again, and in line with our earlier findings, shocks in turnover and real house prices, are key in explaining price dynamics in Europe. In a country such as Germany the contribution of turnover is twice as high as in Europe on average. In combination with a low volatility of turnover, this explains why Germany does not have a very price-volatile market. This is an interesting fact for real estate investors, again highlighting the important role of market liquidity in explaining house price dynamics. In France, the autoregressive component plays a more prevalent role. The housing market in France is also more volatile. And, finally, in the UK housing market, which is typically considered to be a highly volatile market, both turnover and momentum, but also unexplained macroeconomic shocks, are key determinants of price dynamics. House prices in the UK decreased considerably in 2008 and 2009, but also turnover decreased by 60% in 2008. This is key in explaining the price volatility in the UK market. In sum, we show that although the actual price dynamics has been different across countries, the underlying components have been largely the same.

The remainder of this paper is organized as follows. Section “European data on house prices and turnover” discusses the data used in this study. Section “Methodology” covers the empirical methodology. In Section “Results”, we present the regression results. Section “Conclusion and discussion” provides a conclusion.

European Data on House Prices and Turnover

Several statistical publications published by the European Mortgage Federation (EMF) have been combined to create a dataset on house prices and turnover for a selected sample of European countries. The data in the EMF reports is based on a variety of sources including National Statistical Offices, the Central Banks of several member

states, Eurostat, and the OECD. The dataset contains information on the housing stock, the outstanding mortgage balance as a percentage of GDP, the interest rate on new mortgage loans, and GDP at current market prices. Population, the share of young population (18–30 years old), and inflation (based on the Harmonised Index of Consumer Prices, HICP) are taken from Eurostat.

We use the EMF (2013) report to create our main dataset. It contains information from 2001 to 2012. Based on two additional report, EMF (2012) and EMF (2011), we extent the data to 1999 and fill in some missing gaps in our main dataset. The EMF (2005) report also contains some information to fill in missing observations and it contains data up until 1995. Unfortunately, as the time period increases the number of cross-sectional units that remain in the analysis drops considerably (from 16 to 10 countries) or the dataset becomes highly unbalanced, which would result in a comparison of different housing market periods across different countries, a situation we want to avoid. As a consequence, we decided to use data as of the year 1999. The EMF (2014) report is used to update the data to include the year 2013. Hence, our main period of analysis is 1999–2013.

The following 16 countries are included in the dataset: Belgium, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, The Netherlands, Norway, Portugal, Sweden, and the UK. It is evident that most of the Eastern European countries are missing. The main limiting variable is turnover. Consistent data about the number of transactions in, for example, Latvia, Luxembourg, Poland, Romania, Slovenia, Spain, and Ukraine, is simply not available. In addition, if more than 3 years of turnover are missing, we excluded the country from the dataset. The (strongly balanced) dataset on 16 countries for a period of 15 years, however, provides us with sufficient observations to empirically analyze the price-turnover relationship. Table 1 contains the descriptive statistics of the variables in levels and, similarly, Table 2 reports descriptive statistics in (log) differences. The empirical analysis, see section “Methodology”, will be based on the differenced variables. Note that we also report several variables (house prices, GDP, and interest rates) in real terms. The analysis in this paper, however, starts in nominal terms since it allows us to distinguish between (nominal) price increases and price declines. As a robustness check, we will show that using real values will not change our main results. Finally, Fig. 5 in the Appendix contains the time series plots of house prices and transaction volume for the 16 countries. Although these time series are sometimes volatile, ‘eyeballing’ these plots suggest that the time series are reasonably well behaved.^{1,2}

¹ There are quite some differences in the underlying methodologies used to construct the price and turnover series. For example, the price series for Belgium is based on the average prices of existing homes and that of Estonia also includes new dwellings. The transaction volume for Denmark excludes self builds and the data for Ireland is based on mortgage approvals (for a detailed discussion, see EMF 2013). This implies that, as is often the case with cross-country studies, the data is not perfect and caution should be taken with interpreting the results. We are fully aware of this limitation.

² There is also quite some heterogeneity across countries in terms of changes in turnover and prices (also see the high min-max spread in the differenced series, Table 2). For example, Estonia had a very large price decrease from 2008 to 2009 (−0.446), Iceland a large turnover decrease from 2007 to 2008 (−0.925), and Hungary a large price/turnover increase from 1999 to 2000 (0.621/0.418). Also, we noticed a negative real interest rate for Iceland in 2010. Although it is questionable whether these values should be interpreted as outliers, the estimates excluding these values are much in line with the final model estimates presented in the results section of this paper.

House Prices

We use a nominal house price index as our main house price indicator. The year 2006 is the base year (Index = 100). Especially the percentage change in this variable, not the level of the index in itself, is interesting. The average annual return (log-differences) across the European countries in our dataset has been 4.8% between 1999 and 2013. Most of the price series are hump shaped as a result of the financial crisis. Table 3 contains the average percentage return for each of the 16 countries before and during the financial crisis. The starting point of the financial crisis per country, based on the first year house prices started to decrease, is also reported.

Table 3 shows several important results. First, it is evident that house price changes between 1999 and 2013 differ considerably across European countries. Iceland has had the highest annual house price appreciation (8.1%) and Germany the lowest (1.2%). Second, the start of the financial crisis, and to which extent prices declined, is different across European countries. Germany responded relatively fast to the financial crisis, while Portugal and Sweden responded relatively late. Belgium did not have a price decline at all. For most countries, however, the average returns have decreased substantially as a result of the financial crisis. Interestingly, some countries still have positive average house price appreciation (after the start of the crisis and until 2013) suggesting that they already recovered from the price declines. A country such as Germany, for example, has had a very small response to the crisis and its average annual return after 2006 is actually higher than before the crisis. The question we examine in this paper is what can explain these differences in house price dynamics.

Turnover

Besides house prices, the transaction volume of owner-occupied houses – in this paper denoted as turnover – will be used as a key dependent variable. The average number of transactions (houses sold) per year across the European countries is about 300,000. The highest turnover is in the UK, 1.3 million transactions per year, and the lowest in Iceland with 8500 transactions per year. The average growth in transactions, however, shows a yearly decrease in the number of transaction of 2.3%. This can be explained by the financial crisis.

Instead of the actual transaction volume as dependent variable, we have used the housing stock per country (and year) to normalize turnover.³ In almost all countries the housing stock has been steadily increasing over the years, with the growth decreasing during the financial crisis. The average increase has been 1.2%. Germany and France

³ The housing stock is a proxy for the total potential size of the housing market within a country. As such, it includes rental housing. To the extent that owner-occupancy rates do not change over the sample period (i.e. we only have 15 years of data), the differences in owner-occupancy rates are captured by the fixed effects we will include in the empirical model. Unfortunately, there are no consistent owner-occupancy time series available for Europe. A second issue is that the housing stock is an inherently endogenous process. Instead of increasing the dimensionality of the system of equations (we do not have that many observations), we decided to normalize turnover by the housing stock, which makes turnover more comparable across countries. The effect of changes in housing stock (construction) on prices and turnover, and the interplay between rent and price dynamics, would be interesting avenues for future research.

Table 1 House prices, turnover, and other macro-economic variables (levels)

Variables	Mean	Std. Dev.	Min.	Max.
House prices (index)	88.8	22.2	28.8	147.3
Real house prices	86.7	17.9	33.7	130.4
Number of transactions	293,408	355,858	3039	1,785,000
Housing stock ($\times 1000$)	10,336	12,615	103	41,217
Turnover rate (trans./housing stock)	0.039	0.024	0.007	0.115
Outstanding mortgage balance to GDP (%)	51.19	29.50	1	159
Interest rate new mortgage loans (%)	5.05	2.18	1.89	16.07
Real interest rate (%)	2.00	2.20	-9.20	10.84
GDP (euros, current prices)	603,111	735,802	5359	2,714,807
Real GDP	597,811	724,658	6385	2,396,969
Population (in millions)	22.07	26.18	0.28	82.54
Share of population between 18 and 30 years of age	0.172	0.017	0.137	0.219
HICP (level index)	101.6	13.9	65.8	168.0
Inflation (%; HICP)	2.66	2.06	-1.66	16.26
Sample period	1999–2013 (15 years)			
Number of countries	16			
Number of observations	240			

The number of observations is a bit different per variable since we do not have a fully balanced panel dataset. The dataset is strongly balanced with the number of observations per variable ranging from 228 to 240

are the countries with the highest housing stock. The housing stock is about 4.2 million and 3.5 million in 2013, respectively. This suggests that, although the housing stock and turnover are highly correlated (correlation coefficient of 0.77), the correspondence between housing stock and turnover is not one-for-one. Especially interesting is the turnover rate: the number of transactions as a fraction of the housing stock. This variable gives a better and more comparable indication of the demand side pressures in each of the European housing markets. Figure 1 shows the average turnover rate for each of the selected European countries. There is considerable heterogeneity in this rate. In countries such as Norway about 8% of the total housing stock is sold each year. Instead, in a country such as Greece this is 2%. We are particularly interested to examine how these differences (and their changes over time) can explain the different experience in terms of price dynamics in European countries. Specifically, Fig. 2 depicts the (contemporaneous) correlation between the change in the log normalized measure of turnover and the change in house prices. Although there are some differences among European countries, there indeed seems to be a positive correlation between prices and turnover. In Poland, Belgium, and Finland this correlation is relatively low (about 0.2). In Norway, Hungary, and Italy it is relatively high (>0.6).⁴ As mentioned, this paper goes into more detail about the underlying forces and dynamics underlying this positive relationship.

