Residential Mortgages, the Real Estate Market, and Economic Growth:

Evidence from Europe

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Abstract

The amount of residential mortgages outstanding (RMI) c*hanges year by year based on market conditions that could affect the risk assumed by lenders offering credit to customers. The literature shows that the amount of RMI is mainly driven by housing prices and the gross domestic product (GDP), but there is no clear evidence on the causal relation between the variables, especially for the European market.*

This paper aims to explain the linkage between house prices and RMI in Europe and to evaluate whether policy makers can significantly influence economic growth by supporting residential lending. The results show that, in the short term, the volume of residential mortgages is positively influenced by growth of the house price index and of the GDP and vice versa but, in the long term, the amount of RMI remains positively influenced by the GDP and negatively influenced by the house price index.

1. Introduction

Home ownership is greatly influenced by a country's culture. In southern Europe, for example, home ownership is an important achievement for a family, unlike in Germany, where the share of people owning or renting a house is more or less the same (Hypostat, 2016). Moreover, applications for residential mortgage financing to purchase property are quite common in Europe and, on average, 25% of families have a mortgage (Cerutti *et al.*, 2017), but the percentage varies country by country. Northern countries, such as Sweden, the Netherlands, and Denmark, show above-average usage of lending, with more than half of the population holding mortgages. At the height of the real estate market cycle in 2008, the residential mortgage market represented almost 50% of the gross domestic product (GDP) for Europe, but with the bursting of the housing bubble and the related increase in bank capital requirements, the supply of mortgage loans significantly decreased (Case *et al.*, 2000).

The literature on the interaction between the housing market and the economy shows the housing market can assume a double role, as a consumption good and as an investment (Leung, 2004). In both cases, macroeconomic trends can affect housing prices: if the house is a family's essential living asset, when house prices rise faster than household income, families require more funding to cover the costs related to real

estate investment, whereas, if the house is used as an investment, the greater the wealth available for the individual, the greater the real estate price growth for income-producing assets. The effect of GDP growth on real estate prices is mainly relevant in the medium-long term but macroeconomic trends cannot explain more than the 10% of the total variability of housing prices (Tsatsaronis and Zhu, 2004).

Another important factor that influences residential mortgages is house price growth. In Europe, the growth in house prices has been particularly noticeable in countries such as Spain, the United Kingdom, and Ireland, where house prices have increased by more than 180% between 1997 and 2007. Mortgage financing has also been the focus of the debate in Europe, although the actual dynamics of the relation between mortgage credit and house prices are not, so far, well known (Carbo-Valverde and Rodriguez-Fernandez, 2010).

This paper focuses on the European market to evaluate whether the house price index (HPI) and GDP are macroeconomic variables that influence the performance of residential mortgages outstanding (RMI) and whether the causality goes in the opposite direction. Residential mortgages are expected to influence housing prices because housing prices, mortgages, and the GDP are related to each other, but the magnitude and type of linkage can change based on each country's specific features. Moreover, local trends at the regional or subregional level can affect the housing sector, the credit market, and the overall economy in every national market. This paper's main contribution is a combined analysis of the interaction of mortgages, the GDP, and housing prices at the national and international levels that allows a comparison among countries of spillover risks in the lending market, real estate prices, and the real economy.

The paper is organized as follows: Section 2 briefly reviews the literature on the linkage between RMI, house prices, and the GDP. Section 3 describes the empirical analysis. Section 4 concludes by summarizing the results and policy implications.

2. Literature review

The literature on the residential real estate market underlines the linkages among the amount of RMI, the GDP, and real estate price dynamics.

2.1 Housing and economic growth

The real estate industry is one of the key sectors in every economy worldwide (Andrews *et al.*, 2011) and an increase in housing investments impacts the overall economy because the sector's value chain involves firms with different specializations that are not only in the real estate industry (e.g. Wells, 1985). The impact of housing on the GDP is mostly relevant in the medium-long term because the types of jobs normally created thorough a real estate development project are expected to be stable over time and, due to specific asset features, the investment is not capital intensive because it can be easily financed through the lending market (Turin, 1980).

The linkage of housing investment and the GDP changes based on the degree of economic development, following a reverse U–shaped trend: in developing economies, the housing sector role increases with economic growth and reaches its peak, whereas, in mature economies, it starts decreasing (Burns and Grebler, 1980). Especially for developed and mature economies, the analysis of the linkage between housing and GDP cannot distinguish what portion of the increase in the GDP is due to real estate development or the extent to which real estate investing is driven by better or worse economic conditions (Drewer, 1980).

The analysis of the impact of housing on the GDP has to consider that the real estate market is characterized by a rigid supply due to the length of the construction process, which does not allow for immediate reactions to market changes (Capozza, 2002). Analysis with a short horizon can thus underestimate the effect of housing on the GDP (and vice versa) and a long-term analysis is necessary to understand the phenomenon (e.g. Wigren and Wilhelmsson, 2007). The literature has pointed out that residential real estate (e.g. housing) usually drives growth, whereas nonresidential real estate is normally a consequence of economic growth (Green, 1997). The results on causality are robust, even considering other GDP components that could affect GDP growth, such as housing growth (Coulson and Kim, 2000), but the results can be affected by the economy analysed, especially if it is closed with respect to international investment or the real estate market is strictly regulated (e.g. Ofori and Han, 2003).

In addition, the impact of housing growth on the GDP is not homogeneous among different asset classes and could lead to a misallocation of resources in society (e.g. Mills, 1987).

2.2 Mortgages and housing prices

The literature shows that credit market trends are strictly related to real estate market trends, because housing investment is frequently financed through mortgages and almost never fully paid in cash (Hoffmann, 2001). Studies show that, in a scenario of low interest rates, the more affordable cost of lending increases the mortgage supply and directly impacts housing prices (e.g. Adelino *et al.*, 2012).

The linkage of the mortgage supply to housing demand not only is driven by the cost of lending but can also be affected by lending standards, because different lenders apply more or less selective criteria in loan applications (Martínez Pagés and Maza, 2003). Moreover, credit standards can change over time due to a new regulatory framework (Gerlach and Peng, 2005) and the degree of independence in the borrowers' selection is normally the main issue that can affect the mortgage supply (Favara and Imbs, 2015). If lenders achieve a level of debt outstanding that is above the equilibrium, usually, they can decide on their own to revise the policy for the next years to more quickly align the outstanding debt with their target level. Borrowing requirements can thus change over time, even without changes in supervision (Gimeno and Martínez-Carrascal, 2006).

Normally an increase in competition in the lending industry has a significant effect on housing price dynamics and the literature has pointed out that an increase or decrease in competition changes the sensitivity of the real estate and mortgage markets (Brown *et al.*, 1997). In a competitive scenario, an increase in the lenders' market share is usually related to innovation in the financial products offered, since usually the main goal of such innovation is to increase the number of first-time buyers, who are also those who have the most to lose from a reversal of the real estate market trend (Girouard *et al.*, 2006).

Mortgage demand is also affected by expected real estate trends, because individuals can benefit from investing in housing when positive growth expectations can increase the value of the assets bought with the loans. International evidence shows that an increase in housing prices that impacts home equity increases the wealth of individuals and their consumption expenditures (Mian and Sufi, 2011).

The lending supply is positively affected by housing price trends, because real estate assets are the main collateral of mortgages (Doling *et al.* 2013) and the easier the foreclosure procedures, the higher the correlation between outstanding loans and real estate (Égert and Mihaljek, 2007). Analysis of the impact of real estate price dynamics on the mortgage supply must also consider asymmetry in the adjustment of current market prices with respect to the average medium-long term, because the speed of adjustment is higher when the house is overpriced and lower in the event of underpricing and the home equity advantage can thus disappear faster than expected (Holly and Jones, 1997). The different adjustment speeds for boom and bust real estate markets must be considered, because it can impact banks' financial stability due to the lower recovery rate achievable through fire sales of assets (Fitzpatrick and McQuinn, 2007).

The impact of real estate market trends on the mortgage supply is also affected by financial market efficiency, where the higher the degree of efficiency, the greater the impact of real estate price changes Badev *et al.* (2014). In efficient lending markets, lower transaction costs are an incentive for individuals and firms to borrow money for investing and, normally, the value of the guarantee (if the loan-to-value ratio must remain stable) is updated by the lender on the basis of the most updated market trend (Adams and Füss, 2010). Independent of the market considered, real estate trends and the mortgage supply will never be perfectly aligned, because the housing market supply is less elastic to changes in the market whereas outstanding loans can react immediately to new market conditions (Igan and Loungani, 2012).

2.3 Mortgage and the GDP

Real estate is an opaque asset with no unique or standardized pricing criterion and borrowers' valuations of collateral can be affected by overall economic trends (Bernanke et al., 1994). Every country is characterized by its banking sector's different approach to evaluating loan applications and collateral value. Markets where evaluations are more linked to market trends also have clearer linkages between mortgages and macroeconomic trends (Tsatsaronis and Zhu, 2004). In a credit-rationing scenario, borrowing capability is

cyclical and it increases with a rising economy and falls with a shrinking one (Kiyotaki and Moore, 1997). An increase in the GDP can have a magnified effect on the mortgage market because it changes the housing preferences of individuals and the technology standards for real estate assets.

Investment decisions, such as house ownership, are usually based on individuals' current income and expected permanent future income and every change in the macroeconomy can thus affect the forecast of future income and current investment choices (Goodhart and Hofmann, 2008). In a growing economy, current and expected wealth increase and individuals have in incentive to become homeowners because their prospective wages and wealth are better than their current state (Hubbard and Mayer, 2009). Real estate investments are almost never fully paid in cash and, therefore, every increase in homeownership is expected to be linked to growth in the mortgage lending market. On the other hand, economic declines also influence the mortgage market, because consumption and investment expenses decrease and long-term investors may wait before making a new residential real estate investment (Mogaka *et al.*, 2015).

Usually, GDP growth is related to technology innovation, which can also have an impact on construction techniques and/or the quality of housing services requested. The higher the quality standard of materials used for the housing investment, the greater the value of the asset as collateral in a loan request and, therefore, the higher the amount of loans outstanding (Iacoviello and Neri, 2010). The linkage between the real estate market and overall economic trends must take into account the higher volatility that characterizes housing investment with respect to other assets and services produced by an economy (Davis and Heathcote, 2005).

