LUND UNIVERSITY
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Monetary Policy and the European Housing Demand

A Global VAR Analysis

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Abstract

This study investigates the impact of monetary policy on the demand for housing following a common shock to the mortgage rate. This is done through a global model linking individual country vector error correction models in which the domestic variables are related to the country-specific foreign variables. The Global Vector Autoregressive (GVAR) model is estimated for 10 Euro area countries, over the time period 1999-2011 using quarterly data. The GVAR model is used in order to account for static, dynamic and spatial dependencies in the housing market in Europe. The generalized impulse response analysis reveals that a shock to the common mortgage rate has, on average, a negative effect on the house prices in the sample countries. However, this effect is not homogenous across the countries, indicating that the demand for housing does not respond uniformly.

Keywords: Monetary Policy, Global VAR, General Impulse Response Functions, EMU

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1 Introduction

In Europe, the general view is that the housing market plays an important economic role as it is highly intertwined with the rest of the economy, being affected by macroeconomic, prudential, and structural policies. At the same time, expansions in the housing market are seen to have significant effects on economic activity in other areas of the economy. In addition, housing finance is of importance as housing loans often constitute the largest liability of households and account for a large proportion of bank lending e.g. for most households in Europe, real estate is the largest share of their assets and the mortgage is their largest liability. Mortgage debt accounts for around 70 percent of the Euro area households' total liabilities (ECB 2009: 74), indicating that conditions in mortgage markets ought to be a crucial component when looking at the transmission of monetary policy shocks.

There has been substantial efforts made to work towards economic and financial convergence in Europe and since 1999, the European Central Bank has the formal responsibility for the common monetary policy in the Euro area. The ECB's main objective is to uphold price stability, i.e. the Euro should have the same value in all member states (ECB 2013a). This is done through the main monetary transmission channel: the interest rate (ECB 2011: 62). Even though, a decade later, there are still major fluctuations in house prices between the European countries and evidence showing that mortgage rates differ substantially.

It is the combination of improvements in living standards and low interest rates that has increased the ability of households to finance higher mortgage levels, resulting in increased demand and the subsequent upward pressure on house prices. The rising house prices have occurred at a time when also the level of indebtedness in the EU has increased. This has made the households more vulnerable for changes in the economy resulting in monetary policy shocks having more striking effects through the impact on disposable income and consumption (ECB 2009: 74). This can be seen in relation to the fact that per capita disposable income has not been able follow the increase in property prices (Hilbers et al., 2008: 12). In addition, high household indebtedness can have substantial macroeconomic effects as can be seen from the most recent financial crisis, over-indebtedness can lead to financial distress and aggravate the effects of a crisis (The Swedish Riksbank 2011: 121).

However, when discussing monetary policy on a national, as well as transnational level, there is not a unison political voice. For instance, there has been an ongoing discussion within the Swedish Riksbank whether the central bank should even take house prices into account when setting the policy rate. One of the theoretical stances argue that the prices are determined more by the real economy and not as much by the mortgage rate indicating that the central banks thus should not be as concerned with house prices (Svensson, 2013).

In this thesis we will examine whether the housing demand in Europe is affected by a shock to a common mortgage rate. More specific, we aim to investigate the monetary policy in relation to the sensitivity of European household's demand for real estate, using house prices as a proxy for demand. This cumulates into:

Is there a unison response in housing demand for the EMU countries following a shock to a common mortgage rate?

Following applied economic theory, we expect the demand for housing to decrease when there is an increase in the mortgage rate i.e. when there is a positive shock to the mortgage rate. Taking the outcome of the recent financial crisis into account and the countries' characteristics, we would not expect them to have a unison reaction following a shock. To study how shocks are propagated and the impact of cross-country interdependencies, a Global Vector Autoregressive model (GVAR) is estimated. The model is applied on a sample constituting of 10 EMU countries for the period from the introduction of the common monetary policy in 1999Q1 to 2011Q4.

This thesis adds to current research through application of the model on chosen time period and the emphasis on a common mortgage rate. In accordance with our expectations we find that the countries do not act in a unison manner after a shock to the mortgage rate and that some countries do not show a significant reaction at all. The study is concluded with an assessment of the common monetary policy in relation to the outcome of the model.

The remainder of the paper is organized as follows. First we give a brief introduction on previous relevant research and literature. In section 2 the underlying theory is presented. Section 3 describes the applied econometric method and the reasoning behind the GVAR model. In section 4 is the estimation and specification of the model found. In section 5 we present the results of the dynamic analysis accompanied with a robustness check. Lastly, concluding remarks are made in section 6.

1.1 Literature Review

There is a plethora of research conducted on the relationship between house prices and the interest rate and also on the integration of the European mortgage markets. One can divide the literature this thesis builds on into three different parts. First we present relevant research conducted in the area of monetary policy and the theory of housing pricing. Secondly, we lay forward papers developing the econometric theory and modeling of the GVAR. In relationship to the model we present some relevant papers applying the GVAR model on economic research relevant to our thesis.

The substantial literature on the impact of housing and credit in monetary transmission is thoroughly reviewed in Mishkin (2007). He examines what is known about the role of housing in the monetary transmission mechanism and relates this knowledge to the conduct of monetary policy. Further, Mishkin discusses how financial crises can be seen as disinflationary shocks and how the economy has an impact on the housing market fluctuations and how these fluctuations can be severe and a call for the central banks to act. In this thesis the channels presented by Mishkin is adopted to help explaining the results presented in part 3.

Berg and Berger (2005) use Tobin’s transparent q-theory to investigate the Swedish housing market. They argue that major changes in economic policy may result in a more market driven demand for housing investment. Their model also gives an indication of the state of the market where a q-value larger than one signal excess demand (and vice versa) on the market and a q-value equal to unity would indicate equilibrium. In accordance with Berg and Berger the q-theory is considered when variable selection is conducted for this thesis.

In the paper "A Spatio-Temporal Model of House Prices in the US", Holly, Pesaran and Yamagata (2006) model the dynamic adjustment of real house prices in a context where the interactions between housing markets are examined looking at the role of spatial factors, In particular they take into regard the role of contiguous states by use of a weighting matrix. This paper presents a helpful foundation for future research as it analysis the cross sectional dependencies and apply a panel VAR model framework. For an extensive survey on the different panel VAR models used in macroeconomics and finance, see Canova and Ciccarelli (2013).

The literature building the econometric model used in this thesis can be attributed Pesaran, Schuermann and Weiner (PSW), who first developed the GVAR model in 2004. It was then further developed in a paper by Dee, Di Mauro, Pesaran and Smith (DdPS) in 2005. The GVAR methodology have since then been used in a number of papers where spillover effects are to be expected.

In "Do House Price Developments Spill Over Across Euro Area Countries" (2009), Vansteenkiste and Hiebert use the GVAR methodology to analyze the spillovers experienced when shocks to house prices and interest rates occur. They find that there is some evidence of overshooting in the first 1-3 years after a shock. Their results suggest that there is in general a positive correlation between the house price response and the country specific house price shocks in the long run.