⁴ By comparison, the correlation (using similar data) is about 0.55 for the US.

Table 2 House prices, turnover, and other macro-economic variables (differences)

Variable	Mean	Std. Dev.	Min.	Max.
Δ log house prices (index)	0.048	0.096	-0.446	0.621
Δ log real house prices (index)	0.021	0.094	-0.448	0.526
Δ log number of transactions	-0.023	0.167	-0.925	0.418
Δ log housing stock	0.012	0.011	-0.004	0.088
Δ log turnover rate	-0.035	0.168	-0.949	0.409
Δ outstanding mortgage balance to GDP (%)	2.137	3.897	-13.6	32.8
Δ interest rate new mortgage loans (%)	-0.241	1.045	-4.58	2.53
Δ real interest rate	-0.086	1.029	-5.18	5.51
Δ log GDP	0.036	0.065	-0.372	0.206
Δ log real GDP	0.009	0.068	-0.492	0.192
Δ log population	0.0045	0.0060	-0.0066	0.0309
Δ share of population between 18 and 30 years of age	-0.0013	0.0028	-0.0132	0.0051
Δ log HICP (level index)	0.026	0.020	-0.017	0.151
Δ log inflation	-0.009	0.780	-3.954	2.805
Sample period	1999–2013 (15 years)			
Number of countries	16			
Number of observations	224			

The number of observations is a bit different per variable since we do not have a fully balanced panel dataset. The dataset is strongly balanced with the number of observations per variable ranging from 211 to 224

Other Macro-Economic Indicators

There are several other factors that we include in the analysis as exogenous control variables. In particular, we include two mortgage market indicators: the outstanding mortgage loans to GDP and the interest rate on new mortgage loans. The average loan-to-GDP is 52%. This ratio has been increasing in most countries over time with a stabilization or decline as a result of the financial crisis. Interestingly, the loan-to-GDP has been decreasing during the sample period for Germany. In 2013, the lowest loan-to-GDP ratios are in Hungary (19%) and Italy (23%). The highest ratios are in Iceland (159%) and the Netherlands (104%). The loan-to-GDP ratio is a proxy for credit constraints in the economy. Instead, the interest rate measures the price of credit and it is therefore an indicator of the availability of credit. Both variables are expected to have a negative effect on prices and turnover. In all countries, the interest rate is currently low. The average interest rate is highest in Hungary (12.1%), which can probably explain why the loan-to-GDP ratio is so low in this country. In Sweden and Finland mortgage credit is cheapest with an average interest rate of 3.7%.

Further macro-economic factors include GDP, population, inflation, and the share of young population (between the years of 18 and 30) in a country. GDP and population are both demand side factors and should have a positive effect on prices and turnover. Inflation is added to the analysis such that we can estimate a model in real terms. Finally, we expect that countries with a high share of young population are more likely to be affected by house price shocks. In particular, young people usually do not have a

Table 3 House price changes and the start of the financial crisis

Country	Annual return 1999–2013	Before crisis average return	Start crisis	Until 2013 average return
Belgium	0.066	-	-	-
Denmark	0.034	0.082	2007	-0.031
Estonia	0.094	0.270	2007	-0.053
Finland	0.044	0.047	2009	0.036
France	0.057	0.101	2007	-0.002
Germany	0.012	0.008	2006	0.016
Greece	0.027	0.084	2008	-0.075
Hungary	0.075	0.145	2008	-0.050
Iceland	0.081	0.134	2007	0.009
Ireland	0.019	0.116	2007	-0.110
Italy	0.029	0.056	2008	-0.020
Netherlands	0.024	0.064	2008	-0.048
Norway	0.071	0.091	2007	0.045
Portugal	0.015	0.025	2010	-0.020
Sweden	0.062	0.070	2011	0.011
UK	0.064	0.109	2007	0.003
Sample period	1999–2013 (15 years)			

The house price changes are based on the differenced log nominal house price index per country. According to our data nominal house prices did not decline in Belgium due to the crisis, so the returns before/after the crisis are omitted from the table

considerable degree of accumulated wealth and they are typically starters at the housing market. Older households might, to some extent, recoup losses on their house because buying a new house is typically also cheaper (see Sinai and Souleles 2005). We are particularly interested whether this variable affects price and turnover dynamics. The share of young population in many countries, such as Belgium, Denmark, Germany, Sweden, The Netherlands, Norway, Iceland, shows a U-shaped time series pattern. On average, the lowest share of young population is in Germany, about 15.4%. Finally, average growth in GDP between 1999 and 2013 has been 3.6% and inflation about 2.7%. Average GDP Growth has been highest in Estonia, 8.7%, and lowest in Iceland, 1.8%. Iceland virtually went bankrupt due to the financial crisis which affected its economic growth severely. In conjunction with a high inflation rate of 5.0% (only Hungary had higher inflation, 5.8%), Iceland's real GDP growth has been -3.7%. Instead, Estonia had the highest real GDP growth, 4.6% per year.

Stationarity

A well-known fact is that many macro-economic time series are non-stationary. Table 4 contains the Fisher type of test (based on the Dickey-Fuller test) of non-stationarity. The null hypothesis is that all panels are non-stationary versus the alternative that at least one panel is stationary. We only report the inverse chi-squared

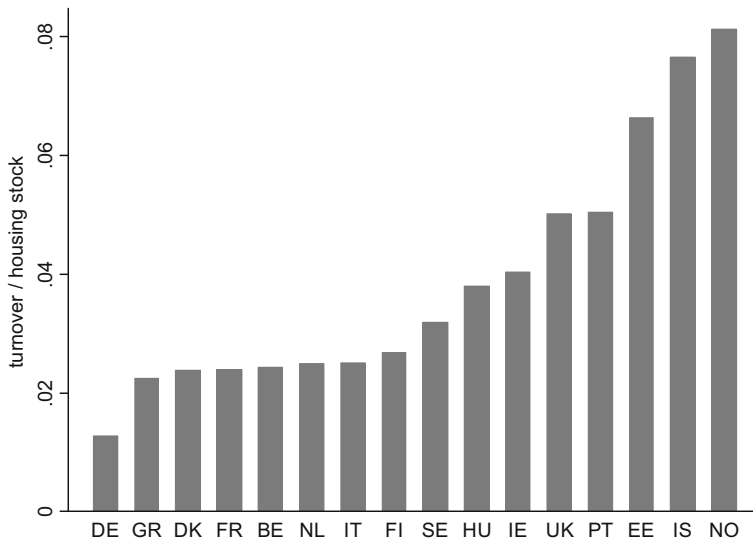


Fig. 1 The turnover rate in different European countries. Based on data from 1999 to 2013. The turnover rate is the number of transactions relative to the total housing stock. This figure reports the average turnover rate (between 1999 and 2013) per country. DE (Germany), GR (Greece), DK (Denmark), FR (France), BE (Belgium), NL (Netherlands), IT (Italy), FI (Finland), SE (Sweden), HU (Hungary), IE (Ireland), UK (United Kingdom), PT (Portugal), EE (Estonia), IS (Iceland), NO (Norway)

statistic. The inverse normal, inverse logit, and modified inverse chi-squared statistic gave very similar results.