3. Empirical analysis

3.1 Sample

The sample includes 16 residential real estate markets in Europe, from 2007 to 2015, with quarterly data for the European market as a whole and for each of the 16 European countries.[1] The data are from Hypostat and are relative indexes (base date 2010:Q4) of the overall amount of outstanding residential mortgage loans, the HPI, and the GDP. Following Gerlach and Peng (2005), both the HPI and the GDP are deflated to avoid foreign exchange dynamics, using the current Consumer Price Index inflation rate available on Eurostat (Table 1).

[1] These countries are Belgium, the Czech Republic, Germany, Denmark, Finland, France, Hungary, Ireland, Italy, the Netherlands, Poland, Portugal, Romania, Spain, Sweden, and the United Kingdom.

Table 1. European RMI, HPI, and GDP, 2007–2015

	RMI	HPI	GDP
2007	94.25	101.67	104.70
2008	91.63	102.28	102.50
2009	95.43	99.12	100.30
2010	100.00	100.00	100.00
2011	102.66	101.37	102.70
2012	104.91	98.65	101.60
2013	104.61	97.17	102.20
2014	107.08	97.71	103.50
2015	100.41	99.53	114.64

Notes: RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Table 1 shows the year-end European averages of RMI, the HPI, and the GDP. The data show that the amount of RMI follows an increasing trend for the overall period considered, starting at 94.25 in 2007 and rising to 107.08 in 2014, with a small correction in 2015 (100.41). The value of the HPI does not change significantly from year to year, starting with 101.67 in 2007 and reaching 99.53 in 2015, with an average value of 99.55 and a peak in 2008 (102.28), before the real estate bubble burst. The value of the GDP starts at 104.70 in 2007, decreases until 2010, and increases from 2012 to the end of the period.

The data collected were transformed into quarterly growth rates to compare the growth trends of the three variables for the overall European area and for each of the four geographical areas in Europe.[2]

[2] According to Eurostat's classification, the northern area includes Denmark, Ireland, Finland, Sweden, and the United Kingdom; the southern area includes Spain, Italy, and Portugal; the eastern area includes the Czech Republic, Hungary, Poland, and Romania; and the western area includes Belgium, Germany, France, and the Netherlands.

Table 2. Yearly growth rates for RMI, the HPI, and the GDP in Europe and in European areas (in percentages)

		2007	2008	2009	2010	2011	2012	2013	2014	2015
Overall Europe	RMI	1.61	1.47	1.22	1.35	1.12	1.12	0.97	1.03	1.09
	HPI	0.17	-0.07	-0.12	-0.01	-0.13	-0.10	0.01	0.14	0.19
	GDP	0.44	-0.21	-0.27	-0.01	-0.08	-0.14	-0.07	-0.03	0.04
Northern Europe	RMI	1.33	0.91	1.34	1.25	1.13	1.18	0.96	1.05	1.14
	HPI	0.19	-0.35	-0.11	0.04	-0.25	0.00	0.19	0.37	0.35
	GDP	0.27	-0.28	-0.21	0.16	-0.01	-0.06	0.03	0.16	0.35
Eastern Europe	RMI	2.68	2.64	1.28	1.74	1.12	1.25	0.97	1.09	1.16
	HPI	0.32	0.06	-0.25	-0.16	-0.21	-0.17	-0.02	0.14	0.38
	GDP	0.92	-0.28	-0.62	-0.33	-0.31	-0.40	-0.28	-0.30	-0.21
Southern Europe	RMI	1.23	1.08	1.13	1.23	1.02	0.93	0.91	0.91	0.93
	HPI	0.03	-0.03	-0.05	-0.04	-0.14	-0.18	-0.09	-0.02	0.05
	GDP	0.20	-0.21	-0.19	0.06	-0.03	-0.05	0.00	0.01	0.00
Western Europe	RMI	1.21	1.26	1.13	1.19	1.21	1.13	1.06	1.09	1.14
	HPI	0.14	0.04	-0.08	0.12	0.06	-0.04	-0.02	0.06	-0.03
	GDP	0.34	-0.08	-0.07	0.07	0.04	-0.05	-0.01	0.02	0.04

Notes: RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Looking at the average of each variable, the trend in RMI is noted to be quite stable, around 1.00%, with a maximum in 2007 (1.61%) and a minimum (0.97%) in 2013. The HPI and the GDP show values close to zero over the entire period, with values below zero during the financial crisis. In terms of geographical areas, the eastern area has a higher RMI value, particularly in 2007–2008 (2.68% and 2.64%, respectively) but the GDP exhibits a greater shock, with a low in 2009 (-0.62%). The other area and variable growth rates have similar median values.

3.2 Methodology

As a preliminary step, a standard integration test is performed for each time series (Dickey and Fuller, 1981) to determine whether there is a trend in the variables that leads to spurious regression. Using time series analysis, a random walk, a drift, and a drift and trend model, respectively, are utilized as a benchmark, as follows:

$$GDP_t = \alpha GDP_{t-1} + u_t + \varepsilon_t \quad (1a)$$

$$GDP_t = \beta_0 + \alpha GDP_{t-1} + u_t + \varepsilon_t \quad (1b)$$

$$GDP_t = \beta_0 + \tau t + \alpha GDP_{t-1} + u_t + \varepsilon_t \quad (1c)$$

$$Mrtg_t = \alpha Mrtg_{t-1} + u_t + \varepsilon_t \quad (2a)$$

$$Mrtg_t = \beta_0 + \alpha Mrtg_{t-1} + u_t + \varepsilon_t \quad (2b)$$

$$Mrtg_t = \beta_0 + \tau t + \alpha Mrtg_{t-1} + u_t + \varepsilon_t \quad (2c)$$

$$HPI_t = \alpha HPI_{t-1} + u_t + \varepsilon_t \quad (3a)$$

$$HPI_t = \beta_0 + \alpha HPI_{t-1} + u_t + \varepsilon_t \quad (3b)$$

$$HPI_t = \beta_0 + \tau t + \alpha HPI_{t-1} + u_t + \varepsilon_t \quad (3c)$$

where

$Mrtg_t$ is the natural logarithm of the amount of RMI for 16 European countries at time t,

GDP_t is the natural logarithm of the GDP for the 16 European countries at time t,

HPI_t is the natural logarithm of the HPI for the 16 European countries at time t,

μ is a vector of constants,

τ_t is a deterministic time trend, and

ε_t is a vector of white noise error terms.

The interaction among real estate prices, bank lending, and the GDP is analysed using a vector autoregressive (VAR) model. Following the approach proposed by Gerlach and Peng (2005), the three equations tested are the following:

$$\begin{cases} Mrtg_{it} = \sum_{i=1}^{k} \beta_k Mrtg_{it-k} + \mu + \delta\tau_t + \varepsilon_t \\ GDP_{it} = \sum_{i=1}^{k} \gamma_k GDP_{it-k} + \mu + \delta\tau_t + \varepsilon_t \\ HPI_{it} = \sum_{i=1}^{k} \theta_k HPI_{it-k} + \mu + \delta\tau_t + \varepsilon_t \end{cases} \quad (4)$$

The analysis focuses on the sign and significance of the coefficients to identify the type and strength of the causality linkage among the variables.

Additionally, impulse response analysis is conducted to evaluate whether a shock to a variable has a persistent effect on the other variables or whether the impulse reverses and the length of time necessary to revert to initial conditions and overcome the effects of the initial shock. A VAR model is run for the overall European market to identify the sign of the relations among the variables and evaluate the effect of a shock (using an impulse response function) on one variable with respect to all the others. The same analysis is performed country by country to determine any outliers among the 16 European countries that show a different trend for at least one of the variables. Gray *et al.* (2013) explain the main advantages of using the generalized VAR (GVAR) model and highlight the significant reduction in multicollinearity, a characteristic of the time series variables, summarizing information for the long-term relations of the variables.

To investigate the propagation risk among countries, a GVAR model is constructed to distinguish the impact of local markets with respect to geographical area trends (e.g. Pesaran *et al.*, 2004). We therefore have

$$\begin{cases} Mrtg_{it} = \sum_{i=1}^{k} \beta_k Mrtg_{it-k} + \sum_{j=1}^{4} \sum_{i=1}^{k} \beta_{jk}^{*} Mrtg(j)_{it-k}^{*} + \mu + \delta\tau_t + \varepsilon_t \\ GDP_{it} = \sum_{i=1}^{k} \gamma_k GDP_{it-k} + \sum_{j=1}^{4} \sum_{i=1}^{k} \gamma_{jk}^{*} GDP(j)_{it-k}^{*} + \mu + \delta\tau_t + \varepsilon_t \\ HPI_{it} = \sum_{i=1}^{k} \theta_k HPI_{it-k} + \sum_{j=1}^{4} \sum_{i=1}^{k} \theta_{jk}^{*} HPI(j)_{it-k}^{*} + \mu + \delta\tau_t + \varepsilon_t \end{cases} \quad (5)$$

where, with respect to the standard VAR, the trends of the j geographical areas are added to each equation. The variables $Mrtg(j)_{it-k}^{*}$, $GDP(j)_{it-k}^{*}$, and $HPI(j)_{it-k}^{*}$ are computed by assigning different weights to each area and to each country based on the country's share of the overall amount of trades for the GDP and based on the share of capital flows for mortgages outstanding and the HPI.

3.3 Results

A requirement for the application of the VAR model to the data is analysis of cointegration among the time series for the GDP growth rate, the housing price index quarterly rate of change, and the percentage of increase of residential mortgages. The analysis is performed using a Johansen cointegration test considering quarterly data for the full time period (Table 3).

Table 3: Johansen's cointegration test

	Osterwald-Lenum		Max lambda	
	H = 0	**H ≤ 1**	**H = 0**	**H ≤ 1**
EU	35.10*	51.76*	15.09	16.66
BE	11.63	19.21	7.36*	7.53*
CZ	32.90*	52.25*	12.67*	19.35
DE	51.91*	70.39*	16.20	18.48
DK	16.85	30.47*	12.04*	13.62*
ES	22.96*	35.53*	8.56*	12.56*
FI	25.31*	39.26*	9.57*	13.94*
FR	33.33*	45.77*	9.22*	12.55*
HU	38.34*	55.34*	12.15*	17.00
IE	19.40	29.48*	9.40*	10.08*
IT	38.85*	51.02*	11.59*	12.16*
PL	34.64*	62.07*	18.84	27.43
NL	17.64	27.10	7.83*	9.46*
PT	55.51*	72.40*	16.81	16.89
RO	78.79*	86.62*	7.33*	7.83*
SE	20.96*	27.60	5.76*	6.64*
UK	28.36*	38.78*	9.88*	10.41*

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
* Hypothesis of no cointegrating relation rejected.
Source: Hypostat and Eurostat data processed by the authors.