In this thesis we continue and further analyze the effect of the interest rate on the housing market and focus on the role that the mortgage rate has on housing demand. We contribute with a sample more up to date and the inclusion of the mortgage rate in relation to the common monetary policy in the Euro area. We will further extend the discussion on the econometric method and data in chapter 3.

2 Theory

The underlying theory this paper builds on is twofold. First, theory on how housing demand can be modeled is presented by application of a simple version of Tobin's q-theory. Secondly, we present current research on how the housing market is highly intertwined as well as the causal mechanisms explaining how the monetary policy affects large parts of the economy. The second part builds on the ECB's official policy documents and the work following Mishkin (2007). The theoretical background presented in this section is used as a context for the use of the Global VAR model in the empirical estimation which is further discussed in chapter 3.

2.1 Theoretical framework of housing demand

Even though there are numerous studies done on the topic of modeling the housing market, there is still no consensus on how to operationalize the demand. One can argue that it is in fact impossible to incorporate all types of modifications of a neoclassical model into only one model. What is evident is that there has been an increase in house prices all over Europe. The Swedish Riksbank believes that the underlying reason for this can be related to a variety of reason; for example, urbanization, the population growth, mortgage rates, household income and wealth, monetary policy expectations, as well as construction costs and unemployment and credit growth, but also due to the fact that the housing market can be characterized by rigidity. The deregulation of credit markets in the 1980's in most countries has also been a factor contributing to making owner-occupied housing more attractive (The Swedish Riksbank 2011: 26).

2.1.1 A Simple q-theory model of housing pricing and demand

There is a strong relationship between the housing market and the total output in an economy, e.g. an increase in housing prices may initiate an increase in economic activity, and a downturn in housing prices can be a signal for forthcoming economic recession. Also, since renting is an alternative to buying a home, developments and conditions in the rental market affect those in the housing market. The rent should be equal to the user cost of owning a house in the long run (see for instance Poterba 1984).

At any point in time there will be a specific market price for a certain unit of housing. Following the work of Sörensen & Whitta-Jacobsen (2010), this price can be explained by using a simplified model drawn from the q-theory[1]. The q-theory is commonly used in research as a model to explain housing investment and identifies the factors that may cause fluctuations in the market value of the housing stock. However, it can also be seen as any simple model to explain the demand for housing H^d relative to housing prices p^H as following:

P^H	Market-clearing price of housing
H^d	Demand of housing
η	mark-up
$\delta = \delta\text{-}g^e$	Depreciation
g^e	Expected capital gain
$(r+\delta)\, p^H$	User cost of housing
Y	Disposable income
r	Interest rates: mortgage and risk-free rates/ Opportunity cost

Giving us[2]:

$$H^d = \frac{\eta Y}{(r+\delta)p^H}$$

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[1] The q-theory of business investment (Tobin's q) $q = \frac{Market\ value\ of\ installed\ capital}{Replacement\ cost\ of\ capital}$

The value of Tobin's q is typically viewed as the expected future dividends per unit of capital which are positively affected by an increase in the current profit rate. A q-value greater (less) than one signaling excess demand (supply) on the market and unity value indicates equilibrium." Using the q-theory for a housing market that is assumed to be homogenous, we adopt a line of reasoning saying that if the marginal price for one unit of real estate in a certain market is higher than its marginal production cost (q >1), then we assume that the demand for housing is sufficiently large and put a upward pressure on price creating a profit margin inducing the suppliers to build more housing i.e. the housing stock increases. The new construction continues until the market forces creates a new equilibrium where (q <1) and it is no longer profitable to build new housing.

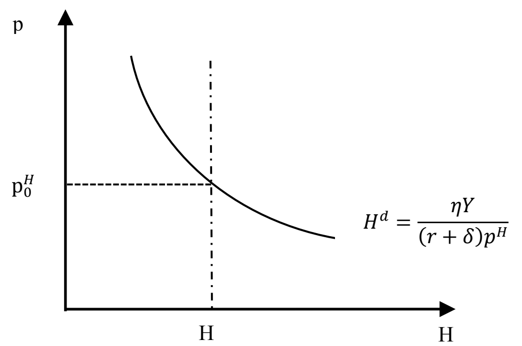
[2] For a complete derivation see Sörensen & Whitta-Jacobsen (2010)

Where housing demand can be seen to vary positively with income and negatively with the user cost of housing. The aggregate supply of housing is assumed to be fixed in the short run as it takes time to construct new housing i.e. $H^d = H$. Applying this relation and solving for p^H we get the market-clearing price of one unit of housing:

$$p^H = \frac{\eta Y}{(r+\delta)H}$$

In the short run the housing stock is predetermined as it takes time to develop new properties. Thereof, housing prices must adjust to keep preexisting housing stock equal to the demand. As can be seen from the figure below; a larger quantity of housing will put a downward pressure on the housing price. This will affect the expansion of new development negatively as it will not be as profitable to invest in new property projects. An upward shift in housing demand will be fully absorbed by an increase in price in the short run. However, over a longer time period the increase in house price will encourage construction of new properties and dampen the initial price increase (Sörensen & Whitta-Jacobsen 2010: 409-413).

It is also evident that an increase in income or decrease in real interest rate will shift the housing demand curve and encourage the demand for housing. As an effect the prices will increase and so will also the construction of new housing. In this empirical study the mortgage rate shock should result in a shift downwards, as the plotted impulse response function should experience a negative reaction and stable around a new lower level.



Finally, the model describes the following relationship; if the user cost of housing decreases, the expectations of possible future capital gains on housing will possibly increase housing prices and boost property investments i.e. higher interest rates generate overvaluation by increasing user costs and when user cost rises, prices drop in the long run and this is what is generating overvaluation today. Nonetheless, it will take some time to adapt the supply of housing to the increased demand as construction is time-consuming and the existing stock is relatively large (Ibid: 409-413).