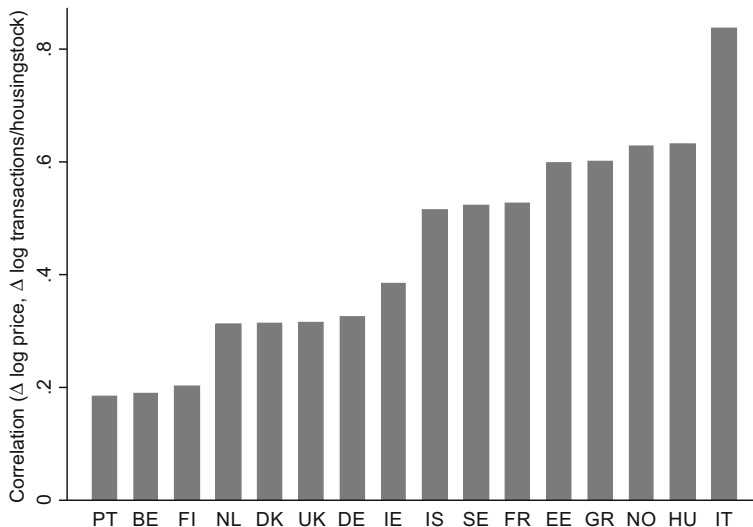


Fig. 2 Correlation between house prices and turnover. Based on data from 1999 to 2013. This figure reports, per country, the correlation between the change in the log turnover rate and the change in log house prices. DE (Germany), GR (Greece), DK (Denmark), FR (France), BE (Belgium), NL (Netherlands), IT (Italy), FI (Finland), SE (Sweden), HU (Hungary), IE (Ireland), UK (United Kingdom), PT (Portugal), EE (Estonia), IS (Iceland), NO (Norway)

Table 4 suggest that log normalized turnover, loan-to-GDP, and log (real) GDP are non-stationary. Interestingly, house prices turn out to be stationary (in at least one of the panels). Typically, we would expect house prices to be non-stationary. It might be that the time series are too short for house prices to be non-stationary. On the other hand, the results also hinge on including a trend. Excluding a trend in the Dickey-Fuller test results in an inverse chi-squared statistic of 33.50 (p -value of 0.394) for house prices. In any case, given the evidence about non-stationarity of several of the variables, and the overwhelming evidence that the variables are stationary in differences, we decided to include all variables in first-differences in the regression analysis.

Cointegration

Given that several of the variables are non-stationary, it might be that they are cointegrated. Table 5 reports residual-based cointegration tests (again the Fisher test) of several different cointegrating vectors. We estimated those vectors with (ordinary least squares) OLS but also using dynamic OLS (DOLS). In case of panel data, ordinary OLS leads to inconsistent estimates (Kao and Chiang 2000). Although there are alternative estimation methods, such as fully modified OLS, it turns out that the DOLS estimator outperforms most other alternative estimators (Wagner and Hlouskova 2009). For the DOLS estimates, however, we need full time series (1999–2013). Unfortunately, we only have such series for 9 of the countries.

Table 4 Stationarity: Panel unit root tests

Variable	Levels		Differences	
	Inverse Chi-sq.	p-val.	Inverse Chi-sq.	p-val.
Log house prices (index)	59.63	0.002	51.39	0.016
Log real house prices	53.25	0.011	48.26	0.033
Log number of transactions	29.44	0.600	57.62	0.004
Log turnover rate (trans./housing stock)	31.32	0.501	64.67	0.001
Outstanding mortgage balance to GDP (%)	33.49	0.395	78.44	0.000
Interest rate new mortgage loans (%)	70.29	0.000	105.29	0.000
Real interest rate (%)	50.04	0.022	202.23	0.000
Log GDP (euros, current prices)	22.02	0.907	60.44	0.002
Log real GDP	24.29	0.834	64.40	0.000
Log population (in millions)	97.00	0.000	46.05	0.005
Share of population between 18 and 30 years of age	63.18	0.001	29.23	0.607
Log HICP (level index)	56.81	0.004	91.59	0.000
Log inflation	49.48	0.025	196.50	0.000
Sample period	1999–2013 (15 years)			
Number of countries	16			

Null hypothesis: All panels unit root Alter.: At least one panel stationary

Fisher type of test based on the Dickey-Fuller test. All the tests on the level variables are based on the demeaned variables to account for cross-sectional dependence and include one lag, to account for serial correlation, and a trend. For the tests on the differenced variables we do not include a trend

Table 5 Cointegration

Cointegrating vector	Inverse Chi-sq.	<i>p</i> -value
OLS		
Log house price, log turnover rate	9.22	1.000
Log house price, log turnover rate, log GDP	81.19	0.000
Log house price, log turnover rate, log GDP, loan to GDP	31.74	0.480
DOLS		
Log house price, log turnover rate	4.62	0.999
Log house price, log turnover rate, log GDP	33.53	0.014
Log house price, log turnover rate, log GDP, loan to GDP	20.58	0.301

Null hypothesis: No cointegration

Fisher type of test based on the Dickey-Fuller test. One lag and a time trend are included in the Dickey-Fuller equations. The estimated cointegration equations include fixed effects

The results in Table 5 indicate that there is mixed evidence for a generally applicable European cointegration mechanism. This does not imply that there is no cointegration in some of the countries but that, on average, we do not find much statistical evidence of such a mechanism. Even if, in some of the cases we tried (e.g. with turnover and GDP), we did find some evidence of cointegration, the (estimated) adjustment parameter on the resulting error correction mechanism in the price or turnover model would be close to zero or, for example, some of the long run equilibrium parameters would be statistically insignificant. Given these consideration, we decided not to use an error correction approach.

Methodology

We estimate the following reduced form bivariate panel vector autoregressive, PVAR(1), model with price and the normalized turnover as dependent variables:⁵

$$\begin{bmatrix} \Delta \log p_{it} \\ \Delta \log \text{rate}_{it} \end{bmatrix} = \begin{bmatrix} \Delta \tau_{1,t} \\ \Delta \tau_{2,t} \end{bmatrix} + \begin{bmatrix} \gamma_1 & \delta_1 \\ \gamma_2 & \delta_2 \end{bmatrix} \begin{bmatrix} \Delta \log p_{it-1} \\ \Delta \log \text{rate}_{it-1} \end{bmatrix} + \begin{bmatrix} \beta_1' \\ \beta_2' \end{bmatrix} \Delta x_{it} + \begin{bmatrix} \epsilon_{1,it} \\ \epsilon_{2,it} \end{bmatrix} \quad (1)$$

where $\Delta \tau_t$ are time fixed effects (differenced time dummies) and Δx_{it} are the differenced macro-economic variables (loan-to-GDP, interest rate, log GDP, log population,

⁵ We only include one lag of prices and turnover as independent variables. Besides the fact that we have a limited time dimension in our dataset – adding more lags substantially decreases the number of observations –, we decided to separate the discussion of the marginal effects (Section “Results, Full model” – “Results, Ignoring the feedback between prices and turnover leads to biased estimates”) from the long-run dynamic properties of the system of equations (Section “Results, Impulse response functions”). The results based on adding, for example, a second lag are in line with the impulse response functions as presented in Section “Results, Impulse response functions”. In addition, we also examined whether more lags would increase the fit with the data. Adding a second lag to equation (1), however, resulted in a decrease of the AIC criterion.

the share of young population, and log HICP), which are assumed to be exogenous.

As mentioned, we estimate the model in first differences because of the non-stationarity of many of the variables. As a result, the constant and the fixed effects are differenced out. This also implies that, although we control for the fixed effects, we do not separately identify them. More importantly, although we estimate the model in first differences, the interpretation of the coefficients remains in levels. That is, as is customary, we use first differences as estimation method to identify the parameters of the underlying equation in levels.

Since both the price equation and turnover equation include a lagged dependent variable we use the standard Arellano and Bond (1991) approach and instrument the differenced lagged dependent variables with its second and third lag in levels. The γ_1 and δ_2 coefficients capture the autoregressive components (momentum) in prices and turnover, respectively. We would expect these coefficient to be positive. The coefficients δ_1 and γ_2 allow for (lagged) feedback between prices and turnover. If the turnover rate is regarded as predominately a demand side factor it should have a positive effect in the price equation (δ_1 is positive) and, conversely, an increase in house prices should decrease turnover (γ_2 is negative).

We estimate several versions of eq. (1). First, we report a full model that includes all of the macro-economic variables (see above). We estimate eq. (1) in a simple equation-by-equation fashion. In essence, this implies that we do not allow the error terms to be correlated across equations. Second, we estimate a more parsimonious model that only includes the interest rate and log GDP as macro-economic variables. Third, we look in more detail at the impact of credit constraints. Fourth, we decompose the lagged differenced log price in a positive and negative component. This allows us to examine the effect of prices on turnover in a rising versus a declining market. Fourth, we re-estimate eq. (1) based on real prices, real interest rates, and real GDP. Finally, we show a joint estimate of the deflated model based on GMM. It turns out that, regardless of the choice of model and estimation procedure, the results are fairly robust.