The results show that, for both the assumptions (r = 0 and r = 1), the test exceeds the critical value and leads to rejection of the hypothesis of no cointegrating relation for all the countries, except for Belgium, Denmark, Ireland, and the Netherlands for r = 0.

A preliminary analysis of the data is performed to determine the existence of a unit root for the GDP, RMI, and the HPI (Table 4).

Table 4. Dickey–Fuller test for the GDP, RMI, and the HPI, by country

	GDP			RMI			HPI		
	No cost (1a)	Drift (1b)	Trend (1c)	No cost (2a)	Drift (2b)	Trend (2c)	No cost (3a)	Drift (3b)	Trend (3c)
EU	-0.39	-6.70***	-7.66***	-0.44	-8.39***	-8.69***	-0.99	-11.59***	-14.50***
BE	0.38	-6.47***	-11.62***	8.90	-2.44**	-1.13	0.67	-2.29**	-1.75
CZ	-0.01	-5.60***	-6.69***	-0.16	-2.05**	-6.63***	-0.20	-3.14***	-3.21*
DE	-0.21	-2.93***	-5.64***	-0.73	-7.52***	-17.89***	1.69	1.10	-4.43***
DK	-0.05	-4.69***	-5.18	-0.37	-3.14***	-6.44***	-1.41	-5.19***	-4.15**
ES	0.29	-2.79***	-2.91	-1.25	-0.57	-1.35	-1.27	-0.02	-5.20***
FI	-0.48	-8.14***	-8.47***	2.70	-0.58	-2.03	1.38	-6.57***	-9.45***
FR	0.18	-3.55***	-5.75***	-0.02	-1.75**	-16.58***	-0.74	-4.20***	-4.33***
HU	0.13	5.03***	-5.24***	-0.97	-2.97***	-2.97	0.51	-0.29	2.10
IE	0.62	-0.12	-1.08	0.56	-4.78***	-15.98***	-2.41**	-2.01**	1.13
IT	-1.00	-9.47***	-12.47***	1.06	-0.79	-1.41	-3.80***	1.01	-2.72
PL	0.40	-2.82***	-8.12***	-0.11	-1.91**	-4.02**	0.07	-1.05	-5.70***
NL	-0.58	-11.96***	-11.95***	3.29	-4.95***	-3.46*	-0.06	-1.26	-4.21**
PT	-0.68	-3.67***	-4.81***	-0.97	-6.67***	-6.49***	-0.48	-1.03	0.24
RO	0.09	-5.19***	-5.40***	0.61	-0.95	-5.51***	-0.98	-2.07**	0.19
SE	-0.23	-6.56***	-8.98***	-0.44	-3.02***	-14.23***	3.42	-1.78	-3.16
UK	-0.21	-3.13***	-5.32***	-0.11	-1.96**	-2.75	-0.42	-3.85***	-7.00***

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
*, **, and *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively.
Source: Hypostat and Eurostat data processed by the authors.

A Dickey–Fuller test is conducted, assuming the null hypothesis of a unit root and the alternative hypothesis being a stationary process. The results for all three proxies (the GDP, RMI, and the HPI) show that the null hypothesis is rejected when the approach does not include a constant term, but the hypothesis cannot be rejected in the case of fixed drifts or time trends. Moving from the overall Europe to specific country data, the results are confirmed for almost the entire sample, except for Ireland, for which the null hypothesis for the GDP is rejected, and Hungary, Italy, and Portugal, for which the null hypothesis for the HPI is rejected. Finally, regarding RMI, the null hypothesis is reject for Estonia, Finland, and Italy.

Analysis of the causal relations among the variables is performed using a VAR model following the approach proposed by Johansen (1988, 1991, 1995), in which the dependent variables are, respectively, residential mortgages, the HPI, and the GDP, while the independent variables are the same three variables with one- and two-quarter-lagged values (Table 5).[3]

[3] The choice of the number of lags is driven by the data, but the results are also confirmed for greater lags.

Table 5. VAR analysis

		EU	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	PL	NL	PT	RO	SE	UK
RMI	RMI_{t-1}	0.08	1.19***	0.84**	-0.09**	0.23**	0.30	0.57***	0.62***	0.66***	-0.04	0.86***	0.50	0.77***	1.66***	1.00***	0.37***	0.53***
	RMI_{t-2}	-0.68***	-0.22	0.00	0.24***	-0.01	0.30	0.22	0.13	-0.21	0.21***	0.01	0.09	0.06	-0.63***	-0.02	0.39***	-0.01
	HPI_{t-1}	0.22	0.09	0.92	0.82***	-0.34***	-0.27	0.21***	-0.20	-1.05	-0.25*	0.29***	-0.14	-0.15	0.10	-0.19	0.07	0.48**
	HPI_{t-2}	-0.29	-0.08	-1.34	-0.30	-0.19*	0.47	0.12*	-1.20**	1.12	0.51***	-0.30***	0.44	-0.04	-0.06	0.21	0.96***	-0.37**
	GDP_{t-1}	-0.84*	0.00	-1.31	0.07	0.02	-0.02	-0.14***	0.81	-0.58*	-0.3***	0.03	0.17*	0.48	0.00	0.01	-0.54***	-0.52
	GDP_{t-2}	1.07**	0.09	0.08	-0.14*	0.01	-0.02	-0.04	1.74***	-0.24	-0.22**	0.09***	0.22***	0.46	-0.01	0.07***	-0.63***	1.39***
	α	6.63***	-0.31	8.38	1.87***	5.78***	1.22	0.30	-4.19	5.9**	5.08***	0.09	-1.25	-2.68	-0.25	-0.30	1.69	-2.32*
	R^2	0.479	0.997	0.649	0.957	0.940	0.872	0.999	0.841	0.543	0.950	0.973	0.740	0.976	0.991	0.992	0.945	0.807
HPI	RMI_{t-1}	-0.11**	-0.21	-0.09*	-0.31***	-0.83***	0.68*	2.04***	-0.26***	-0.05	0.47***	-0.18	0.36	-0.01	1.01**	0.03	0.03	0.26
	RMI_{t-2}	-0.14***	0.29	0.06	0.04	0.33***	-0.53*	-1.57***	0.18**	0.00	-0.28***	-0.02	-0.29	-0.03	-1.28**	0.07	-0.04	0.06
	HPI_{t-1}	0.31***	0.70***	1.31***	1.17***	1.12***	1.87***	0.94***	1.14***	1.02***	1.61***	1.41***	1.35***	0.87***	0.82***	0.9***	1.43***	0.79***
	HPI_{t-2}	0.06	0.02	-0.58**	-0.03	-0.59***	-0.96**	-0.82***	-0.76***	-0.08	-0.71***	-0.42**	-0.58	-0.10	-0.05	0.19	-0.47***	-0.79***
	GDP_{t-1}	-0.17	-0.21	-0.19*	0.06	-0.12	-0.05	0.10	0.37*	0.13*	0.22***	-0.05	-0.09	-0.17	0.01	0.08*	0.12**	-0.37
	GDP_{t-2}	0.12	-0.22	0.02	0.01	0.27***	0.03	0.17**	0.59***	0.22***	-0.07	0.09	-0.12**	0.06	0.06	0.07	0.06	1.71***
	α	4.27***	2.90*	2.16**	0.28*	3.69***	-0.16	0.65	-1.21	-1.05*	-1.15***	0.78	1.76**	1.76**	1.91***	-1.56	-0.61*	-3.07**
	R^2	0.57	0.78	0.49	0.99	0.95	0.97	0.93	0.64	0.92	0.99	0.99	0.92	0.94	0.96	0.90	0.98	0.79
GDP	RMI_{t-1}	-0.02	0.52	-0.14*	-0.39**	-0.44***	0.79	3.33***	-0.04	-0.14*	-0.01	-0.51	1.89**	0.11	-0.31	-0.82	0.08*	0.19**
	RMI_{t-2}	-0.24***	-0.40	0.19*	0.27*	0.24**	-0.62	-3.22***	0.09	-0.11	0.08	0.12	-1.14*	-0.11	0.44	1.45***	-0.02	0.08
	HPI_{t-1}	0.03	0.29	1.65**	0.95*	0.45***	1.76**	1.24***	0.36**	0.19	0.05	2.56***	1.37	-0.15	0.31	0.05	-0.13	0.22*
	HPI_{t-2}	-0.43***	-0.35**	-1.37**	-0.65	-0.57***	-2.03**	-1.09***	-0.33*	-0.11	-0.13	-2.34***	-1.81	0.06	0.59**	0.63	0.42*	-0.33***
	GDP_{t-1}	0.00	-0.25	-0.27	0.57***	0.07	0.09	-0.05	0.03	-0.13	0.65***	-0.43***	-0.04	-0.08	-0.09	-0.06	-0.27**	0.16
	GDP_{t-2}	1.09***	0.60***	-0.01	-0.09	0.69***	0.53***	0.83***	0.56***	-0.30*	0.57***	0.16	0.06	0.58***	-0.78***	-0.84***	0.52***	0.39**
	α	2.61***	2.70**	4.41***	1.62***	2.54***	2.21	-0.20	1.49*	7.38***	-0.99	6.72***	3.08	2.70**	3.86***	2.82	1.80**	1.36*
	R^2	0.82	0.71	0.20	0.73	0.51	0.63	0.66	0.58	0.37	0.84	0.80	0.46	0.40	0.90	0.85	0.72	0.73
	No. obs	36	24	36	36	36	36	36	36	36	36	22	35	34	26	26	36	36

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
*, **, and *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively.
Source: Hypostat and Eurostat data processed by the authors.

The European market analysis shows that RMI is positively affected by shocks to the GDP, but the effect is reversed within one quarter. This result is consistent with an overhang effect that reduces the net effect of the initial shock on the economy (Calza *et al.*, 2003). This is the only strong common evidence that can be obtained from the full-sample analysis, but a more detailed country-by-country analysis allows interesting differences to be identified among the countries. In particular, the results for residential mortgages as the dependent variable show that RMI_{t-1} is positively related for all countries, except for Estonia, Ireland, and Poland.