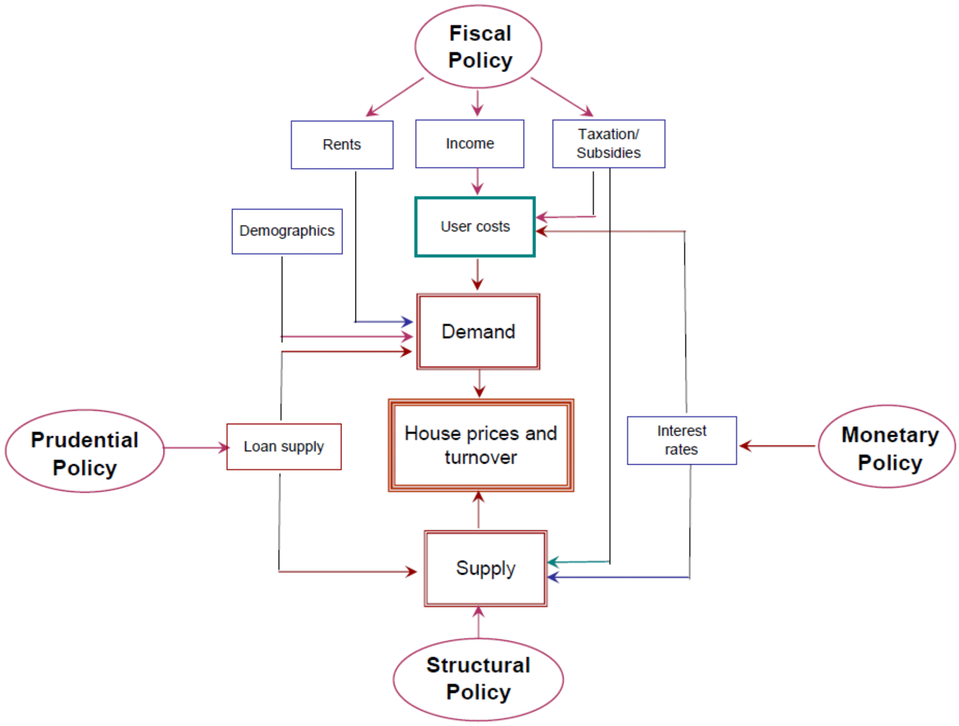
Following the outlined theory, we will use house price in the econometric model as a proxy for the demand for real estate. This is done to model how the common monetary policy in the Euro area affects the households' demand for housing. We further assume that depreciation rate as well as the mark-up is constant over time, indicating that it is only changes in the interest rate that will affect the user cost of housing. The relation between the interest rate and the housing market through the monetary policy will be discussed in more detail in the section below.

2.2 Monetary Transmission Mechanisms

The interest rate is the ECB's main monetary transmission channel (ECB 2011: 62) and by increasing or decreasing the interest rates, the monetary policy will affect the housing market as well as the overall economy. The monetary transmission mechanism is however a complex web of different economic interacting channels. Yet, the ECB does not specifically target asset prices; it rather follows the development of market dynamics to see to what degree they may pose a risk to the overall price stability in the long run (ECB 2011: 86).

In relation to the fact that the economy is affected by lags and stochastic uncertainty in the transmission process, the effect of the ECB's policy today will only see its full effect after a period of time, i.e. the policy of today must be forward looking to be able to maintain price stability in the future. These transmission lags is also a reason not to focus on the short run, as the ECB deems it impossible to offset shocks to the price level in the short run. Thereof; the ECB's monetary policy aims to have a medium-term focus to account for unavoidable volatility (Ibid: 63). In relation to this, the ECB elucidates *"that monetary policy cannot offset all unanticipated disturbances to the price level"*, and it is important to be prepared for unexpected shocks (Ibid: 68).

A stylized illustration of the different channels which may affect the housing market in relation to the monetary policy as well as other policy aspects can be seen in the figure below.



(Hilbers et al., 2008: 11)

Mishkin (2007) in turn, divide the transmissions mechanism of monetary policy into six different categories, either indirect or direct.

i. the user cost of capital,
ii. expectations of future house-price movements
iii. housing supply

Indirectly through:

iv. standard wealth effects from house prices
v. balance sheet, credit-channel effects on consumer spending
vi. balance sheet, credit-channel effects on housing demand.

Mishkin first discusses the impact on the user cost[3]. In short, when the user cost increases, the demand for housing falls. This rise in user cost is due to a rise in the

[3] The User Cost of housing typically consist of current transactions costs, the forgone return to housing equity and/or the cost of mortgage payments plus future expected transaction costs, maintenance and property taxes, minus expected capital gains (Diaz & Luengo-Prado 2011: 5)

interest rate. Further, the fall in demand will lower the aggregate demand in the economy (Ibid: 6).

Secondly, Mishkin discusses how the interest rate will cause effects through expected appreciation of house prices. The expected appreciation of house prices is connected with the user cost as the user cost will rise when monetary policy tightens. This could lead to a lower expected appreciation rate as this in turn would lower demand for housing and a decline of the housing production (Ibid: 7). Mishkin argues for two factors that have generated fluctuations in the home price appreciation; the fact that there are restrictions on land-use limits the amount of housing production and thus making the elasticity of housing supply less elastic. The other factor takes into regard that people often have preference on location; where they want to live (Ibid: 8).

Thirdly, Mishkin raises the question of housing supply. He argues that higher short run interest rates will increase the cost of building new housing as the founding get more expensive and thus lowering supply. He then moves on to the fourth topic; how wealth effects on consumption will be an effect from changes in house prices. Mishkin argues in line with the life cycle theory which suggests that all types of wealth effect are the same.

Another aspect is that housing prices is not as volatile as for example stocks making the effect last longer. However, there is one aspect that contradicts this result, namely the fact that individuals can inherent their housing. If elderly individuals plan to bequest their housing to relatives the wealth effect would not have an effect other than negative as it would only raise their living cost. Mishkin makes a point with that the rise in housing prices can be a result from supply not catching up to the increase in demand in some areas which is not a direct indication that the economy is expanding (Ibid: 11).

Fourthly, Mishkin brings up the subject of balance sheet and credit-channel effects on consumer spending. He argues that a rise in house prices will have a positive effect on consumer spending as it allows individuals to borrow more. This can be explained by the fact that the households will have more collateral.
Lastly, continuing on the same note, he brings forth the topic of balance sheet and credit-channel effects on housing demand. Drawing from the neo-classical theory, only long-term interest rate should affect housing demand and it does not matter whether a homeowner has a variable rate or fixed rate mortgage. If a homeowner

has a variable-rate mortgage the relevant interest rate in the user cost of capital is still the long term because it embodies expectations of the average variable rate over the period of homeownership, as was pointed out earlier (Ibid: 17).

Also, the second balance sheet and credit channel suggests that if households are subject to credit constraints or engage in a rule of thumb behavior, then it matter whether homeowners have variable-rate mortgages. When short-term rates on a variable rate mortgage are higher, credit constrained households will have higher interest rate payments and less cash flow, indicating that movements in short-term interest rates can affect housing demand to a higher degree. Given that variable mortgage rates tend to move more with the short-term interest rates which monetary policy makers use as their policy instrument, countries with higher proportion of households choosing variable-rate mortgages could have a larger response to changes in monetary policy (Ibid: 17-20).

As a result of globalization, there has been an increase in the interdependencies among regions and countries, indicating that no country can be treated in isolation. This is particularly evident regarding the recovery following the recent economic crises where the European countries reacted of different magnitude. As the majority of countries are vulnerable to external shocks originating from sources that are often outside the direct economic sphere, it is of importance that ECB, when formulating economic policy, takes several different transmission channels into consideration as spillovers are likely to play a significant role on the housing market.

The empirical model in this thesis allows for analysis of the transmission effects through the impact on the mortgage rate. We will focus on Mishkin's channels one and six, which puts emphasis on demand rather than supply. It is evident from the figure above that the effect the mortgage rate has on housing demand is from the user cost. The shock performed to the mortgage rate in the empirical analysis is thus supposed to have a negative effect on the demand for housing. The focus is foremost on monetary policy and changes in income will not be discussed to any further extent.