Results

Full Model: The Role of Loan-to-GDP, Population, and Inflation

Tables 6 and 7 report the main regression results based on eq. (1). Table 6, column 1, contains the results when a full set of macro-economic indicators is included in the regression. It turns out that changes in the outstanding mortgage balance to GDP, population, the share of young population between 18 and 30, and the HICP are not key determinants of the average price and turnover dynamics across European countries. In part, this can be explained by the fact that we identify the estimates based on changes in the variables over time. That is, there may be substantial cross-sectional differences in, for example, loan-to-GDP and the share of young population, but the changes over time are relatively small and do not contribute much in explaining price and turnover dynamics. Moreover, the fact that loan-to-GDP, as our measure of credit constraints, does not affect house prices and turnover is maybe not that surprising given that the estimated effect is conditional on interest rates and GDP: The key determinants of

mortgage credit. Interestingly, the coefficient on the share of young population has a negative sign in the price equation and a positive one in the turnover equation. This might reflect that young households buy cheaper housing and are more mobile in the housing market.

Further results indicate that the consumer price index does not affect house prices and turnover. We would have expected a positive effect. Although the coefficient estimate is positive, it is not statistically significant. This might be the result of the type of consumer price index we have used. The HICP is based on a basket of goods excluding housing. As such, the HICP measures general inflationary pressures on the economy. This is, at least to some extent, already captured by the time fixed effects. Instead, population increases does seem to affect house prices, although the evidence in favor of such an effect is relatively weak. A 1% increase in population increases house prices by 1%. Even though we estimated the equation using first-differences, note that the interpretation of the coefficients is in levels. The effect of an increase in demand due to more population may already been captured by the (normalized) number of transaction we included in the regression model.

It seems that, of all the macro-economic variables, especially interest rates and GDP are key in explaining changes in house prices and turnover. An increase in interest rates of 1 percentage point increases prices by 0.8%. This is not a very large effect. Instead, it seems that the effect of interest rates mainly goes through turnover. A 1 percentage point higher mortgage interest rate decreases the turnover rate by about 6.5%. The same applies to GDP, a 1% increase in GDP increases house prices by 0.22% while it increases the turnover rate by 1.1%. Lower interest rates and higher income make it easier to obtain a sizeable mortgage, which is a prerequisite to buy a house. Hence, measuring the effect of interest rates and GDP on house prices directly, while ignoring their primary effect on turnover, would most likely leads to biased estimates. Again, this result emphasizes that it is important to model prices and turnover simultaneously.

An interesting part of the estimates reported in column 1 are the coefficient estimates on the lagged prices and turnover variables. In particular, there seems to be quite some persistence (momentum) in house prices and turnover. An increase in house prices of 1% in year t still has an effect of 0.5% in year $t + 1$. Equivalently, there is a 40% intertemporal spillover of turnover between two consecutive years (autoregressive coefficient estimate of 0.414). Given market frictions, such as search and transaction costs, these finding were to be expected. Furthermore, the results indicate that turnover also has a lagged effect on house prices. An increase in turnover of 1% increases house prices by 0.34% the year after. Vice versa, (lagged) prices have an effect of -0.31% on the turnover rate. Note that because lagged prices have an opposite impact in the price and turnover equations, shocks in prices eventually weaken the positive price-turnover correlation.

In sum, these results are important because they imply that turnover dynamics are key in understanding price dynamics (as well as the other way around), a fact that is typically forgotten in studies about house price dynamics. We will go into more detail about the dynamics between prices and turnover (i.e. impulse response functions) in Section “Results, Impulse response functions”. Finally, the estimates suggest that about 50% of the variation in prices and turnover are explained by the model.

Table 6 The price-turnover relationship in European housing markets: Panel VAR estimates I. (Dependent variables: log house prices and log turnover rate).

	(1)	(2)		(3)	
	Full model		Parsimonious model		Credit constraints
	Δlog price	Δlog turn.	Δlog price	Δlog turn.	Δlog price
Δ log house prices [t-1]	0.520*** (0.112)	-0.307 (0.248)	0.503*** (0.089)	-0.446*** (0.165)	0.515*** (0.093)
Δ log turnover rate [t-1]	0.340*** (0.150)	0.414* (0.223)	0.307* (0.165)	0.578*** (0.295)	0.299* (0.169)
Δ interest rate new mortgage loans [t]	-0.008** (0.004)	-0.065*** (0.010)	-0.006 (0.004)	-0.069*** (0.014)	-0.005 (0.005)
Δ int. rate * high loan-to-GDP [t]					-0.012 (0.010)
Δ log GDP [t]	0.215* (0.130)	1.177*** (0.373)	0.219** (0.104)	1.182*** (0.438)	0.165 (0.102)
Δ log GDP * high loan-to-GDP [t]					0.135 (0.106)
Δ outstanding mortgage balance to GDP [t]	-0.001 (0.009)	-0.002 (0.003)			
Δ share of population between 18 and 30 years of age [t]	-1.817 (1.378)	1.946 (3.745)			
Δ log population [t]	1.113* (0.634)	-1.910 (1.215)			
Δ log HICP [t]	0.188 (0.449)	-0.938 (1.103)			
Δ Year fixed effects	Yes	Yes	Yes	Yes	Yes
Number of observations	177	172	177	172	172
Centered R ²	0.546	0.524	0.581	0.458	0.590

Based on data from 1999 to 2013 for 16 European countries. Clustered (country) standard errors are in parentheses. *, **, ***, 10%, 5%, 1% significance, respectively

Table 7 The price-turnover relationship in European housing markets: Panel VAR estimates II (*Dependent variables: log house prices and log turnover rate*)

	(1)		(2)		(3)	
	Nominal loss aversion		Real house price model		Joint estimation	
	Δlog price	Δlog turn.	Δlog price	Δlog turn.	Δlog price	Δlog turn.
Δ log house prices [t-1]	0.503*** (0.089)					
Δ log house prices + [t-1]		-0.345** (0.150)				
Δ log house prices-[t-1]		-0.780** (0.350)				
Δ log real house prices [t-1]			0.350*** (0.079)	-0.675*** (0.144)	0.341*** (0.088)	-0.737*** (0.129)
Δ log turnover rate [t-1]	0.307* (0.165)	0.588** (0.284)	0.314** (0.156)	0.750*** (0.186)	0.240* (0.136)	0.595* (0.151)
Δ interest rate new mortgage loans [t]	-0.006 (0.004)	0.070*** (0.014)				
Δ real interest rate [t]			-0.007 (0.006)	-0.045*** (0.011)	-0.006 (0.004)	-0.044*** (0.009)
Δ log GDP [t]	0.219** (0.104)	1.204*** (0.436)				
Δ log real GDP [t]			0.319*** (0.097)	1.119*** (0.285)	0.379*** (0.092)	1.135*** (0.255)
Δ Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	177	172	165	160	160	160
Centered R^2	0.581	0.455	0.629	0.410	-	-

Based on data from 1999 to 2013 for 16 European countries. Clustered (country) standard errors are in parentheses. *, **, ***, 10%, 5%, 1% significance, respectively

A Parsimonious Model

Given that many of the macro-economic variables were not statistically significant, we also estimated a parsimonious model that is only based on interest rates and GDP, the two standard determinants in explaining house price dynamics. The estimation results are reported in Table 6, column 2. It turns out that the regressions estimates are very similar. This validates our claim that loan-to-GDP, population, and inflation are not the key drivers of price and turnover dynamics in Europe. Prices, however, now have a statically significant effect on turnover – a 1% increase in prices decreases turnover by 0.45%. Also the lagged feedback between turnover is higher. The autoregressive feedback is now 58% instead of 41%. Finally, interest rates are no longer significant in the price equation of the panel VAR model.