The variable HPI_{t-1} significantly affects current housing prices only for Germany, Finland, and the United Kingdom, whereas, in the other countries, the relation is negative when significant. Analysis of the results for HPI as the dependent variable finds a significant positive or negative relation with RMI_{t-1} and RMI_{t-2}, respectively; therefore, causality seems to go in both directions, as confirmed by Hofmann (2003). The author analyses the linkage between bank lending and property prices based on a multivariate empirical framework and finds that causality does, in fact, seem to run in both directions but the effect of property prices on credit appears stronger than the effect of credit on property prices.

Finally, with mortgages as the dependent variable, GDP_{t-2} and GDP_{t-1} are, respectively, significantly positively and significantly negatively related. In this case, causality is strong in the case of the GDP influencing residential mortgages, as expected; in particular, Ireland, Poland, and Sweden show a significant relation for both GDP_{t-1} and GDP_{t-2}, while only one of the relations is significant for the other countries. Hofmann (2001) obtain similar results, finding that, in 16 industrialized countries, the annual rate of change in real credit is closely related to that of the real GDP. These results are also consistent with the findings of Pere and Hashorva (2011), who study the impact of residential mortgages on residential prices, the GDP per capita, and the interest rate on the demand for mortgage loans. They show that the GDP per capita and residential prices are positively correlated with the demand for individuals' housing loans.

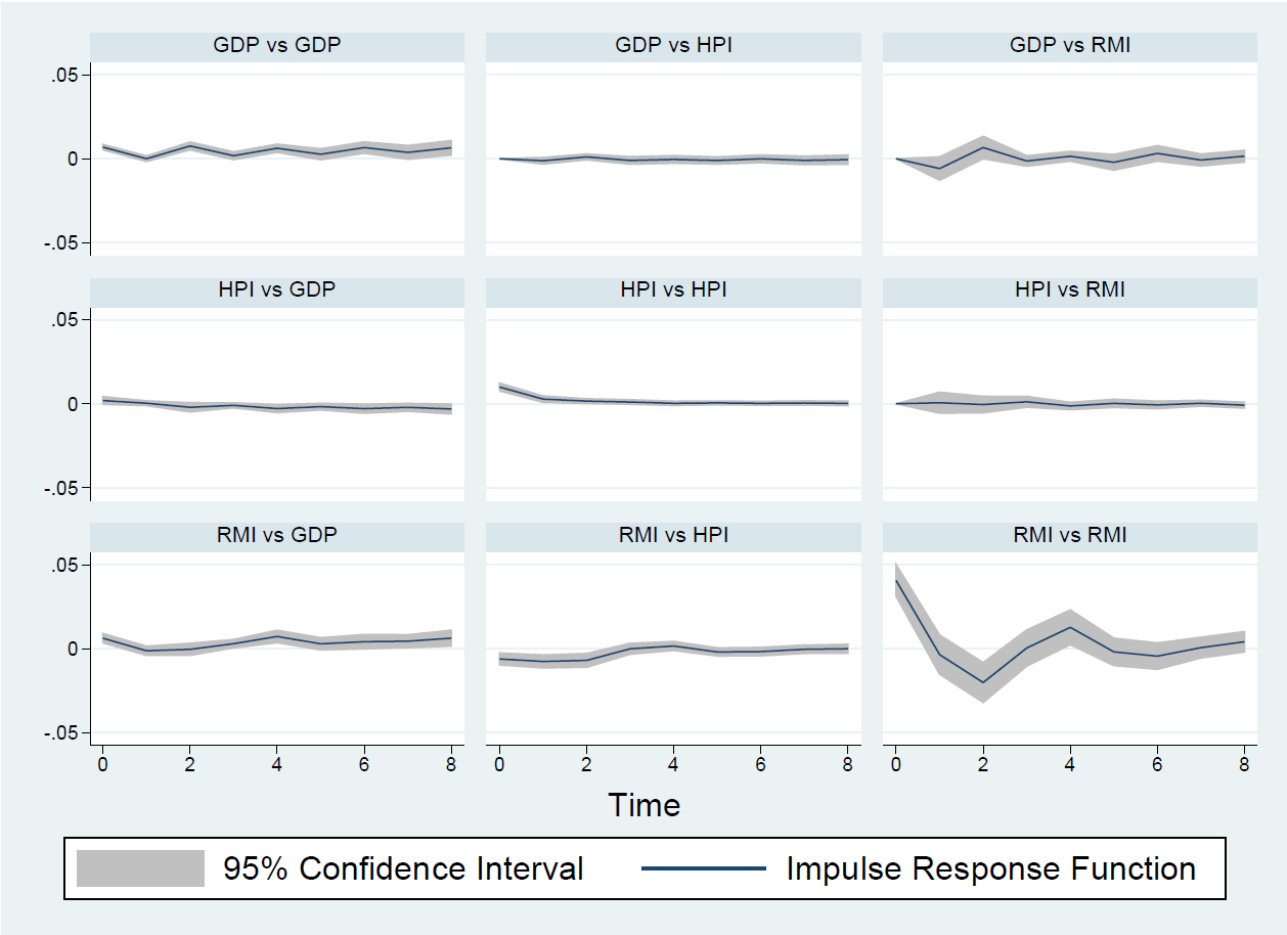
If HPI is considered the dependent variable for each country, RMI_{t-1} and RMI_{t-2} have a positive effect on real estate prices in Denmark, Spain, Finland, France, Ireland, and Portugal. This result is consistent with other studies on European countries (e.g. Spain), where mortgage lending and house price dynamics mutually interact in both the long and short term (e.g. Carbo-Valverde and Rodriguez-Fernandèz, 2010). The variable HPI_{t-1} is always significant and positively related, while HPI_{t-2} is negative when significant.

The variable GDP_{t-1} has a positive impact only for France, Hungary, Ireland, and Sweden and GDP_{t-2} has a positive impact only for Denmark, Hungary, Finland, France, and the United Kingdom. In fact, an increase in the GDP leads to an increase in both housing demand and prices. On the other hand, income also has a feedback effect on house prices, due to the fact that, as assumed in the literature (e.g. Meidani *et al.*, 2011), a house represents the accumulation of a household's wealth that rises with an appreciation of house prices.

Regarding the trend of the overall economy (proxied by the GPD growth rate), in a country-by-country analysis, the independent variables for Germany, Denmark, and Finland are almost always significant. The variables HPI_{t-1} and GDP_{t-2} are positive and significant for most countries. These results are consistent with similar studies, such as that of Goodhart and Hofmann (2008), who highlight that a positive effect of house prices on the GDP could reflect housing wealth but could also be due to forward-looking agents in the housing market predicting movements in the GDP and the repercussions of such movements on the future returns of housing assets

The analysis of the determinants in a long-term horizon is supplemented by an impulse response function analysis of the overall European market for all possible shocks and effects related to the set of the three variables (Figure 1).

Figure 1. Impulse response functions, Europe



Notes: RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Through analysis of a GDP shock, three different reactions are observed for the selected variables. A one-quarter-lagged GDP shock to the GDP initially has a positive impact and the value oscillates around zero until the last quartile. A GDP shock to the HPI creates a negative impact in the first quarter that is gradually

recovered in the following quarters, eventually reverting to zero after four quarters. Eventually the GDP shock to RMI has a positive impact on the GDP in the first quarter after the shock and, afterwards, RMI continues to oscillate around zero. The results for the GDP shock are consistent with the findings of several studies demonstrating a strong short-term relation between the housing market and the GDP (e.g. Davis and Heathcote, 2005). However, Madsen (2002) indicates that this nexus weakens in the long term.

Through analysis of an HPI shock, three completely different reactions are observed for the selected variables. An HPI shock does not affect the GDP in any way. The HPI shock to the HPI has a positive impact in the first quarter that is gradually recovered in the following quarters, with values eventually returning to zero after the second quarter.

Finally, a shock to RMI does not significantly affect the GDP. The RMI shock to the HPI has a negative impact on the HPI in the second quarter after the shock and, afterwards, RMI remains below zero. The results are consistent with the findings of Wilcox (2009), who uses nonconventional data to explain the mortgage market during the housing bubble, showing how an increase in house prices (controlling for all the effects embodied in the lags of the variables modelled), not surprisingly, tended to raise mortgage balances. Initially, RMI exhibits a positive drift and but reverses its trend after two quarters. The results are confirmed by Gambetti and Musso (2016), who study loan supply shocks to the business cycle and find consistent evidence for all the regions assessed in their study (the EU, the United States, and the United Kingdom) both before and after the financial crisis.

Table 6. Impulse response function, country by country: RMI

	RMI (base value 1)			HPI (base value 0)			GDP (base value 0)		
	Max	**Min**	**SD**	**Max**	**Min**	**SD**	**Max**	**Min**	**SD**
BE	1.19	1.12	0.03	-0.05	-0.21	0.06	0.52	0.03	0.20
CZ	0.84	0.28	0.21	-0.03	-0.09	0.02	0.04	-0.14	0.06
DE	-0.03	-0.26	0.08	-0.31	-0.46	0.06	-0.20	-0.39	0.07
DK	0.47	0.23	0.08	-0.41	-0.83	0.14	-0.08	-0.44	0.11
ES	0.39	0.17	0.08	0.97	0.68	0.10	0.88	-0.26	0.44
FI	0.76	0.19	0.18	2.04	0.04	0.81	3.33	-0.14	1.23
FR	0.84	0.53	0.13	0.04	-0.28	0.13	0.10	-0.04	0.05
HU	0.66	0.07	0.19	-0.05	-0.29	0.09	-0.03	-0.19	0.06
IE	0.15	-0.04	0.06	0.49	0.31	0.06	0.10	-0.06	0.05
IT	0.86	-0.18	0.38	-0.18	-1.16	0.37	-0.23	-0.68	0.15
PL	0.94	0.21	0.23	0.36	-0.37	0.28	1.89	0.21	0.58
NL	0.77	0.36	0.14	-0.01	-0.12	0.03	0.11	-0.03	0.05
PT	4.16	1.66	0.88	1.22	-1.44	0.98	1.23	-0.31	0.52
RO	1.00	0.83	0.06	1.15	0.03	0.40	1.38	-0.82	0.79
SE	0.48	0.14	0.12	0.05	0.03	0.01	0.09	-0.02	0.05
UK	0.56	0.30	0.09	0.54	0.26	0.09	0.27	0.18	0.03

Notes: BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Table 6 shows the impulse response function for the residential mortgage exposure of each country, considering the effects on RMI, the HPI, and the GDP. Starting with one-quarter-lagged RMI, heterogeneous results are observed among the countries. Overall, it can only be noted that the majority present either a positive or a null impulse function: Portugal, Belgium, Romania, and the Netherlands have the highest values, while only Germany has a value below zero. The HPI impulse function ranges from high positive values to low negative values, with a few close to zero as well, such as for Germany. Among countries with a high positive maximum value are Portugal, which also shows a low negative value for its minimum, and Finland, which has a high positive maximum value for one-quarter-lagged RMI. The lowest minimum values, besides Portugal, are for Italy and the Denmark, which both have negative maximum values. The GDP impulse function presents a similar overall picture, with countries exhibiting both high positive maxima and low negative minima.