3 Method – The Global VAR Model

To perform the dynamic analysis of monetary policy in the Euro area a Global Vector Autoregressive model (GVAR) is constructed. The model was first introduced by Pesaran, Schuermann and Weiner (2004) and further redeveloped in a paper from Dees, di Mauro, Pesaran and Smith (2007) and Pesaran, Schuermann and Smith (2009), from now on PSS. To compute the model we use MatLab constituting of an Excel-based interface developed for GVAR modeling by Smith & Galesi (2011). The idea behind the model is to evaluate how shocks to global variables are affecting the country specific variables through dynamic analysis i.e. how shocks may be propagated differently across borders and whether there are asymmetries both in pace and in the magnitude of the shocks (Vansteenkiste & Hiebert 2009: 10). Canova and Ciccarelli (2013) and Smith & Galesi (2011) summarize the advantage of a GVAR model in five parts: *(i)* it captures both static and dynamic interdependencies, *(ii)* treat the links across units in an unrestricted fashion, *(iii)* easily incorporate time variations in the coefficients and in the variance of the shocks, *(iv)* account for cross sectional dynamic heterogeneities and *(v)* allows for long run relationships consistent with the theory and short run relationships that are consistent with the data.

The GVAR model can be described partly as a collection of unit specific VARs to which one then add an unobservable vector of common factors. In other words, to analyze the relationship each country has its own VAR model which is linked with each other by including foreign variables in the domestic VAR model. Since the mortgage rate is included in all individual models we are able to isolate a shock happening simultaneous in all countries which is what should be expected when ECB decides to raise or lower the interest rate. The fact that the variable is considered as global will exclude it from the foreign variables. To solve the GVAR model, link matrices are computed and the results from the individual VAR models are stacked together. This, to be able to construct a proxy for common unobserved factors and combined, giving us the global VAR model.

3.1 Technical

In this section, a short presentation of the GVAR methodology will be given. For a complete overview we advise the reader to see PSW (2004) and DdPS (2005).

In the GVAR model, each country i is estimated as a vector autoregressive model VARX(p_i, q_i) augmented by weakly exogenous I(1) variables, where country-specific (domestic) variables are related to foreign-specific and global variables, plus a deterministic time trend (Galesi & Lombardi 2009: 11). Hence, if we include a time trend and an intercept the VARX(1,1) for country i can be written as:

$$x_{i,t} = a_{i,0} + a_{i,1}t + \Phi_i x_{i,t-1} + \Lambda_{i,0} x^*_{i,t} + \Lambda_{i,1} x^*_{i,t-1} + \Psi_{i,0} d_t + \Psi_{i,1} d_{t-1} + u_t$$

Where $a_{i,0}$ is a vector of intercepts, $a_{i,1}$ is the vector of coefficient of the time trend where both are $k_i \times 1$. The terms $x_{i,t}$ in the above equation are domestic variables. The foreign variables denoted as $x^*_{i,t}$ are constructed using weights (w_i) where each column most sum to one:

$$x^*_{i,t} = \sum_{j=0}^{N} w_{i,j} x_{j,t},\ w_{i,i} = 0$$

d_t is a global variable, u_t is an idiosyncratic country specific shock $\sim iid(0, \Sigma_{i,i})$ i.e. with zero mean and serially uncorrelated, although, we allow for cross country dependence $Cov(u_i, u_j) \neq 0$. The corresponding error correction model would be:

$$\Delta x_{i,t} = a_{i0} + a_{i1,t} - (I_{ki} - \Phi_i) x_{i,t-1} + (\Lambda_{i0} + \Lambda_{i1}) x^*_{i,t-1} + \Lambda_{i0} \Delta x^*_{i,t} + u_t$$

Where the coefficients and variables are the same as in the VARX representation.

When the global variable is specified as an endogenous (domestic) variable in each model it will not be reflected as a weakly exogenous (foreign) variable in the foreign models. This seems reasonable since the mortgage rate is assumed to be the same in every country and thus it should not have any explanatory value if the country's economies are linked

The estimation of the GVAR is done in the country specific models and after estimation is completed, the model is solved as a whole by link matrices calculated through the weights. There are two type of weights that can be used, time varying weights or constant weights, for smaller samples the benefits of using time varying weights are not that vast as it is less likely that large differences occur in a short period of time (Galesi & Lombardi 2009: 10-15).

In the following paragraph a short derivation of the GVAR model is presented. The first step to solving the GVAR model is to rewrite the domestic and foreign variables to a vector $z_{i,t} = \begin{bmatrix} x_{i,t} \\ x^*_{i,t} \end{bmatrix}$, the VARX can now be written as:

$$A_i z_{i,t} = a_{i,0} + a_{i,1} t + B_{i,1} z_{i,t-1} + u_t$$

$$\text{Where } A_i = \left(I_{ki}, -\Lambda_{i,0}\right), B_{i,1} = \left(\Phi_i, \Lambda_{i,1}\right)$$

In the next step weights are introduced and using the fact that $z_t = W_i x_t$, where W_i is the link matrices containing identity matrices and weight matrices. For example in a two country (i, j), three variable model the matrix for country i would be a $\left(k_i + k_i^*\right) \times k$ (k is the sum of all k_i) matrix, in this case 6×6:

$$W_i = \begin{bmatrix} I_3 & 0 \\ 0 & w_j I_3 \end{bmatrix}$$

The model can then be written as:

$$Gx_t = a_0 + a_1 t + H_1 x_{t-1} + u_t$$

Where:

$$G = \begin{bmatrix} A_1 W_1 \\ A_2 W_2 \\ \vdots \\ A_N W_N \end{bmatrix}, \quad H_1 = \begin{bmatrix} B_1 W_1 \\ B_2 W_2 \\ \vdots \\ B_N W_N \end{bmatrix}, \quad a_0 = \begin{bmatrix} a_{1,0} \\ a_{2,0} \\ \vdots \\ a_{N,0} \end{bmatrix}, \quad a_1 = \begin{bmatrix} a_{1,1} \\ a_{2,1} \\ \vdots \\ a_{N,1} \end{bmatrix}, \quad u_t = \begin{bmatrix} u_{1,t} \\ u_{2,t} \\ \vdots \\ u_{N,t} \end{bmatrix}$$

Since G is of the dimension $k_i \times k$ known and nonsingular we can then rewrite the model as:

$$x_t = b_0 + b_1 t + F_1 x_{t-1} + v_t$$

$$\text{Where } b_0 = G^{-1}a_0, b_1 = G^{-1}a_1, F_1 = G^{-1}H_1$$

In this form it is possible to solve the function by recursive substitution which can be used to calculate the impulse response functions, which are presented below.

The dynamic analysis is performed using the generalized impulse response functions (GIRF) developed by Koop, Pesaran, Potter (1996) and further developed by Pesaran and Shine (1998). The logic behind the GIRFs is to be able to study the time profile of the future effects following a shock. The main advantaged of these functions compared to the orthogonalized Impulse Response Functions by Sims (1980) is that they do not depend on ordering of variables and countries (Galesi & Lombardi 2009).