Credit Constraints

A particular odd finding based on the previous estimates is the minor role the loan-to-GDP ratio plays in explaining price and turnover dynamics. One particular reason is that, although there might not be a direct effect of the loan-to-GDP ratio, there is an interaction effect with interest rates and GDP. In particular, we would expect that countries with a relatively high loan-to-GDP ratio are more sensitive to interest rate and GDP shocks. Consequently, we estimated a model with interaction effects based on an indicator variable that equals one when the average loan-to-GDP of a country is more than 80%. It turns out that this is the case for the Netherlands, Denmark, and Iceland. The regression results including the interaction terms are reported in Table 6, column 3. Given the relatively small effect of interest rates and GDP on prices directly, it is also not surprising to find that the interaction effects are statistically insignificant. However, the sum of the coefficients on GDP and its interaction term (the same applies to interest rates) is jointly statistically significant (Chi-squared of 28 and 4, respectively). This suggests that there is an effect of interest rates and GDP on prices directly, but only for countries with a high loan-to-GDP ratio. For those countries, a 1 percentage point increase in interest rates decreases house prices by 1.7%. Similarly, a 1% increase in GDP increases house prices by 0.3%. Although these effects are more pronounced, they are still relatively small in comparison to the effects on turnover. In particular, the effect of a 1 percentage point increase in interest rates is about -6.7 percentage points higher than for countries with a low loan-to-GDP ratio. In addition, the effect of a 1% increase in GDP is 0.7 percentage points higher on top of a baseline effect of 0.88%. The effect of GDP and interest rates, including the interaction effects, are in the same direction in the price/turnover equation, which suggest that they act to strengthen the positive relationship between prices and turnover especially in case of high credit constraints. This is much in line with the credit constraints story of Genesove and Mayer (1997) for the US.

Nominal Loss Aversion

Based on Genesove and Mayer (2001), we would expect that, besides credit constraints, price declines have a different impact on the price-turnover relationship than price increases. As such, we decomposed the price change variables in the *turnover* equation in two parts: a positive price change (zero otherwise) and negative price

change part. Basically, for simplicity, we assume that loss aversion has a direct effect on turnover (the decision to sell) and a subsequent (indirect) effect on prices.⁶ The results are reported in Table 7, column 1. If prices decrease we would expect a larger negative effect than the positive effect of an equivalent price increase. Instead, the regression estimates indicate that a price decrease has a larger *positive* effect on turnover. In case of price declines, a decrease in prices of 1% increases the turnover rate by 0.78%. In case of price increases, a 1% decrease in prices increases turnover by 0.35%. Apparently, cheaper housing (*ceteris paribus*) increases housing demand (housing affordability) especially if prices are declining. This is against the classical loss aversion story and it suggests that there are maybe other factors, such as a in loss income, that explain why in case of an economic/financial crisis turnover and prices decrease simultaneously. Of course, our measure of loss aversion (price declines) is at best a very imperfect proxy and more likely measures general differences in price-dynamics during boom-bust periods. However, note that the price decrease and price increase coefficient, although quite different, are not statistically different from each other (Chi-squared of 1.62). This suggests that, with regard to turnover, we do not find much evidence of an asymmetric price effect.

Real versus Nominal House Prices

If inflation is indeed not a key factor in explaining house prices and turnover, we would expect that using real house prices would not change our results. As a consequence, we re-estimated eq. (1) using real house prices, real GDP, and real interest rates. To create real interest rates, we subtracted the expected inflation rate from the nominal interest rates. To measure expected inflation we used a quite standard moving average filter with three lags of inflation and a decreasing weighting scheme (0.70; 0.20; 0.10). The results are reported in Table 7, column 2.

The regression estimates show a very similar pattern as before. The autoregressive coefficient on house prices becomes a bit less (coefficient of 0.35) in comparison with the nominal price model. The effect of lagged prices and turnover on the turnover rate becomes a bit higher (coefficient of -0.68 and 0.75 , respectively). The effect of a 1% increase in the real interest rate on turnover is 4.5% versus 6.9% in the nominal case. Especially the linear fit of the model in case of house prices is relatively good, 63% of the variation in house prices can be explained by the independent variables.

Joint Estimation of the Price-Turnover Equations

Finally, we used the parsimonious model and real values of prices, GDP, and interest rates, and estimated the price and turnover equations jointly using GMM. In essence, this approach allows cross-correlation between the error terms of the two equations, which basically implies that we take into account that there are potential common factors in house price and turnover shocks. This seems to be a relatively realistic approach and, as such, is our preferred way of modeling the price-turnover dynamics.

⁶ There are not enough observations to run separate regressions for price increases and price declines. We did experiment with including a boom-bust interaction effect with the autoregressive component in the price equation. This interaction effect turned out to be statistically insignificant.

Table 8 Granger causality and bias as a result of dynamic misspecification*Panel A: Granger causality prices and turnover*

X granger causes Y	Chi-sq.	p-value
Log turnover rate \rightarrow log real prices	3.22	0.073
Log real prices \rightarrow log turnover rate	6.309	0.012

Panel B: Bias (%) as a result of dynamic misspecification

	Δ log real price	Δ log turnover rate
Δ log real house prices [t-1]	14.4%	-
Δ log turnover rate [t-1]	-	-42.7%
Δ real interest rate [t]	155.4%	-21.1%
Δ log real GDP [t]	21.4%	3.2%
Δ Year fixed effects (average bias)	-203.4%	-61.8%

Panel A reports the Wald test of granger causality. Panel B contains the percentage difference between the jointly estimated price-turnover model and the equation-by-equation estimate of the model without allowing for the (lagged) feedback between the price and turnover equation

It also implies that we have to use orthogonalized impulse response functions to examine the dynamic behavior of the system of equations. The estimation results of the GMM model are reported in Table 7, column 3.

It seems that joint estimation of the price and turnover equation does not change the results by much. This is as expected. In principle, allowing for cross-correlation of the two symmetric equations should not impact the consistency of the estimates, but only the standard errors. The result in column 3 indicate that turnover has a bit less, but still statistically significant, effect on (real) house prices. Real interest rates do still have a small and insignificant effect on house prices and the coefficient on GDP increases from 0.32 to 0.38. Also, the effect of real prices on turnover increases (coefficient of -0.74) in comparison with the equation-by-equation estimate. A 1% increase in the turnover rate has a 0.60% effect on real house prices, while an increase in the real interest rate of 1 percentage point decreases turnover by 4.4%. Finally, a 1% increase in real GDP increases prices by 0.38% and turnover by 1.1%.

Ignoring the Feedback between Prices and Turnover Leads to Biased Estimates

An important question is whether it is actually necessary to model both prices and turnover as two interdependent processes. Table 8, panel A, contains the results of the Granger causality test between real prices and turnover based on the jointly estimated model, reported in Table 7, column 3. The results indicate that prices Granger cause the turnover rate and, vice versa, turnover granger causes prices. This implies that it is essential to explicitly model the interaction between prices and turnover. Not doing so may lead to dynamic misspecification. To get an indication of the bias as a result of such a misspecification, we re-estimated the model without allowing for interaction (lagged feedback and error term correlation) between real prices and turnover. Table 8, panel B, contains the percentage bias based on the difference between the estimated coefficients.

This is based on the assumption that the dynamic model is correctly specified and captures the true data generating process.

The results in Table 8, panel B, indicate that the bias as a result of dynamic misspecification is considerable. Relative to the dynamic model the misspecified model overestimates the AR(1) coefficient on prices by 14.4%. Part of the typical evidence about momentum in house price returns (see Case and Shiller 1989; Lai and Van Order 2010) can, thus, be attributed to the interaction between prices and turnover. The AR(1) coefficient on turnover is even underestimated by about 40%. Moreover, the coefficient on log real GDP is about 21.4% higher in the price equation and 3.2% higher in the turnover equation. The effect of interest rates is underestimated by 21.1% in the turnover equation. Given the small (and insignificant) effect of real interest rates on house prices it is not surprising to find a high relative bias of 155% in the price equation. This particular bias estimate is, therefore, not very meaningful. Finally, the estimated price trends in both the price and turnover equation are severely underestimated. This implies that, for example, price indices that are based on a model that does not take into account the number of underlying transactions, or equivalently the related concept of time on market, should be interpreted with caution. It, again, underlines that a liquidity adjustment, such as for example suggested by Fisher et al. (2003) or Goetzmann and Peng (2006), is essential to correctly measure time trends.