Table 7. Impulse response function, country by country: The GDP

	RMI (base 0)			HPI (base 0)			GDP (base1)		
	Max	**Min**	**SD**	**Max**	**Min**	**SD**	**Max**	**Min**	**SD**
BE	0.12	0.00	0.04	-0.16	-0.31	0.06	0.61	-0.29	0.37
CZ	-0.17	-1.31	0.40	0.04	-0.19	0.08	0.05	-0.27	0.10
DE	0.13	-0.06	0.06	0.25	0.06	0.07	0.57	0.11	0.16
DK	0.05	-0.17	0.08	0.30	-0.12	0.14	0.64	0.07	0.17
ES	-0.02	-0.07	0.02	-0.05	-0.19	0.05	0.43	0.02	0.13
FI	-0.09	-0.15	0.02	0.10	-0.07	0.06	0.50	-0.07	0.20
FR	2.20	0.81	0.42	0.81	0.24	0.19	0.66	0.03	0.19
HU	-0.04	-0.68	0.23	0.43	0.13	0.10	0.28	-0.17	0.15
IE	-0.30	-0.77	0.15	0.66	0.22	0.15	1.76	0.65	0.36
IT	0.09	0.01	0.03	0.03	-0.07	0.03	0.20	-0.43	0.17
PL	0.32	0.04	0.08	-0.09	-0.19	0.03	0.31	-0.04	0.10
NL	1.13	0.48	0.22	-0.08	-0.26	0.06	0.67	-0.08	0.28
PT	0.00	-0.01	0.00	0.07	-0.02	0.03	0.63	-0.77	0.46
RO	0.06	0.00	0.03	0.18	0.04	0.04	0.85	-0.84	0.60
SE	0.25	-0.67	0.35	0.35	0.12	0.08	0.53	-0.30	0.34
UK	1.29	-0.52	0.55	1.63	-0.37	0.57	0.61	0.16	0.14

Notes: BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Table 7 shows the impulse response function for the GDP for each country, considering the effects on RMI, the HPI, and the GDP. Heterogeneous results are observed for RMI among the countries. The majority present either a positive or a null impulse function, the only exception being the Czech Republic, Finland, Hungary, and Ireland, which have negative maximum and minimum values. The countries with the highest positive values are France, Poland, and the United Kingdom, while Belgium, Italy, Germany, Portugal, and Romania have an impulse function close to zero. Regarding RMI, the HPI impulse function shows either a positive or a null impulse function for all but a few countries, namely, Belgium, Spain, the Netherlands, and Poland. The United Kingdom presents by far the highest positive maximum. Only the Netherlands and Portugal have an impulse function close to zero. Finally, regarding the one-quarter-lagged GDP impulse function, heterogeneous results are found across countries as well. The only common evidence noted is the complete absence of minimum and maximum values close to zero.

Table 8. Impulse response function, country by country: The HPI

	RMI (base 0)			HPI (base 1)			GDP (base 0)		
	Max	**Min**	**SD**	**Max**	**Min**	**SD**	**Max**	**Min**	**SD**
BE	0.09	0.04	0.02	0.70	0.13	0.19	0.29	-0.18	0.17
CZ	0.92	-2.50	1.07	1.31	0.08	0.42	1.65	-0.28	0.64
DE	0.82	0.63	0.06	1.34	1.15	0.07	0.95	0.57	0.13
DK	-0.34	-0.65	0.11	1.12	0.47	0.21	0.45	0.02	0.14
ES	0.94	-0.27	0.46	2.42	1.87	0.18	1.76	-0.64	0.86
FI	0.28	0.06	0.08	0.94	0.01	0.34	1.24	-0.03	0.46
FR	-0.20	-1.89	0.59	1.14	-0.06	0.41	0.36	-0.21	0.19
HU	0.08	-1.05	0.40	1.09	0.97	0.04	0.22	0.05	0.07
IE	0.83	-0.25	0.38	1.80	1.09	0.25	0.05	-0.74	0.28
IT	0.61	0.16	0.16	1.51	0.83	0.24	2.56	-0.21	0.94
PL	0.88	-0.14	0.32	1.35	-0.07	0.51	1.37	-0.29	0.51
NL	-0.15	-0.76	0.22	0.87	0.25	0.22	-0.05	-0.15	0.04
PT	0.56	0.10	0.16	0.82	0.14	0.25	0.79	-0.09	0.28
RO	0.02	-0.19	0.07	1.84	0.90	0.32	0.90	-0.15	0.37
SE	3.15	0.07	1.08	1.98	1.43	0.18	0.91	-0.13	0.35
UK	0.48	-0.14	0.20	0.79	-0.27	0.32	0.22	-0.14	0.10

Notes: BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product.
Source: Hypostat and Eurostat data processed by the authors.

Table 8 shows the impulse response function for the HPI for each country, considering the effects on RMI, the HPI, and the GDP. Starting with RMI, the Czech Republic, Spain, and Sweden show interesting results. The Czech Republic has both the third highest maximum (0.92) and the lowest negative minimum (-2.50), Spain has a high, positive maximum value (0.94) and a low, negative minimum (-0.27), and Sweden's maximum and minimum values are both positive (3.15 and 0.07, respectively). The other countries also have interesting and heterogeneous results: Hungary, for example, has a definitively low, negative minimum (-1.05), as does France (-1.89), which also has a negative maximum (-0.20). Regarding the HPI, almost all the maxima and minima are positive, the only exceptions being France, the Netherlands, and the United Kingdom, which, despite having positive maximum values, have negative minimum values. The GDP impulse function is much more heterogeneous across countries. Its highest positive maximum values are found for Italy, Spain, and the Czech Republic, while its lowest negative minimum values belong to Spain and Ireland.