Given the property of the functions it does not demand any a priori knowledge of the ordering based on economic theory, i.e. we do not have to make any assumptions of which countries affect each other. Although, this might be considered limiting in monetary policy analysis, GIRF have been used for analysis of monetary policy before. Also, due to time limitations and the required level of prior knowledge, calculations of orthogonalized impulse response functions in the framework of GVAR are beyond the scope of this thesis[4]. However, even if the GIRFs have some benefits one must be cautious when interpreting the outcome as they allow for correlation of the error terms i.e. the error terms are not orthogonal (Smith & Galesi 2011: 101).

The GIRF consisting of a one standard error global shock can be modeled as:

$$\psi(h, x : u_t^g) = E(x_{t+h} \mid u_{lt}^g = \sqrt{\sigma_{ii,\lambda\lambda}}, \Omega_{t-1}) - E(x_{t+h} \mid \Omega_{t-1})$$

Where Ω_{t-1} is information available at t-1and $\sigma_{ii,\lambda\lambda}$ is the diagonal elements from the variance-covariance matrix corresponding to equation λ for country i. This can be rewritten for the GVAR model scenario as:

$$\psi(0, x : u_t^g) = \frac{G^{-1}\sum_u a_1}{\sqrt{a_1'\sum_u a_1}}$$

Here a_1 is a selection vector with unity as the value for the λ^{th} element.

[4] See Sims (1980) and Pesaran Shin (1998) for further discussion on OIRF versus GIRF.

3.2 The Data

In the model we have $N + 1$ (10 countries in the global economy), indexed by $i = 1, 2, 3, \ldots, N$ and a sample period spanning over 13 years. The GVAR is estimated using quarterly data for 10 European countries which joined the EMU in 1999. These countries are: Austria (AUT), Belgium (BEL), Finland (FIN), France (FRA), Germany (GER), Ireland (IRL), Italy (ITA), the Netherlands (NED), Portugal (PRT) and Spain (ESP).

The data covers the period from the first quarter in 1999 (Q1) to the fourth in 2011 (Q4). The relatively limited time period may affect the robustness of our results, however, we made this trade-off due to the lack of data in some of the countries and to have a full panel system. Most importantly, before 1999 the countries did not have the same common monetary policy.

Drawing from the theory in section 2, we include two country-specific variables for each VARX constituting the GVAR model; the house price index (hpi_{it})[5] and disposable income (i_{it}). The global variable, common to all countries in the sample is the common interest rate (mir_t)[6].

The global variable, the mortgage rate constitutes of the interest rate collected by MFI interest rate statistics. These rates are compounded to be able to analyze the monetary transmission mechanism, as monetary policy is transmitted through the economy via the change in interest rates (ECB 2003: 8). MIR EA on loans to Euro area households for house purchases is one of the rates the monetary financial institutions (MFI) apply to Euro-denominated deposits and loans by households and non-financial corporations which are resident in the Euro area. Since the policy rate in EMU tends to keep steady, we found that the most suited variable available for the purpose of this thesis was the MIR EA on loans to Euro area households for house purchases. We argue that this rate can be seen as a foundation to a policy rate as the groundwork of a common economic area is that the price level in all countries should be equally affected by an increase (decrease) in the interest rate.

[5] The house price index is used as a proxy for demand.
[6] Appendix provides a more detailed description of the data and its sources.

To construct the foreign variables, a weight matrix is subsequently constructed in line with theory using trade-based weights. The weights are the product of average exports plus imports over the years 1999-2010[7] and divided by the total trade of a country in order to sum up to one, w_{ij} is the share of country j in the trade of country i. They are used as a proxy to reflect a specific country's share of the intra EMU trade, i.e. the individual unit's importance in the aggregate. Also, they can be an indicator of relative variability when there are signs of different degrees of cyclical fluctuations in the cross sections (Canova & Ciccarelli 2013: 40).

The weight matrix can also be constructed by different types of weights, for instance, Galesi & Lombardi (2009) uses the GDP shares of each country (the Purchasing Power Parity's adjusted GDP series (PPP-GDP) for each given country (2009: 14)). The weights are fixed over time in line with previous research (for example Galesi and Lombardi 2009), given that our sample is relatively short it will not be necessary to use time-varying weights.

As can be seen from the descriptive statistics in table one in appendix, the house price are relatively disperse between the different countries. The house price in Germany have not changed much over time whereas the house price in Ireland, France and Spain seems to be more volatile. The same pattern reoccurs when it comes to the real disposable income where Germany is found to be least volatile and Ireland is found to be most volatile. When looking at the Global variable, the mortgage rate, it is evident that the dispersion is relatively low.

[7] See appendix for weight matrix details

4 Estimation

The section below contains relevant information for specification of the econometric model. First, a presentation of the lag structure and the number of cointegrating variables is given. Secondly, we outline the presence of a unit root following the Augumented Dickey Fuller test and subsequently the Phillips-Perron test. Thirdly, verification of the hypothesis of weak exogeneity through an F-test is performed. Fourthly, we show the contemporaneous effects the foreign variable have on their domestic counterparts. Lastly, we present the Generalized Impulse Response Functions.

4.1 Specifying the Model

The global variable *(mir)* enters into each individual VARX model as endogenous[8], which allows for the global shock to affect all countries simultaneously when the dynamic analysis is performed.

The lag selection for country models are found in table two. These are based on minimizing the Schwartz Bayesian information criteria (SBC). SBC have proven to choose models with fever lags than Akaike Information Criteria (AIC) which is preferable with shorter time series. The maximum lag length is then chosen to two, this, partly as a result from data limitations and in line with other studies in the same research area.

The cointegration rank can be chosen on the basis of trace or max eigenvalue statistics. Trace test statistics is chosen over the maximum eigenvalue statistics as the Trace test is known to yield superior results when it comes to small samples (see Johansen 1992 and 1995, DdPS 2005 and also Pesaran, Shin and Smith 2000 for further discussion). The distribution of the test will depend on whether the

[8] This can be seen in contrast to the study by for example Vansteenkiste and Hiebert (2009)

coefficients on the deterministic trend are restricted or unrestricted and also whether there is an intercept included. In line with PSS (2000) discussion on case IV versus case III, we chose case IV i.e. unrestricted intercepts and restricted trends. The results for rank test statistics are reported in table two below at the 95% critical value level[9].

The number of cointegrating vectors can be found in table two and indicates that there are cointegrating relations in our sample. However, the results do not tell us which variables are integrated and we cannot positively say that there are a unique cointegrating relationship between them, this, we do not deem indispensable. However, the results indicate that there is more than one cointegrating vector for some countries. Furthermore, there is no academic consensus on whether one should only find one unique vector. Therefore we will continue on estimating the error correction models on the basis that the cointegrating vector used is valid.

4.2 Unit Root

To test for the presence of unit roots Augumented Dickey Fuller test (ADF) are performed on level, first difference and second difference. In table three, test for unit roots are presented for both the endogenous and the weak exogenous foreign variables. In line with Galesi & Lombardi (2009) and Vansteenkiste and Hiebert (2009) we found that the vast majority of the series are I(1). Some results indicates integration of order 2 which is the case in named studies aswell.