Impulse Response Functions

Figure 3 depicts the eigen values (two endogenous variables) based on the jointly estimated VAR model (γ, δ matrix). If these values are within the unit circle, shocks to the system are eventually absorbed such that the VAR process itself is stationary. Since

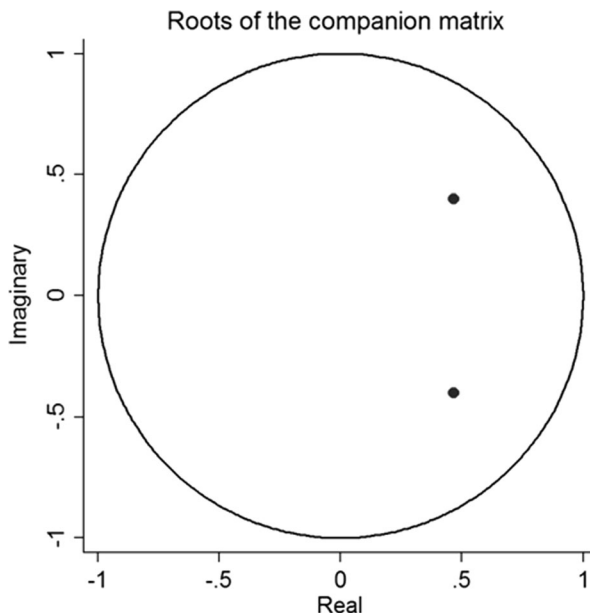


Fig. 3 Stability of the VAR model. Based on the jointly estimated real price-turnover panel VAR model (data from 1999 to 2013). This figure reports the eigen values based on the price-turnover coefficient matrix

we are talking about (growth in) prices and turnover, from a long run perspective we would expect a stable process. If this would not be the case it would be a potential indication of misspecification, for example as a result of not including the correct number of lags in the VAR model. Alternatively, we might not have appropriately taken into account a potential error correction mechanism. As such, the results in Fig. 3 – the eigen values are inside the unit circle – suggest that the modelled VAR process is stable and correctly specified.

Figure 4 contains the cumulative impulse response functions (IRF) between real prices and the turnover rate based on the jointly estimated price-turnover model (see Table 7, column 3). In essence, these impulse response functions allow us to examine the dynamic impact of shocks in prices and turnover as they propagate through the system of equations. Since we allow for cross-correlations across shocks (error terms) the impulse response functions are not unique and depend on the ordering of the variables. In Fig. 4, we chose the ordering in such a way that turnover is allowed to have an immediate impact on prices. Figure 6 in the Appendix reports the results in case of a reverse ordering. The results turn out to be similar in terms of both the order of magnitude and pattern. Only the effect of prices on turnover turns out to be substantially less.

The impulse response functions in Fig. 4 show several important results. A unit shock, a 1% change, in turnover has a persistent effect on turnover and prices of 0.16 and 0.08%, respectively. Vice versa, the long-run elasticity as a result of a unit shock in (log) real prices is -0.08% with respect to turnover and 0.04% with respect to prices. Except for the persistency in turnover, the other long run (10 years) effects are very close to zero. This suggest that the price-turnover correlation is most likely the result of

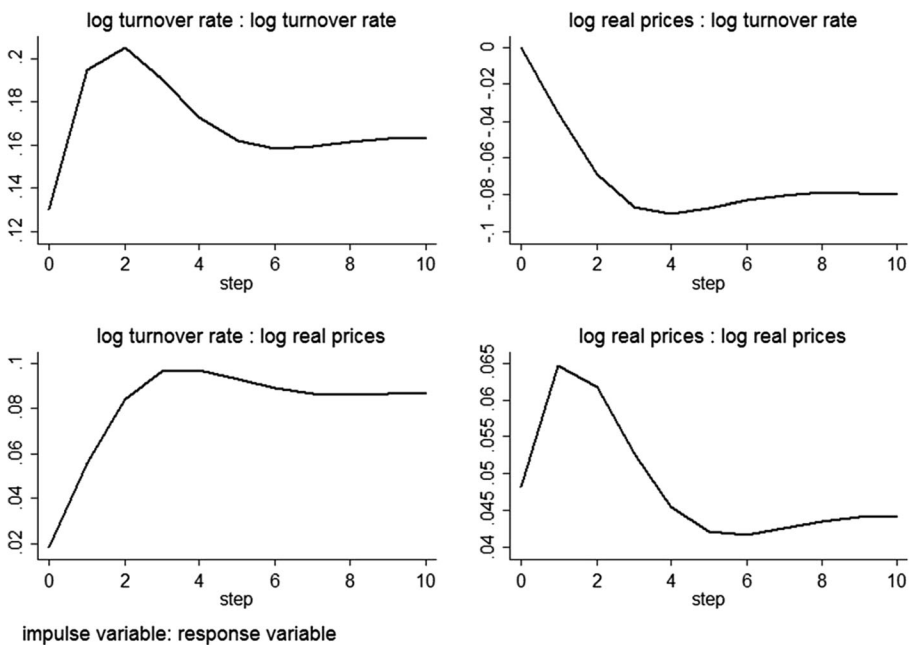


Fig. 4 Cumulative impulse response functions house prices and turnover. Based on data from 1999 to 2013. The turnover rate is the number of transactions relative to the total housing stock. This figure reports the orthogonalized impulse response functions (Cholesky ordering: turnover, prices)

repeated shocks to the housing market that result in both a short-run autoregressive effect in prices and turnover and lagged feedback between the two. The autoregressive effect in prices and turnover seems to peak after one to two years after which its effect dissipates over time. The effect of turnover on prices peaks after 4 years and is exactly opposite to the effect of prices on turnover. As such, price increases in themselves, *ceteris paribus*, seem to weaken the positive correlation between prices and turnover. The autoregressive, momentum, effects and the impact of turnover on prices, however, seem to outweigh this negative effect. Finally, it is important to note that the exogenous shocks in prices and turnover can also be interpreted in terms of shocks in interest rates and GDP. A one unit shock in log prices is equivalent to a 2.6% increase in GDP ($1/0.379$, see Table 7, column 3). Alternatively, a one unit shock in turnover is equivalent to a 0.88% increase in GDP and a 0.23 percentage point increase in real interest rates.

Decomposition of House Price Dynamics in the UK, Germany, and France

It is quite standard to show a forecast error variance decomposition based on the estimated VAR model. The purpose of this paper, however, is not to forecast house price dynamics. Instead, Table 9 reports a historical decomposition – a very much related concept – of house price dynamics based on the jointly estimated VAR model (Table 7, column 3).

In essence, we calculate the changes (shocks) in house prices, turnover, GDP, and real interest rates between 1999 and 2013 and use the IRF's to calculate the accumulated predicted responses to house prices. The difference with actual price changes remains unexplained variation. This includes general economic trends, EU-wide shocks, but also (time-varying) country-specific shocks. Relative to the actual year-to-year price changes we can calculate the percentage contribution of each factor. Table 9 reports the average contribution for the EU (average shocks), UK, Germany, and France. We normalized the resulting decomposition such that it adds up to 100%. As mentioned, we imposed the restriction that the marginal effects are the same across countries. Nevertheless, the total (decomposed) effect for each country can differ. This allows us to examine which factors are the most important in explaining house price dynamics and how this varies across countries.

The results in Table 9 indicate that, besides the unexplained shocks in house prices, the turnover rate is key in understanding house price dynamics.⁷ Based on EU (16 countries) average changes in the variables, changes in the turnover rate explain about 12.4% of real house price changes. The contribution of house price shocks on subsequent price changes is the next important factor with a contribution of 6.7%. Real GDP and real interest rates have a contribution of 1.2 and 0.4%, respectively. These results imply that, from a dynamic point of view, it is especially the feedback between prices and turnover and the momentum in prices, and not so much the shocks in the underlying fundamentals, which explains house price dynamics.

There is also quite some variation in these contributions across countries. In particular, we have used the VAR model to decompose price dynamics in the UK, France, and Germany. In Germany, the turnover rate explains about 25.3% of house price dynamics.

⁷ The decomposition shows a bit higher unexplained variation compared to the regression estimates (R-squared, 55–63% explained variation). This is because shocks (error terms) accumulate and potentially correlate over time. In addition, the year fixed effects are included in the unobserved shocks.