Table 9. GVAR analysis of mortgages among European countries

	EU	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	PL	NL	PT	RO	SE	UK
RMI_{t-1}	0.99***	-0.93***	-0.28	-1.44	-1.47***	-2.76***	-2.27*	-1.05*	-0.23***	1.46***	-1.20***	-0.03	-1.18***	1.55***	1.17***	-0.76	-0.64***
RMI_{t-2}	-0.38	-0.36***	1.92***	-0.97	0.07	1.96***	-2.52***	0.92*	-0.07	-0.80***	0.09***	0.35	-1.10***	-0.96***	-0.56***	1.87***	1.07***
HPI_{t-1}	0.88***	4.60***	8.33***	1.02	-2.00***	1.44***	4.94*	-4.29**	0.83***	-0.25*	0.43***	1.58***	-6.48**	0.16***	0.18***	0.13	3.39***
HPI_{t-2}	-0.06	0.48	7.38***	0.95***	-0.08	0.02	5.72***	3.58*	1.44***	0.27***	-0.26***	-3.22***	-0.10	0.36***	-0.23***	0.59	-2.60***
GDP_{t-1}	-0.69***	0.38	-9.83***	-0.59	-0.29	0.62***	-7.80**	6.02	-0.80**	0.67***	-0.34***	-0.56	-5.02	-1.45***	0.52***	-0.52	-2.94***
GDP_{t-2}	0.02	1.86***	-18.44***	-0.55	-0.94***	-0.70***	5.32***	-11.84**	-1.11***	0.48***	0.46***	-1.46***	12.61***	0.2***	0.46***	-1.64***	3.48***
$RMI\text{-}N_{t-1}$	-0.74***	0.43	11.37	1.88**	-1.02***	-3.60***	-0.11	21.02***	-2.94***	10.14**	0.56***	-0.56	-20.25***	0.35***	-10.12***	2.57***	2.26***
$RMI\text{-}N_{t-2}$	-1.26***	-6.99***	-2.94	1.11	0.5***	0.66	-0.20	-14.70**	-1.68***	-6.07	0.23***	0.72	-25.54***	0.34	0.56***	-0.26	-1.90***
$HPI\text{-}N_{t-1}$	0.80***	-2.19***	44.97***	-1.88	-0.47***	5.36***	-1.41	-12.89	0.09	9.42**	0.45***	-2.36***	5.59	0.98***	0.67***	1.68	1.01
$HPI\text{-}N_{t-2}$	0.08	7.76***	57.74***	1.30	-0.42***	-3.75***	3.02*	29.04***	0.44	-1.39	0.67***	-2.36***	72.59***	0.67***	0.34***	-1.30*	-4.25
$GDP\text{-}N_{t-1}$	28.01***	2.08***	-5.37***	-3.44**	0.44***	1.67	1.46*	-13.55	0.70***	-5.80***	0.87***	-0.35	-6.48	-2.77***	0.87***	-0.33	4.30***
$GDP\text{-}N_{t-2}$	17.47***	0.08	-0.43	-4.36***	-0.29***	2.01**	-1.22*	10.57	-1.42***	17.25***	0.34	-0.78***	-19.99***	4.44***	10.42***	3.80***	-2.31*
$RMI\text{-}E_{t-1}$	-2.40*	14.89**	12.87	7.47*	-2.92	10.85	-17.38	-3.75	10.47***	13.55***	0.45***	-2.46	-20.79	0.56***	-3.83***	18.95***	-19.56
$RMI\text{-}E_{t-2}$	-4.88***	-6.82**	38.04***	1.22	8.25***	44.42***	-21.88	-69.58***	7.97***	7.21**	-0.4***	-0.04	-122.94***	0.23***	-2.12***	20.00***	-9.75
$HPI\text{-}E_{t-1}$	4.33***	-22.35***	51.72***	14.49**	12.55***	-85.36***	16.04	24.16	-62.81***	-39.29***	0.67***	-17.94***	-11.78	0.45***	3.95***	-25.05	-2.84
$HPI\text{-}E_{t-2}$	-5.95***	7.11**	34.54*	-11.4*	15.27***	-2.2	-14.72	28.19	-75.02***	15.05***	0.45***	8.85**	-54.93***	0.12***	3.66***	-18.92*	78.95***
$GDP\text{-}E_{t-1}$	-97.2***	6.67***	-3.79***	-2.15*	4.84***	-13.96***	-53.9*	-29.73***	4.09***	3.61***	0.42***	-2.15***	-38.65	0.15***	-1.81***	-12.31***	9.14
$GDP\text{-}E_{t-2}$	71.01**	-2.69***	2.97***	-1.91	-3.6**	21.7***	-28.31	16.11**	-13.09***	-4.57***	-0.45***	3.23***	-4.30	0.23***	-6.23***	-4.03**	29.97***
$RMI\text{-}S_{t-1}$	-2.45***	-4.24**	-29.61	-8.15***	8.59***	2.1**	35.93	-13.48*	-25.27***	-11.98***	0.12***	2.96***	-23.79*	-0.18***	-0.31***	-76.81***	27.73***
$RMI\text{-}S_{t-2}$	3.93***	8.41***	-89.62**	-3.47	-5.46***	-3.76***	39.88	33.73***	-22.11***	-3.55	0.43***	1.41**	73.70***	-1.85***	-0.50***	2.45	2.21
$HPI\text{-}S_{t-1}$	-7.82***	34.19***	-788.88***	-3.03	-9.53**	9.54***	-94.88**	-42.76***	-30.07***	10.74	0.24***	-18.47***	-81.94***	0.00***	-6.89***	-15.53***	-78.41***
$HPI\text{-}S_{t-2}$	3.78***	-2.77	-216.23**	2.89	-0.89	-2.21	-28.54	-42.8***	94.34***	-9.45	0.34***	-10.7***	109.15***	0.11***	0.45***	138.5***	-19.63
$GDP\text{-}S_{t-1}$	34.85**	-1.64	-4.41***	-2.09**	2.83***	-0.33	-15.85	3.59*	20.92***	0.00	0.45***	1.89*	-21.10***	1.84***	1.47***	-13.05***	11.81
$GDP\text{-}S_{t-2}$	23.84	0.43	-0.17	2.33**	-1.22***	-0.33	-9.44	-0.46	-20.58***	1.57***	0.76***	-2.96***	7.76	-1.32***	3.58***	-4.24	2.02
$RMI\text{-}W_{t-1}$	0.69***	0.30	-8.10***	-1.18**	0.63	0.31	-5.88*	-3.07*	-2.80***	0.22	0.14***	-1.25*	-22.20***	0.41***	0.28***	2.07**	0.13
$RMI\text{-}W_{t-2}$	0.44***	3.28***	9.17***	0.38	-1.98***	0.35**	6.61	-0.26	1.89***	-0.95*	-0.07***	-4.37***	23.40***	-0.38***	-1.1***	-1.35***	0.52
$HPI\text{-}W_{t-1}$	-0.37***	-0.69***	7.88***	0.75***	1.10***	-1.06***	6.90***	1.50*	1.50***	-0.93***	0.03***	-0.71***	6.19***	0.47***	0.28***	-0.03	0.31
$HPI\text{-}W_{t-2}$	-0.12	-0.72***	-2.52	0.01	0.32	0.57***	0.86	-2.03**	-0.22	0.45*	-0.05***	-0.39	-18.08***	0.37***	-0.79***	-1.86***	-0.53**
$GDP\text{-}W_{t-1}$	-3.09***	-0.40***	0.61***	0.55**	-0.75***	-0.35***	4.53**	0.18	0.26***	0.03	0.03***	1.39***	4.87***	0.39***	-0.01***	0.61***	-0.19
$GDP\text{-}W_{t-2}$	-3.78***	-0.44***	0.04	0.23	0.63***	0.08	0.45	1.00	0.93***	-0.16	-0.03***	0.74*	0.85	-0.28***	-0.09***	-0.84***	0.33
α	1.13*	-23.76***	53.82***	11.89***	26.03***	2.06	-11.9	35.46***	4.36**	-3.89**	8.44	19.91***	9.84	5.16	-2.34***	6.07***	-3.51**
R^2	0.99	0.90	0.87	0.86	0.85	0.88	0.86	0.843	0.76	0.90	0.96	0.74	0.84	0.94	0.97	0.93	0.94
No. obs	34	34	34	34	34	34	34	34	34	34	22	33	34	26	26	34	34

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product, N = Northern Europe, E = Eastern Europe, S = Southern Europe, W = Western Europe.

*, **, and *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively.

Source: Hypostat and Eurostat data processed by the authors.

Table 10. GVAR analysis of residential real estate prices among European countries

	EU	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	PL	NL	PT	RO	SE	UK
RMI_{t-1}	0.55	0.41***	-0.15***	-1.64	1.42***	-10.6***	-0.43	0.34***	0.44***	2.09***	-2.90***	-0.17	0.10	2.51***	-0.17***	0.35***	0.16**
RMI_{t-2}	-1.01	-0.40***	0.30***	-2.04	0.55***	5.04***	-0.6**	-0.01	-0.04	-1.77***	0.12***	0.19	0.17***	-2.27***	0.23***	-0.33***	-0.18***
HPI_{t-1}	0.91**	-0.77***	-0.15	1.02	1.26***	4.14***	0.63	0.61***	-0.28***	-0.63***	1.35***	-0.62***	0.84**	-0.10***	0.70***	1.78***	2.29***
HPI_{t-2}	-0.34	0.46	0.26***	1.64**	0.39***	0.37*	1.65***	-0.83***	-0.19	0.35***	-0.17***	2.71***	0.30	-1.00***	0.32***	-0.84***	-1.00***
GDP_{t-1}	-0.86*	-1.96***	-0.45***	-0.84	-0.62***	1.21***	-2.99**	-2.19***	1.48***	0.96***	-0.49***	0.51*	0.42	-1.84***	0.39***	0.02	0.84***
GDP_{t-2}	0.39*	-0.91***	-1.81***	-0.90	0.53***	-1.57***	0.72	0.98*	1.33***	0.64***	0.23***	0.88***	-2.28***	-0.25***	1.02***	0.23**	-1.24***
$RMI\text{-}N_{t-1}$	-1.72**	4.02***	-1.03	3.72**	0.96***	-8.91***	0.16	-1.15**	-0.12	2.70	0.23***	-0.16	1.64*	0.56***	-15.3***	-0.70***	-0.54*
$RMI\text{-}N_{t-2}$	-0.27	6.09***	-2.64***	1.32	-0.26***	0.14	0.23	1.99***	-1.92***	0.66	0.45***	0.05	3.29***	0.78	0.22***	0.08	-0.15
$HPI\text{-}N_{t-1}$	-0.46	-0.63	9.05***	-3.53	0.28***	12.56***	-0.67	0.64	-0.07	28.18***	0.89***	2.85***	0.90	0.67***	0.56***	0.37	-1.70***
$HPI\text{-}N_{t-2}$	-0.55**	0.68	5.61***	4.88	0.29***	-7.72***	0.24	-2.99***	-1.29***	-11.49**	0.12***	1.93***	-7.29***	0.45***	0.44***	-0.75***	-2.65***
$GDP\text{-}N_{t-1}$	29.70***	1.31***	-0.61***	-5.79*	-0.47***	7.33**	0.59**	3.58***	-0.53**	-20.92***	0.78***	0.5***	0.99	5.74***	0.67***	0.47***	-1.91***
$GDP\text{-}N_{t-2}$	43.61***	-0.95*	-0.07*	-9.56***	0.22***	3.10	-0.01	0.05	0.38*	22.26***	0.11	0.53***	2.34***	22.08***	10.78***	-0.87***	1.91***
$RMI\text{-}E_{t-1}$	-0.04	-30.85***	-0.09	12.59	2.44*	58.7**	-8.03	-7.84***	-12.27***	27.45***	0.24***	-2.48*	-2.49	0.67***	-0.81***	-5.79***	18.42***
$RMI\text{-}E_{t-2}$	0.04	-4.10*	4.35***	2.38	-4.79***	92.33***	1.82	-1.63	-16.98***	19.58***	-0.06***	1.04*	20.28***	0.98***	-3.3***	-2.73***	13.11**
$HPI\text{-}E_{t-1}$	-0.40	33.11***	1.32*	25.55*	8.44***	-21.8***	64.97	3.16	43.56***	-23.16**	0.47***	18.59***	-14.65	0.24***	3.99***	5.49*	2.05
$HPI\text{-}E_{t-2}$	19.10***	-11.75***	10.84***	-20.65*	-3.57	-12.92**	-14.3	1.93	50.28***	13.82***	0.98***	-2.65	82.7***	0.34***	-6.51***	14.29***	-14.05***
$GDP\text{-}E_{t-1}$	37.99	-8.53***	-0.39***	-5.23**	-5.75***	-42.2***	-10.25	2.11***	3.38**	4.10***	0.80***	1.37***	-2.00	0.33***	3.49***	2.7***	-5.78**
$GDP\text{-}E_{t-2}$	-89.02**	1.19**	0.36***	-2.80	8.08***	32.27***	-11.84**	-2.41***	0.41	-2.68**	-0.96***	-0.94	8.04**	0.12***	-2.72***	-2.73***	-18.13***
$RMI\text{-}S_{t-1}$	-0.90	1.40	21.51***	-14.76***	-2.82*	1.15	21.61	0.34	4.23	-23.24***	0.45***	0.32	4.72**	2.49***	4.37***	14.35***	-5.14*
$RMI\text{-}S_{t-2}$	-0.47	12.41***	-6.13***	-4.75	-1.37	-8.81***	7.46	1.00	6.22	-35.17***	0.35***	-1.34***	-9.86***	-4.2***	1.92***	9.63***	-4.40*
$HPI\text{-}S_{t-1}$	-4.96	-62.29***	-17.71***	-8.44	14.79***	16.50***	-47.93***	-5.02***	46.59***	74.99***	0.16***	15.72***	19.8***	0.23***	-3.04***	-2.81	4.16
$HPI\text{-}S_{t-2}$	-3.59	-26.57***	-17.18***	1.78	10.92***	6.15	-54.58*	2.81**	-4.86	35.52***	0.17***	10.62***	-13.58**	7.99***	0.47***	-6.66	12.46***
$GDP\text{-}S_{t-1}$	15.56***	1.03	-0.49***	-3.53**	-3.18***	-2.31	0.98	-0.98***	-3.88	-3.75***	0.56***	-1.91***	2.79***	5.61***	-4.77***	-3.80***	13.24***
$GDP\text{-}S_{t-2}$	-14.02**	-0.88	-0.08***	4.20**	-0.12	2.77	-3.59	0.55*	16.43***	-0.42	0.25***	1.18***	-2.42**	-3.92***	1.24***	-2.81***	-5.92***
$RMI\text{-}W_{t-1}$	-0.30	-3.96***	-0.46***	-2.59***	0.36	-1.05	-1.93*	0.10	3.72***	1.42	0.28***	1.90***	3.66***	1.60***	0.62***	-0.16	-0.26**
$RMI\text{-}W_{t-2}$	-0.43	-2.77***	1.50***	0.91	1.14***	1.10***	0.68	-0.46***	-0.75**	-1.53**	0.06***	1.87***	-2.91***	1.05***	0.37***	-0.10*	-1.16***
$HPI\text{-}W_{t-1}$	0.49*	0.87***	-0.01	1.48***	-1.00***	-1.90***	2.55***	0.28***	-1.04***	-2.58***	0.08***	0.49***	-1.48***	0.56***	1.05***	0.00	-0.80***
$HPI\text{-}W_{t-2}$	-0.50	-0.63***	-0.30***	-0.27	-0.36***	1.21***	1.39	0.04	-0.98***	1.18***	0.12***	0.03	1.72***	1.24***	-0.65***	0.18*	-0.30***
$GDP\text{-}W_{t-1}$	-2.75	0.61***	0.05***	0.90**	0.94***	-0.53*	1.05	0.08	-0.88***	1.01***	0.13***	-1.33***	-0.69***	0.30***	-0.86***	0.05	0.44***
$GDP\text{-}W_{t-2}$	4.01	0.55***	0.00**	0.63*	-0.75***	-0.02	0.44	-0.13**	-0.89***	-0.78***	-0.07***	-0.05	0.15	-0.59***	-1.79***	0.48***	0.43***
α	6.21***	19.52***	13.83***	17.37**	-11.53***	11.35*	9.21	9.73***	-8.12***	-3.45	13.25	-11.44***	6.73*	17.83	-6.91***	-0.99***	0.64
R^2	0.89	0.79	0.88	0.94	0.95	0.96	0.98	0.88	0.92	0.99	0.92	0.95	0.94	0.98	0.93	0.95	0.98
No. obs	34	34	34	34	34	34	34	34	34	34	22	33	34	26	26	34	34