The Phillips-Perrons test for unit root is performed to give a second opinion on this result. The result indicates that most foreign variables are I(1) and estimation will henceforth be carried out on the assumption that all variables are integrated of order 1.

[9] For detailed results for the Trace statistics; see appendix Table 4.

4.3 Structural Breaks

Another possible problem in time series are structural breaks, which can affect the parameter estimates and error variance. The possibility of breaks are likely to be found due to the chosen variables. In this section the precense of structural breaks is investiagted by testing and complementary discussion of its effects for the GVAR model. The focus of this thesis lies within the monetary transmission effects and thus the structural stability of the long run parameters is not of particular interest. The emphasis hereafter will hence be on the short run parameters. Structural breaks in the error variances is taken into account by using heteroskedasticity-robust errors and the dynamic analysis by bootstrap means and confidence bounds for the impulse response functions.

Evidence of structural breaks is found in four cases when testing with Maximal OLS cumulative sum (CUSUM). Although these findings are somewhat troublesome it have been suggested that the GVAR model is more robust against structural breaks compared to reduced form single equation models. The thought behind this reasoning is that the individual models underlining the GVAR might be subject to breaks or changes at roughly the same time and as all variables enter into all VARX models. This concept is known as co-breaking and it is likely that this is the situation in present dataset due to the integration between the economies analyzed (DDPS 2005: 22-24).

4.4 Test for Weak Exogeneity

In order to perform the GVAR analysis the assumption of weak exogeneity must be fulfilled. The weak exogeneity in this context refers to the fact that there is no long run feedback from domestic variables to their foreign counterpart. However, the model allows for short term feedback through lagged values of foreign variables. This assumption implies that the error correction in the country specific model do not enter in the marginal model of the foreign variable (Vansteenkiste & Hiebert 2009: 11).

To verify the hypothesis of weak exogeneity for the foreign-specific variables we employ tests following the work of Johansen (1992) and Harbo et al,. (1998). The main assumption for estimation of the VARX models is weak exogeneity of the foreign variables

$$\Delta x^*_{it,l} = a_{il} + \sum_{j=1}^{r_i} \zeta_{ij,l} E\hat{C}M_{ij,t-1} + \sum_{k=1}^{s_i} \varphi'_{ik,l}\, \Delta x_{i,t-k} + \sum_{m=1}^{n_i} \psi'_{im,l}\, \Delta x^*_{i,t-m} + \eta_{it,l}$$

Where $E\hat{C}M_{ij,t-1}$, $j = 1,2,K\ ,r_i$ are the estimated error correction terms from the error correction model for country i. The term r_i is the number of cointegrating relationships, s_i and n_i are the lag orders for the domestic and foreign variables.

The test for weak exogeneity is an F statistics test with the null hypothesis $\zeta_{ij,l} = 0,\ j = 1,2, K\ , r_i$. The results are found in table six and indicate that all but one cannot be said to be significant at the 5% level. We thus assume that our foreign variables are weakly exogenous.

4.5 Contemporaneous Effects and Impact Elasticities

Thanks to the model set-up we are able to look at the contemporaneous effects the foreign variable have on their domestic counterparts. These results can be interpreted as impact elasticities which measure the effect in a domestic variable due to a 1 percent change in the corresponding foreign variable. High elasticities would imply strong co-movements between the foreign and domestic variables. This is particularly interesting in a GVAR framework where we want to examine how a specific variable act at the same time in different countries. Also, the model takes into account how a country-specific variable partly acts as domestic variable, but at the same time its foreign counterpart will also be subject to the same shock and subsequently affect the outcome of a simultaneous shock in the specific country. The results are provided in table five together with t-ratios computed based on White's heteroskedasticity-consistent variance matrices (Smith & Galesi 2009: 93).

If the estimates are not significant, this would imply that there are little or no co-movements in named variable across countries and that the dynamics are independent from internal movements in foreign countries. This would indicate that if countries are negatively affected by a rise in interest rate, this will not affect the other countries in the model.

When observing the house price index, several of the estimates are positive and significant. The highest values regarding house price index is found for Belgium, Ireland and Spain and whereas the lowest value found is for Austria (-0,300). However, it is not certain that this value is different from zero as the t-statistics is only (-0,577) and cannot be said do be statistically significant indicating the relationship explained above. We find significant results for eight out of 10 countries and when looking at the relationship for the income-variable; only for four countries. The significant results further reinsurance the choice of econometric model.

4.6 Generalized Impulse Response Functions

Following the more detailed discussion in section 4.1 on the fundaments of the generalized impulse response function we will now continue with presenting the subsequent results where the effect of a one standard error shock on expected values of x at time $t+h$ for $h=1,2,...,24$. Each GIRF demonstrate the dynamic response of each domestic variable to a standard error unit shock to the mortgage rate *(mir)* up to a limit of 24 periods (i.e. six years). A longer period is found not to be of necessity as we see no change in the series when extending the horizon. In addition, it seems highly likely that there are new shocks in the economy disregarding the initial shock even when restricting the period. The ECB concludes that in normal times the effect on output following an increase in the interest rate typically reaches its maximum between one and two years whereas prices will decline more unevenly over time. In addition the ECB stipulates that this relationship has not changed after the introduction of the common monetary policy (ECB 2011: 62).

The confidence intervals are constructed together with 90 percent error bounds. These significance levels are calculated using the bootstrap method with

1500 replications[10]. The bootstrapping procedure is similar to the Monte Carlo experiment. However, there is one main difference, where the MC method generates random variables from a given distribution, whereas in the bootstrap method the variables are drawn from their observed distribution and we end up with a distribution that is the best estimate of the actual distribution (Enders 2010: 263). Results can be found in the chapter 5: Results, figure two.