Table 9 Decomposition of house price dynamics

	UK	France	Germany	EU
$\Delta \log$ real house prices	6.5%	6.8%	4.0%	6.7%
$\Delta \log$ turnover rate	13.4%	7.5%	25.3%	12.4%
Δ real interest rate	0.4%	0.5%	1.5%	0.4%
$\Delta \log$ real GDP	3.6%	0.6%	2.4%	1.2%
Unexplained shocks	76.1%	84.7%	66.8%	79.2%
Total	100%	100%	100%	100%

This table reports a historical decomposition of real house price dynamics based on the jointly estimated price-turnover model. The results are based on data from 1999 to 2013 for 16 European countries. The average contribution of each factor is reported

Prices in Germany are relatively stable (standard deviation of real housing returns of 0.012, actually during the sample period real house prices have been declining by -0.5% per year). In part, our results suggest that this is due to a more steady rate of sale relative to the housing stock (1.2% per year) relative to other countries. Instead, in France, changes in the turnover rate play a less important role in house price dynamics (contribution of 7.5%). The intertemporal spillovers in real house prices themselves are a bit more important (contribution of 6.8%), relative to Germany, in explaining the quite high house price increases in France (3.9% on average per year). In addition, country-specific shocks, which could be anything from changes in policy to economy wide trends, are far more important in France than in other countries. France is relatively more risky in terms of housing returns (standard deviation of 0.063).

Finally, in the UK both the turnover rate and unexplained shocks are key in explaining house price dynamics.⁸ Turnover shocks explain about 13.4% of price changes. When the financial crisis hit the UK in 2008 and real prices decreased with 4.5% in 2008 and 10.2% in 2009, the turnover rate dropped substantially as well, by 60% in 2008 and an additional 5.5% in 2009. A decrease in real GDP of 27% in 2008 also had a detrimental effect. In the UK, shocks in GDP have had about three times the percentage impact on house price changes in comparison with the EU in total. These factors have surely contributed to the UK being a relatively price-volatile market (standard deviation of real housing returns of 0.077). In sum, the results in this section imply that price dynamics in many of the European housing markets are driven by similar key factors even though the actual price dynamics has been substantially different across countries. Turnover, but also momentum in house prices, are key in explaining house price dynamics in European countries.

Conclusion and Discussion

Prices and turnover in housing markets are positively correlated. This paper has investigated this positive price-turnover relationship across 16 European countries.

⁸ For a discussion on the price dynamics in the UK versus Germany in the 1970s, 1980s, and 1990s, see Muellbauer (1992).

The panel VAR estimates indicate that there is strong feedback between house prices and turnover. A 1% increase in (lagged) real prices decreases turnover by 0.74%. Vice versa, a 1% increase in the turnover rate increases real prices by 0.24%. There is also quite some momentum in prices and turnover which can in part explain why they are so highly correlated. The autoregressive coefficient on house prices is 0.34 and in the turnover equation it is 0.60. As expected, (lagged) prices have an opposite impact in the price and turnover equations and, consequently, weaken the positive price-turnover correlation. Key other determinants of prices and turnover are GDP and the interest rate on (new) mortgage loans. The effect of GDP and interest rates, however, mainly goes through turnover. Interestingly, the outstanding mortgage balance to GDP, population increases, the share of young population, and inflation are not found to be key in explaining price and turnover dynamics. A high loan-to-GDP ratio does increase the effect of interest rates and GDP on prices and turnover though. Furthermore, we do not find evidence of nominal loss aversion. Instead, price declines seem to increase turnover, *ceteris paribus*, which is in line with improved housing affordability if prices decrease. A historical decomposition of real house price dynamics shows that, besides unexplained shocks, turnover and lagged house price changes explain most of the changes in house prices, with a EU-wide (16 countries) contribution of 12.4% and 6.7%, respectively. There is considerable variation in these contributions across countries.

The results in this paper imply that, to understand house price dynamics, it is essential to model both house prices and turnover simultaneously. This is in extension to previous recommendations made in the literature to adjust housing returns (Cheng et al. 2013) or property price indices (Fisher et al. 2003; Goetzmann and Peng 2006) for liquidity. It seems that especially the feedback between prices and turnover is vital to explain house price dynamics. Our results show that ignoring this feedback leads to considerable bias in the price and turnover regression coefficients. For example, the autoregressive coefficient in the house price model is overestimated by 14% if turnover is not explicitly taken into account. The overestimation of the autoregressive coefficient also suggests that part of the momentum in house prices, a typical finding in the housing market literature, can be explained by the feedback between prices and turnover. Given the considerable impact of housing transactions on house price dynamics, we further recommend that information on housing transactions is made publically available through statistical offices such as Eurostat. Eurostat currently publishes harmonized house price indices, but it is unclear on how many transactions those are based.

There is an increasing interest in the impact of the liquidity of real estate on housing market returns. This paper contributes to the existing literature by explicitly highlighting the important role of turnover in house price models. As more data on house prices and turnover will come available in the coming years it will be possible to better differentiate between the differences in house price dynamics, and the determinants of such differences, across European countries. Moreover, it would allow us to examine the short- versus long-run dynamics in house prices in more detail. House prices and turnover are two endogenous processes that are interrelated. A natural extension would be to also allow construction (the housing stock) to be endogenous and to further examine price versus rent dynamics in European housing markets.

Acknowledgements We thank Paloma Taltavull, Alex van de Minne, two anonymous referees, and participants of the ERES 2015 and international AREUEA 2015 conferences for useful comments.

Appendix

Time series plots house prices and transaction volume

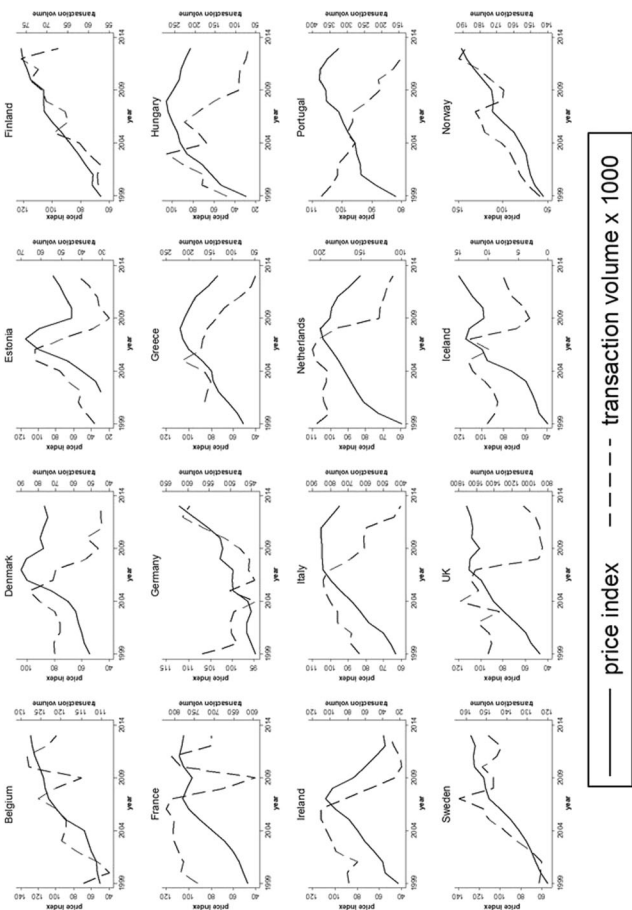


Fig. 5 House prices and transaction volume. Time series plots of house price indices and transaction volume for 16 European countries. Based on data from 1999 to 2013

Impulse response functions, alternative ordering

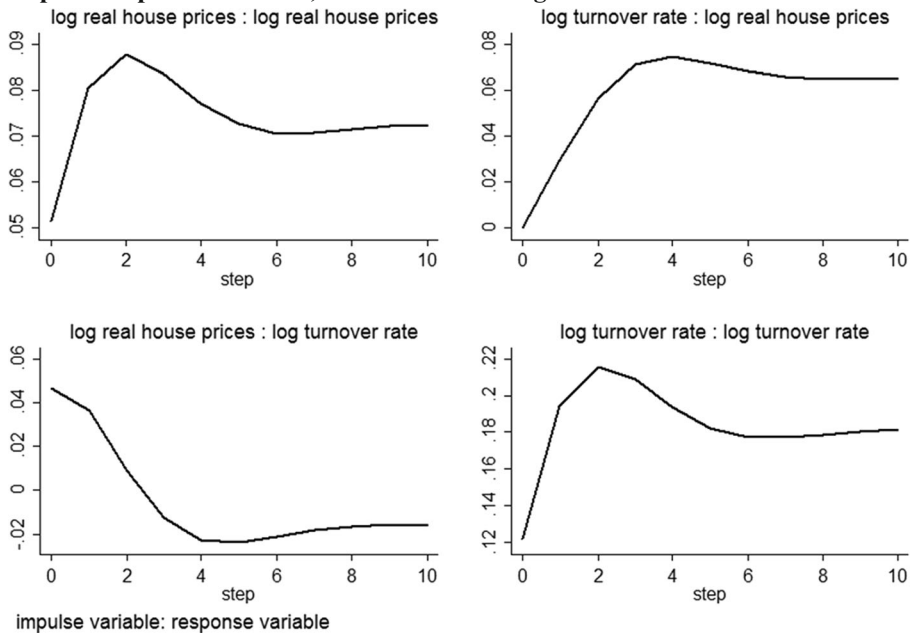


Fig. 6 IRF's: house prices and turnover, alternative ordering. Based on data from 1999 to 2013. The turnover rate is the number of transactions relative to the total housing stock. This figure reports the orthogonalized impulse response functions (Cholesky ordering: prices, turnover)