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product, N = Northern Europe, E = Eastern Europe, S = Southern Europe, W = Western Europe.

*, **, and *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively.

Source: Hypostat and Eurostat data processed by the authors.

Table 11. GVAR analysis of the GDP among European countries

	EU	BE	CZ	DE	DK	ES	FI	FR	HU	IE	IT	PL	NL	PT	RO	SE	UK
RMI_{t-1}	-0.04	-0.49***	-0.01	-4.58***	0.9***	-0.93	0.28*	-0.02	0.02	-2.94***	-0.79***	-0.78*	-0.09***	0.93***	-0.36***	-0.20***	0.20***
RMI_{t-2}	-0.35***	-0.06**	0.26***	-2.62***	0.44***	-0.50	0.84***	0.13**	-0.04	0.38	-0.07***	-0.14	0.01	-1.59***	0.32***	0.37***	-0.11***
HPI_{t-1}	-1.13***	-0.03	1.25***	2.65***	0.65***	0.03	0.08	-0.58**	-0.17***	-0.32	-0.15***	1.96***	-0.34**	-0.10***	-0.73***	-0.10	0.60***
HPI_{t-2}	0.03	1.89***	0.65***	2.35***	0.42***	-0.49***	-1.74***	-0.23	-0.49***	0.19	0.19***	-3.73***	0.00	-0.18***	0.42***	0.4***	-0.29***
GDP_{t-1}	0.78***	0.33***	-0.88***	-0.61**	-0.18	-0.5**	1.86***	0.79	-0.26***	-2.15***	0.05***	0.20	0.70***	-0.49***	0.03***	-0.17***	0.06
GDP_{t-2}	0.09***	-1.43***	-1.69***	-1.11***	0.92***	-0.49***	-1.23***	-0.20	0.77***	-0.59	0.01***	-1.14**	0.63***	0.59***	-0.45***	-0.07**	-0.08
$RMI\text{-}N_{t-1}$	0.31***	-4.23***	0.00	0.18	-0.15	-0.02	-0.29***	1.16*	-1.08***	-40.71***	0.21***	-2.27***	-3.03***	0.23***	-10.25***	0.49***	-0.95***
$RMI\text{-}N_{t-2}$	0.88***	0.54	-1.64	1.86**	0.03	0.00	-0.02	-3.4***	0.31***	19.36	0.23***	0.43	-1.59***	0.00	0.36***	0.16***	-0.56***
$HPI\text{-}N_{t-1}$	0.49***	3.09***	9.30***	-1.94**	-0.02	0.38	0.36*	0.46	-0.39***	6.38	0.89***	-1.16	2.23***	0.55***	0.69***	0.75***	0.25
$HPI\text{-}N_{t-2}$	-0.05**	-0.93***	5.53***	-3.96***	0.14**	-2.62**	-0.84***	3.51***	0.64***	-8.89	0.56***	-1.18**	4.03***	0.64***	0.48***	-0.10*	1.17***
$GDP\text{-}N_{t-1}$	0.93	1.54***	-0.65***	-6.79***	-0.14***	-4.85**	-0.16	-2.84***	0.27***	1.24	0.37***	-0.43	-0.47*	-0.73***	0.37***	-0.26***	-0.77***
$GDP\text{-}N_{t-2}$	-10.72***	0.74***	0.05	-2.52***	-0.15***	4.28***	0.47***	2.58*	-0.52***	-29.77***	0.00	-0.95***	-1.67***	-3.41***	-2.82***	-0.25***	-0.23
$RMI\text{-}E_{t-1}$	-9.46***	-14.05***	2.29***	11.72***	3.50**	18.73	-13.14***	3.86	4.04***	-19.41	0.25***	-7.74***	-3.90*	0.35***	0.02***	2.84***	-6.97***
$RMI\text{-}E_{t-2}$	-5.32***	1.30*	2.96***	3.80***	3.63***	-6.75	6.12	-6.83**	3.85***	-4.16	-0.42***	-1.27	-8.18***	0.34***	0.12***	2.21***	-7.41***
$HPI\text{-}E_{t-1}$	7.39***	-2.89	6.28***	8.29**	2.19	-22.15	-16.42	-13.76***	-3.34*	63.27***	0.46***	-27.57***	-12.5***	0.56***	11.32***	-9.17***	-0.23
$HPI\text{-}E_{t-2}$	9.08***	0.03	1.53	-17.48***	-12.91***	-53.86	81.63***	-1.42	-13.12***	-8.97	0.57***	16.78***	-26.78***	0.35***	-3.72***	10.16***	-13.26***
$GDP\text{-}E_{t-1}$	-77.69***	-5.71***	-0.34***	-1.54**	-1.65	-1.66	13.34***	-2.5**	1.98***	-5.20*	0.55***	-3.42***	1.24	0.78***	3.21***	4.07***	1.01
$GDP\text{-}E_{t-2}$	-38.59***	-1.99***	0.30***	-2.8***	0.44	-5.57	17.9***	3.07***	-0.77	12.97***	-0.29***	7.12***	0.27	0.68***	3.28***	0.52***	3.41***
$RMI\text{-}S_{t-1}$	0.44***	2.62***	-2.47	-9.78***	-1.08	-2.15*	17.78***	-0.59	-0.37	25.78**	0.57***	6.63***	0.33	-0.37***	1.34***	-9.69***	-2.71***
$RMI\text{-}S_{t-2}$	-1.79***	-4.13***	-12.54***	-7.74***	-2.03**	-0.76	-10.71***	2.57**	-13.05***	-18.36	0.37***	3.42***	4.38***	-0.73***	-0.44***	-5.9***	-2.40***
$HPI\text{-}S_{t-1}$	7.26***	-21.28***	-44.29***	4.79**	-9.45***	-5.22	6.02	-3.71**	-16.38***	39.89	0.94***	-27.4***	-2.19***	0.46***	10.29***	18.99***	14.42***
$HPI\text{-}S_{t-2}$	-10.74***	10.24***	-3.11	10.02***	5.37*	1.49	-3.43	-6.96***	36.25***	73.2***	0.46***	-16.19***	8.46***	-0.95***	0.86***	3.37*	-17.73***
$GDP\text{-}S_{t-1}$	-51.95***	4.85***	-0.56***	-3.65***	0.21	3.44***	3.11	0.39	5.65***	-3.66*	0.35***	2.21*	-1.39***	0.01***	0.41***	-1.78***	-3.03**
$GDP\text{-}S_{t-2}$	76.72***	0.56*	-0.14***	4.02***	-0.32	0.02	-10.17***	-0.41	-5.97***	-5.44***	0.46***	-4.46***	-0.58*	-0.03***	1.71***	-1.92***	1.03
$RMI\text{-}W_{t-1}$	-0.42***	1.14***	0.09	-0.22	-1.41***	0.54	3.15***	0.32	-0.84***	4.29*	0.31***	-1.33	-0.26	-0.3***	1.74***	0.82***	0.41***
$RMI\text{-}W_{t-2}$	0.48***	-0.36***	1.30***	-0.19	-1.02***	0.68***	-1.65***	0.27	-0.23***	1.70	0.04***	-5.33***	1.67***	-0.31***	-0.06***	0.12***	0.28**
$HPI\text{-}W_{t-1}$	0.21***	-0.08	0.33***	0.84***	0.24***	-0.28	-2.22***	-0.12	0.19***	0.42	0.03***	-0.97***	-0.28***	0.31***	-0.31***	-0.23***	0.08
$HPI\text{-}W_{t-2}$	0.62***	-0.96***	-0.42**	0.48***	-0.43***	0.30	0.39	-0.27**	-0.44***	0.10	0.14***	-1.81***	-1.54***	0.18***	-0.6***	0.16***	0.17***
$GDP\text{-}W_{t-1}$	-0.07	-0.22***	0.07***	1.06***	0.31***	0.45***	-1.16***	0.04	0.02	0.75*	0.03***	1.02*	-0.01	0.08***	-1.76***	-0.05***	-0.06*
$GDP\text{-}W_{t-2}$	-2.41***	0.51***	0.00	-0.22**	-0.01	-0.23	0.07	-0.01	0.16***	-0.72	0.07***	1.28**	0.31***	0.08***	-1.25***	0.44***	-0.20***
A	7.46***	3.47***	6.46***	22.52***	-9.64***	17.97***	4.33**	5.09***	5.35***	29.66***	8.07	21.28***	0.38	8.36	8.15***	3.51***	2.87***
R^2	0.91	0.98	0.74	0.86	0.72	0.70	0.91	0.99	0.92	0.90	0.91	0.93	0.98	0.99	0.96	0.98	0.91
No. obs	34	34	34	34	34	34	34	34	34	34	22	33	34	26	26	34	34

Notes: EU = European Union, BE = Belgium, CZ = Czech Republic, DE = Germany, DK = Denmark, ES = Spain, FI = Finland, FR = France, HU = Hungary, IE = Ireland, IT = Italy, PL = Poland, NL = Netherlands, PT = Portugal, RO = Romania, SE = Sweden, UK = United Kingdom, RMI = outstanding residential mortgages, HPI = house price index, GDP = gross domestic product, N = Northern Europe, E = Eastern Europe, S = Southern Europe, W = Western Europe.