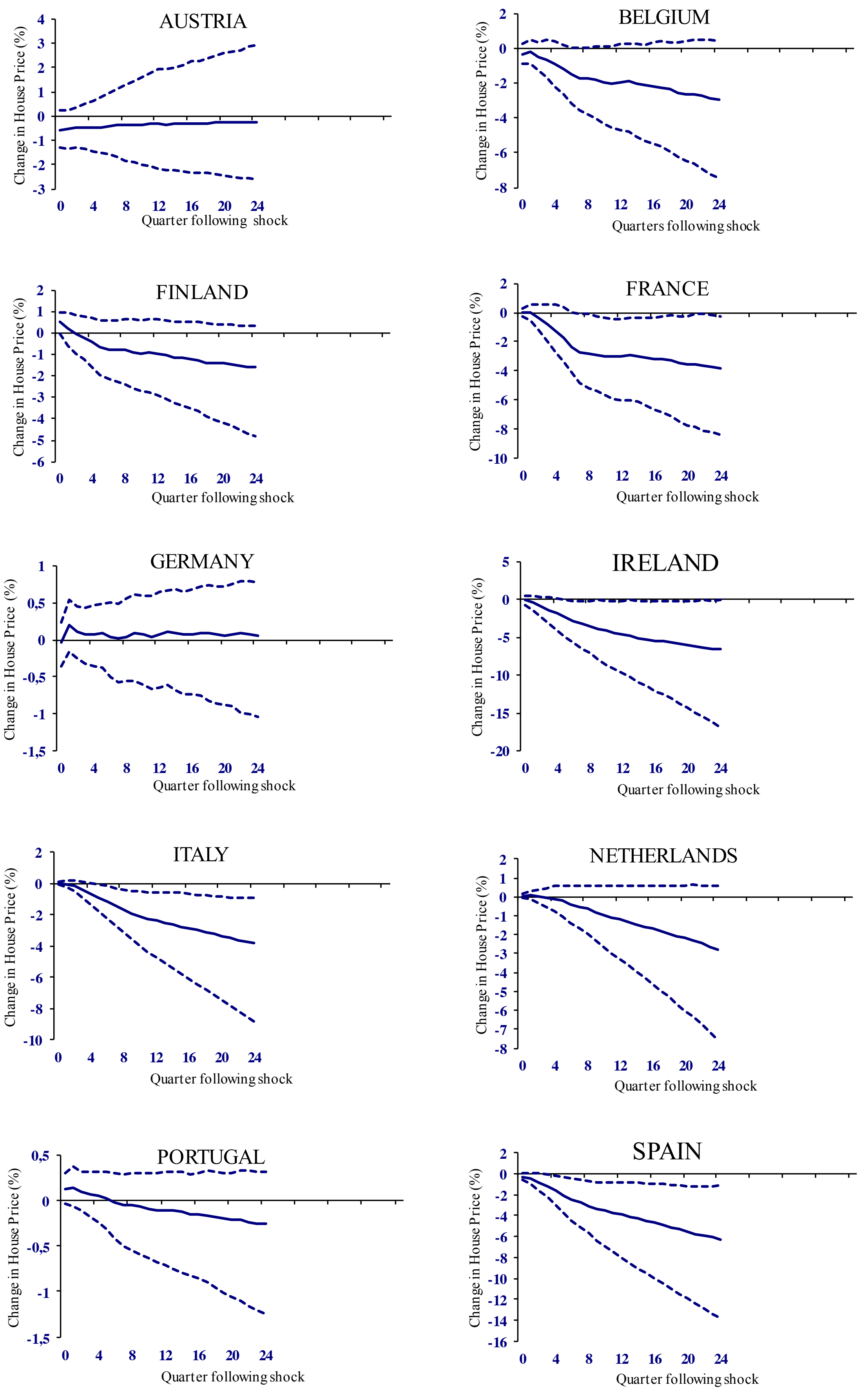
[10] The bootstrap procedure is a rather time consuming one. Therefore, the choice of bootstrap critical values was also due to computer limitations and lack of RAM memory as depending on shocks and horizon it may take several hours.

5 Results

The results from the generalized impulse response functions are found in the figure below. Presenting the results in alphabetical order, starting with Austria where the effect of a shock to the mortgage rate on the house price index is not significant; this is expected since the underlying series are relatively stable over time. Belgium shows a tendency of reacting negatively to the positive shock on the mortgage rate; however, it is not significant. Finland shows a similar negative result as Belgium and is neither significant. France reacts strongly during the first two years where after it stabilizes and becomes significant around the three percent level. Germany yields insignificant results as expected and a cyclical behavior which is likely due to an imaginary eigenvalue root. Ireland is significant after two years and around three percent. Italy shows significant results on the one percent level after one and a half year. The Netherlands shows no sign of being significant. Portugal is neither significant. Spain reacts rather intensely after a year and is trending downwards.

Figure 2. Generalized Impulse Responses of the Euro area house prices

A Positive Unit (1 s.e) Shock to the mortgage rate



5.1 Robustness Check

The GVAR model is presumed to be more robust to structural breaks than single equation models (DdPS 2005: 23). On the other hand, even in the absence of a structural break there may be reason to account for possible outliers which could possibly affect the results. Thereof, we take into account the financial crises outburst in 2007 and re-estimate the model, removing the period 2008Q1-2011Q4 to see if the results can be said to be qualitatively different. Model specification and dynamic analysis is performed following the same procedure as presented in above sections. Corresponding results from the generalized impulse response functions can be found in the appendix, leaving us with the subsequent complementary results.

In accordance with the underlying theory and the empirics, we would expect that when removing the crisis years the series would not be as volatile. This as a substantial part of the financial contraction was removed. However, there is no conclusive substantiation that the results differ when we remove the crisis years, leaving us with the same conclusions as above. Also, restricting the time period and removing almost a third of the observations may affect the result negatively and in fact worsen the robustness of the results.

As a second, alternative check to control for the robustness of our results, we remove Austria and Germany from the model, as they do not show any significant reaction to the shock. Hence, we compute a new weight matrix, foremost due to Germany's large share of the intra-European trade. The subsequent outcome indicates that we cannot say that results are qualitatively different from the original model specification. We can see from the confidence bands that the reaction to the shock is still not significant for all countries. Although, the results are more in line with the suggested theory as all countries now stabilize at a new lower level.

5.2 Discussion

Noteworthy is that the European house prices have not followed a common trend since the introduction of the common monetary policy, rather there have been large discrepancies between countries and no indication of convergence. Furthermore, when real estate prices rise too fast relative to the buyer's income this may be a signal that the value of housing may fall. In relation to rising mortgage rates and increased borrowing costs, this will have substantial impact both on the economy and the private households.

The above line of reasoning is consistent with the results from the generalized impulse response function. According to Mishkin (2007) demand for housing should be affected negatively by a shock to the mortgage rate. We find that the effect of a shock to the mortgage rate is not seen to be unison across countries. However, there are some indications of a pattern as some countries appear to be more affected by the unfolding financial crisis in Europe and hence react more to a shock in the mortgage rate. The relationship between some series is more pronounced and the GIRFs can hence be divided into three groups, where one reacts more. Spain and Ireland reacts strongly to the shock and show a mildly explosive reaction and show only vague signs of stabilizing after six years. The second group experience a similar house price fall, though not as intensely. Interestingly, there are also results indicating of a third type of reaction, or rather lack of reaction which converges towards zero after time. This lack of reaction may create difficulties for the policy makers i.e. ECB and the national central banks, since it is their main economic instrument.

In addition to the outcome of the monetary policy, we expected from the q-theory of housing that the positive shock to the mortgage rate would shift the demand curve for housing downwards in our sample and expected the GIRFs to show a distinct reaction and stabilize after time, whereas this only holds for a few countries. However, this seems well in line with the ECB policy, reasoning that prices do not stabilize as evenly as national accounts over time (ECB 2011: 62).

The general outcome, that most of the series do not show a significant result from a shock to the mortgage rate, might be an indication of other underlying factors playing a more significant role in the housing market in Europe. For instance, the countries' internal economic factors, such as productivity, the level of employment and market structures may have an impact of the demand for housing. Also, as the sample period covers the unfolding crisis in the Euro area, the results that are not significant can be an indication of how the housing market is affected in large by these external shocks and not as much by the monetary policy per se, rather a set of factors that the central banks do not have influence over.