Open Access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

References

- André, C. (2010). A bird's eye view of OECD housing markets, OECD working paper No. 746, ECO/WKP(2010)2.
- Andrew, M., & Meen, G. (2003). House price appreciation, transactions and structural change in the British housing market: a macroeconomic perspective. *Real Estate Economics*, 31, 99–116.
- Andrews, D. (2010). Real house prices in OECD countries: The role of demand shocks and structural and policy factors, OECD working paper No. 831, OECD publishing.
- Andrews, D., Sánchez, A.C., Johansson, A. (2011). Housing markets and structural policies in OECD countries, OECD working paper No. 836, OECD publishing.
- Anenberg, E., Bayer, P. (2013). Endogenous sources of volatility in housing markets: the joint buyer-seller problem, NBER working paper 18980.
- Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies*, 58(2), 277–297.
- Bajari, P., Chan, P., Krueger, D., & Miller, D. (2013). A dynamic model of housing demand: estimation and policy implications. *International Economic Review*, 54(2), 409–442.

- Beracha, E., & Skiba, H. (2011). Momentum in Residential Real Estate. *Journal of Real Estate Finance and Economics*, 43(3), 299–320.
- Case, K. E., & Shiller, R. J. (1989). The efficiency of the market for single-family homes. *American Economic Review*, 79(1), 125–137.
- Case, K. E., & Shiller, R. J. (2003). Is there a bubble in the housing market. *Brookings Papers on Economic Activity*, 2, 299–362.
- Cheng, P., Lin, Z., & Liu, Y. (2013). Liquidity risk of private assets: evidence from real estate markets. *The Financial Review*, 48(4), 671–696.
- Chiuri, M. C., & Jappelli, T. (2003). Financial market imperfections and home ownership: a comparative study. *European Economic Review*, 47(5), 857–875.
- Clayton, J., Miller, N., & Peng, L. (2010). Price-volume correlation in the housing market: causality and Co-movements. *Journal of Real Estate Finance and Economics*, 40(1), 14–40.
- De Wit, E., Englund, P., & Francke, M. K. (2013). Price and transaction volume in the Dutch housing market. *Regional Science and Urban Economics*, 43(2), 220–241.
- Díaz, A., & Jerez, B. (2013). House prices, sales, and the time on the market: a search-theoretic framework. *International Economic Review*, 54(3), 837–872.
- EMF. (2005). Hypostat 2004: a review of Europe's mortgage and housing markets. *EMF publication*, 2005.
- EMF. (2011). Hypostat 2010: a review of Europe's mortgage and housing markets, EMF publication November 2011.
- EMF. (2012). Hypostat 2013: a review of Europe's mortgage and housing markets, EMF publication November 2012.
- EMF. (2013). Hypostat 2013: a review of Europe's mortgage and housing markets, EMF publication November 2013.
- EMF. (2014). Hypostat 2014: a review of Europe's mortgage and housing markets, EMF publication November 2014.
- Engelhardt, G. V. (2003). Nominal loss aversion, housing equity constraints, and household mobility: evidence from the United States. *Journal of Urban Economics*, 53(1), 171–195.
- Fisher, J., Gatzlaff, D., Geltner, D., & Haurin, D. (2003). Controlling for the impact of variable liquidity in commercial real estate price indices. *Real Estate Economics*, 31(2), 269–303.
- Follain, J. R., & Velz, O. T. (1995). Incorporating the number of existing home sales into a structural model of the market for owner-occupied housing. *Journal of Housing Economics*, 4(2), 93–117.
- Genesove, D., & Mayer, C. J. (1997). Equity and time to sale in the real estate market. *American Economic Review*, 87(3), 255–269.
- Genesove, D., & Mayer, C. J. (2001). Loss aversion and seller behaviour: evidence from the housing market. *Quarterly Journal of Economics*, 116(4), 1233–1260.
- Glaeser, E. L., Gyourko, J., & Saiz, A. (2008). Housing supply and housing bubbles. *Journal of Urban Economics*, 64(2), 198–217.
- Goetzmann, W., & Peng, L. (2006). Estimating house price indices in the presence of seller reservation prices. *The Review of Economics and Statistics*, 88(1), 100–112.
- Han, L. (2008). Hedging house price risk in the presence of lumpy transaction costs. *Journal of Urban Economics*, 64(2), 270–287.
- Han, L. (2010). The effects of price risk on housing demand: empirical evidence from U.S. markets. *Review of Financial Studies*, 23(11), 3889–3928.
- Han, L., & Strange, W. (2014). Bidding wars for houses. *Real Estate Economics*, 42(1), 1–32.
- Head, A., Lloyd-Ellis, H., & Sun, H. (2014). Search, liquidity, and the dynamics of house prices and construction. *American Economic Review*, 104(4), 1172–1210.
- Hilbers, P., Hoffmaister, A.W., Banerji, A., Shi, H. (2011). House price developments in Europe: a comparison, IMF working paper, WP/08/211.
- Himmelberg, C., Mayer, C., & Sinai, T. (2005). Assessing high house prices: bubbles, fundamentals and misperceptions. *Journal of Economic Perspectives*, 19(4), 67–92.
- Hort, K. (2000). Prices and turnover in the market for owner-occupied homes. *Regional Science and Urban Economics*, 30(1), 99–119.
- Kao, C., Chiang, M.H. (2000). On the estimation and inference of a cointegrated regression in panel data. In Badi H. Baltagi, Thomas B. Fomby, R. Carter Hill (ed.) *Nonstationary panels, Panel cointegration, and Dynamic panels* (Advances in econometrics, volume 15) Emerald group publishing limited, pp.179–222.
- Krainer, J. (2001). A theory of liquidity in residential real estate markets. *Journal of Urban Economics*, 49(1), 32–53.
- Kuang, P. (2014). A model of housing and credit cycles with imperfect market knowledge. *European Economic Review*, 70, 419–437.

- Lai, R. N., & Van Order, R. A. (2010). Momentum and house price growth in the United States: anatomy of a bubble. *Real Estate Economics*, 38(4), 753–773.
- Ling, D. C., Ooi, J. T. L., & Le, T. T. T. (2015). Explaining house price dynamics: isolating the role of Nonfundamentals. *Journal of Money, Credit and Banking*, 47(S1), 87–125.
- Merlo, A., Ortalo-Magné, F., & Rust, J. (2015). The home selling problem: theory and evidence. *International Economic Review*, 56(2), 457–484.
- Muellbauer, J. (1992). Anglo-German differences in housing market dynamics. *European Economic Review*, 36(3), 539–548.
- Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica*, 49(6), 1417–1426.
- Ortalo-Magné, F., & Rady, S. (1999). Boom in, bust out: young households and the housing price cycle. *European Economic Review*, 43(4/6), 755–766.
- Ortalo-Magné, F., & Rady, S. (2006). Housing market dynamics: on the contribution of income shocks and credit constraints. *Review of Economic Studies*, 73(2), 459–485.
- Piazzesi, M., Schneider, M. (2009). Momentum traders in the housing market: Survey evidence and a search model. NBER working paper 14669.
- Sánchez, A.C., Johansson, A. (2011). The price responsiveness of housing supply in OECD countries, OECD working paper No. 837, OECD publishing.
- Sinai, T., & Souleles, N. S. (2005). Owner-occupied housing as a hedge against rent risk. *Quarterly Journal of Economics*, 120(2), 763–789.
- Sinai, T., Souleles, N.S. (2009). Can owning a home hedge the risk of moving?, NBER working paper 15462.
- Stein, J. C. (1995). Prices and trading volume in the housing market: a model with down-payment effects. *Quarterly Journal of Economics*, 110(2), 379–406.
- Wagner, M., & Hlouskova, J. (2009). The performance of panel cointegration methods: results from a large scale simulation study. *Econometric Reviews*, 29(2), 182–223.
- Wheaton, W. C. (1990). Vacancy, search, and prices in a housing market matching model. *Journal of Political Economy*, 98(6), 1270–1292.