*, **, and *** indicate statistical significance at the 90%, 95%, and 99% levels, respectively.

Source: Hypostat and Eurostat data processed by the authors.

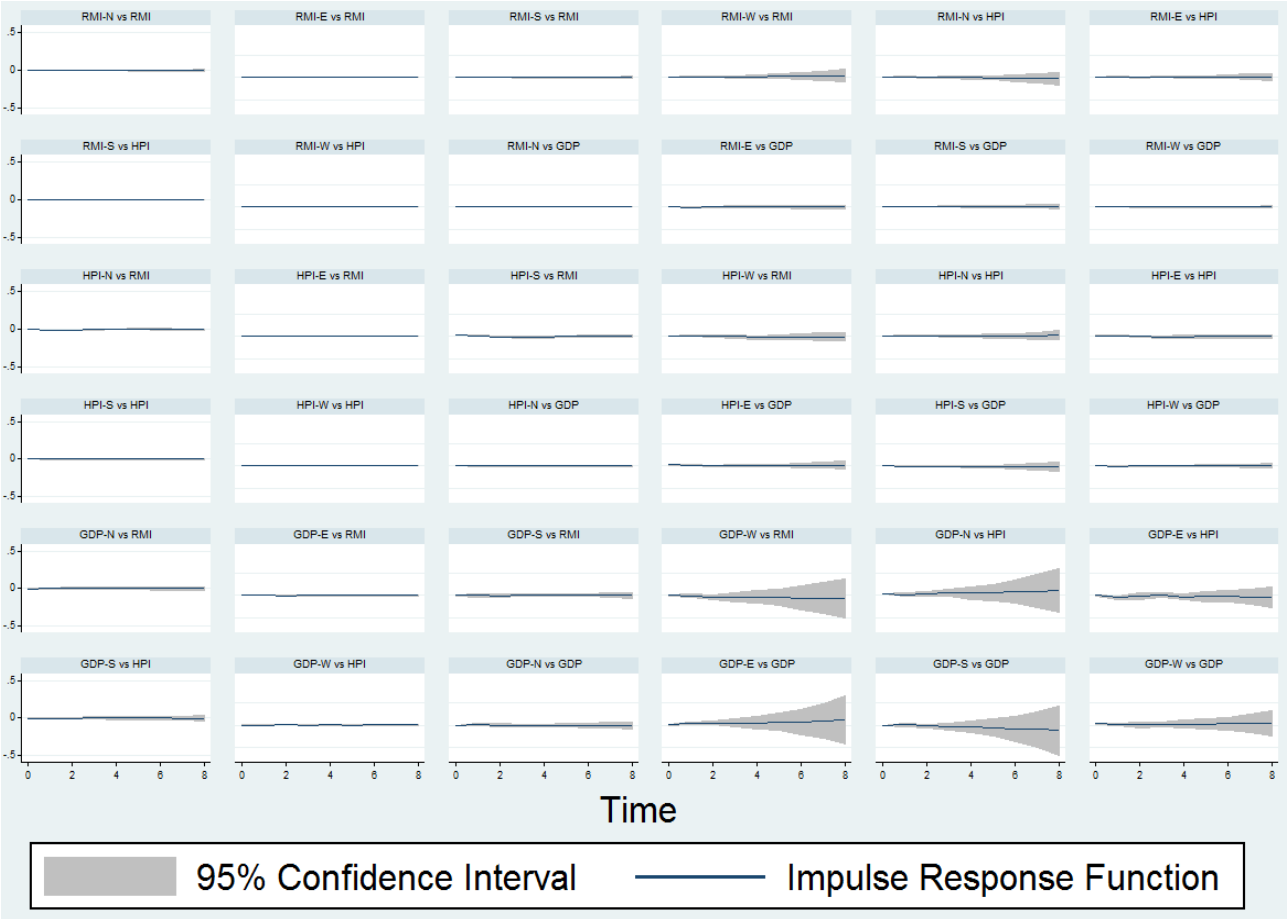
Table 9 considers RMI and shows, at the European level, positive linkages with RMI for Western European countries, with the HPI for Eastern European countries, with the GDP for Northern and Southern Europe, and with RMI in Northern and Eastern Europe. The results are not always confirmed by country-level data. In northern countries, RMI has a stronger and positive impact on the country's residential mortgages, whereas, for all the other variables, only for a few countries' geographical areas does trend matter and the impact is frequently the opposite of that of the European-level data. As for the European areas, the relative variable of the HPI generally assumes positive values, consistent with the evidence provided in the literature for specific country analysis (Bollano and Ziu, 2008). Finally, the GDP at the aggregate level and by geographical area almost always negatively affects residential mortgages, independent of country.

Table 10 considers the determinants of the HPI and show that the real estate trend at the European level is negatively driven by the GDP, the HPI and mortgages, independent of the geographical area (overall or European area data). The only significant exception is the GDP trend for the Northern European countries, which contributes positively to the housing price trend. The analysis is also confirmed by country-level data, even if there are significant differences based on geographical area and more expensive countries (e.g., in Northern Europe) typically react more strongly. The difference in these countries' sensitivity can be ascribed mainly to credit market features that could exacerbate the effect of real estate market changes by modifying the supply of residential mortgages and altering financing conditions (Calza *et al.*, 2013).

Finally, the analysis of the GDP as a dependent variable (Table 11) shows that, at the European level, it is positively related with its past values (overall GDP), the Eastern and Northern European mortgage trends (RMI-N and RMI-E), and the housing price trend in almost all areas. The high relevance of housing prices to the GDP values is consistent with the empirical literature that demonstrates that this evidence is especially relevant outside Eastern European countries (Iacovello and Neri, 2010; Jarocinski and Smets, 2008). Country-level data show, as already identified in the literature (e.g. Cesa-Bianchi, 2013), a negative association between the GDP and residential mortgages independent of the geographical area that could be ascribed to the international spillover of credit market shocks to real economic activity. The analysis of local, country-level GDP shows a negative association with the HPI in Northern Europe only for Germany, Hungary, and the Netherlands; a negative association in Eastern Europe only for the Czech Republic and Poland; and, in Southern Europe, only for the Netherlands, Portugal, and Sweden.

The impulse response function analysis for the shock at the European area level allows for evaluation of the risk of contagion among neighbourhood countries (Figure 2).

Figure 2. Impulse response function by Area, Europe



Notes: RMI, outstanding residential mortgages; HPI, house price index; GDP = Gross Domestic, N = Northern Europe, E = Eastern Europe, S = Southern Europe, W = Western Europe.
Source: Hypostat and Eurostat data processed by the authors.

Analysis of RMI and the HPI shows that, independent of the geographic area, no regional shock has any significant impact on residential mortgages, the HPI, or the GDP in Europe because the change is almost zero. The only regional factor that seems to affect European trends are a shock to the GDP. A shock to the economic growth of Western Europe has a strong effect on RMI, while a shock in Northern Europe affects the HPI trend and GDP growth. The main driver of contagion seems to be related to GDP growth and this evidence is consistent with previous studies that apply GVAR to Asian and African countries (De Waal and Van Eyden, 2016).[4]

[4] The country-by-country analysis results are not tabulated here because they show the same lack of contagion among European countries.

4. Conclusion

Housing prices, mortgages, and the GDP are related to each other, but the magnitude and type of linkage can change, based on country-specific features. Moreover, local trends at the regional or subregional level can affect the housing sector, the credit market, and the overall economy in every national market. This paper considers a set of 16 European countries and evaluates the interactions between house prices, mortgages, and growth at the country and geographical area levels.

Mortgages, the HPI, and the GDP have a positive effect on economic growth, an increase in the amount of mortgages in the past year has a positive effect on the mortgage supply, and a past negative change in the GDP has a negative effect on current house prices and vice versa. The main outlier among European countries is the United Kingdom, whose trends in the GDP, mortgages, and housing data are mostly driven by country-specific data instead of overall European trends.

The impulse response analysis shows that a shock to the GDP has a positive and persistent effect on the amount of mortgages, a shock to the HPI has a negative and persistent effect on mortgages, and a shock to the amount of mortgages seems to have no persistent effect on the GDP or the HPI. This result is consistent with that of Gimeno and Martìnez Carrascal (2006), who show that growing imbalances in the mortgage credit market tend to decrease house prices in the long term.

The analysis of the contribution of the geographical area trends, using a GVAR model, shows that a GDP shock in one European area has an effect on the GDP, real estate prices, and residential mortgages in almost all European countries. The empirical evidence is consistent with the literature for the US market (Eickmeir and Ng, 2015), even if there are interesting differences between geographical areas inside Europe that could justify a higher or lower risk of contagion among countries.

The empirical evidence provided could be useful for policymakers in charge of defining or influencing monetary and economic policies in order to identify the impact of residential mortgages on the real economy and the real estate market. An easier (stricter) lending policy could represent an incentive (disincentive) for economic growth but could also increase national average real estate prices. Moreover, the policy adopted in each country might not be defined independently with respect to the other European countries, because any shock to the GDP in a European area has a contagion effect on the other countries.

Further investigation of the main differences among residential market features in Europe, lending standards, and the cost of lending could allow for a better evaluation of whether differences in sensitivity are related to structural differences in the mortgage market or can be ascribed to omitted variables.

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