Furthermore, it should be taken into consideration that some countries are more geographical linked and this could affect, and possibly skew the trade-weights. The Euro area has been enlarged by 10 countries and there are now 27 members of the European Union possibly changing the trade patterns of the area. However, as our weights are an average over the chosen period i.e. this should not considerably affect our results.

One possible structural factor behind our inconclusive results can be deduced to the fact that the proportion of owner-occupied housing is significantly lower in, for example Germany[11] than the proportion in the rest of Europe. Whereas in France, around 58 percent of households live in their own homes, while this rate is substantially higher in Spain around 83 percent and Italy around 69 percent (Herman & von Kalckreuth 2013). This may well be an indication of the European households not being as homogenous as the policymakers would like, showing different patterns when it comes to consumption, savings behavior and the distribution of wealth and debt.

To acknowledge this possible disturbance and the robustness of our results, we re-estimate the model to take the crisis and possible outliers into account. The result was somewhat ambiguous, indicating that the crisis may not be the underlying reason for the lack of homogenous, significant results. Though, when removing the countries showing the least reaction, the results were somewhat more distinct and the outcome of the model did in fact come close to what we expected from the theory.

To conclude, our results cannot completely be explained by chosen theory. However, the monetary transmission mechanism is a multifaceted complexity of

[11] western Germany (47.1%) versus eastern Germany (33.7%).

different economic interacting channels and there is, to our knowledge, no model that takes into account all different characteristics. Fiscal, prudential and structural policies are all components that will affect the demand for housing through their different indirect channels. However, even if it would be preferably to consider all transmission channels and evaluate the different aspects of the link between theory and empirics in relation to other econometrical models, this is beyond the scope of this thesis. Subsequently, the GVAR model was preferable for this study over variance models and fixed- and random effects models since it gives the authors the means to calculate impulse and response functions as well as taking spatial dependence into consideration.

6 Concluding Remarks

In this paper we have examined the impact of monetary policy on housing demand. This was studied using the Global Vector Autoregressive (GVAR) methodology with the help of Generalized Impulse Response Functions to regard the effect of a common external shock to the mortgage rate and the monetary transmission and impact on housing demand in ten Euro area countries.

Following a data set spanning from the introduction of the common monetary policy in 1999 to 2011, impulse response analysis reveals that a mortgage rate shock have on average a negative effect on house prices in the Euro area. However, this effect is far from uniform across countries. The results indicate that the Euro area countries in the sample do not react in the same way, or of the same magnitude from a shock to the interest rate. Though, the heterogeneity shown can be argued as not particularly strong since the majority of the countries still react to the shock although not all significantly.

Since the policy makers' main monetary transmission channel is through the interest rate, the dearth of reaction may create complications in the long run, making it harder to uphold price stability when there are factors outside the model affecting the demand for real estate in Europe. This gives us reason to question whether the monetary policy makers ought to focus on the housing market per se, or if other policy channels are more suited to steer the demand.

Finally, our results may be an indicator of that the explanatory power of structural factors may reflect a continued lack of integration on the Euro area mortgage markets. Future research and discussion should evolve around the difference between the countries financial systems e.g. what stance central banks' monetary policy should take when developments in house prices and lending appear untenable.

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8 Appendix

Description of Data

	Disposable income
Definition:	Real disposable income. Seasonal adjusted with x12 method. N.B. The data for Ireland was not conclusive and extended back.
Units:	Real
Source:	Data Stream/ Oxford Economics
	House Price Index
Definition:	Seasonal adjusted with x12 method.
Units:	Real Prices, Index 2005 = 100
Source:	Data Stream/ Oxford Economics
	Long-term interest rate: *MIR EA on loans to euro area households*
Definition:	The MIR EA on loans to euro area households was used as interest rate for house purchase for all 10 countries on quarterly basis for the period "*over five and up to ten years initial rate fixation* ". MFI interest rate statistics cover those interest rates that resident monetary financial institutions (MFIs, i.e. "credit institutions") apply to euro-denominated deposits and loans by households and non-financial corporations which are residents of the euro area. These harmonised statistics are used for the analysis of monetary developments and the monetary transmission mechanism as well as for the monitoring of financial stability. It excludes revolving loans and overdrafts, convenience and extended credit card debt. The data is distributed on monthly basis and we subsequently chose the middle value as a proxy for quarterly data. The statistics is used for analysis of monetary developments and the monetary transmission mechanism and for the monitoring of financial stability (http://www.ecb.int/stats/money/interest/interest/html/index.en.html) In a neoclassical framework, only long-term interest rates will affect the demand for housing. Therefore according to this view, it will not matter whether a household has a variable- or a fixed-rate mortgage. Consider a variable-rate mortgage, where the relevant interest rate in the user cost of capital will still be the long-term rate because it includes the expectations of the average variable rate over the period of homeownership (*Assenmacher-Wesche & Gerlach 2008: 18*). N.B. As there were no quarterly date before 2003, Eurostat series extended back using the long term interest rate.
Units:	Percent (%)
Source:	ECB Statistics

Table 1: Descriptive Statistics of Domestic and Global

	Mean	*Mean Growth*	*Max*	*Min*	*Std. dev.*
House Price Index					
Austria	103,43	0,53%	122,43	89,83	8,34
Belgium	103,49	1,92%	153,08	58,80	33,47
Finland	98,01	1,46%	132,07	60,71	22,36
France	98,83	1,82%	135,19	53,93	27,92
Germany	99,97	0,13%	105,75	96,09	1,74
Ireland	89,27	0,70%	129,72	48,42	23,99
Italy	95,59	1,21%	119,85	59,59	20,21
Netherlands	97,34	1,07%	114,94	60,44	14,39
Portugal	102,44	0,57%	113,13	83,60	7,75
Spain	91,15	1,57%	124,70	46,30	26,66
Real Disposable Income					
Austria	449,14	0,17%	477,69	421,13	18,93
Belgium	419,27	0,08%	440,26	398,51	10,83
Finland	386,49	0,57%	439,55	327,53	35,99
France	441,48	0,34%	489,56	398,89	22,94
Germany	443,41	0,16%	461,18	424,89	8,57
Ireland	443,83	0,47%	495,85	326,27	39,96
Italy	417,45	0,07%	447,98	367,22	16,80
Netherlands	401,02	0,08%	426,01	383,37	9,53
Portugal	260,02	0,12%	276,21	241,00	8,20
Spain	331,11	0,26%	357,98	278,86	19,11
Mortgage Rate					
Global	4,460	4,385	5,430	3,520	0,561

Table 2. VARX Order of Individual Models

p: lag order of domestic variables, q: lag order of foreign variables. Lag lenght based on Schwartz Bayesian information criteria (SBC).

Country	*pi*	*qi*	*Number of Cointingrating Relations*
Austria	1	1	1
Belgium	1	1	1
Finland	1	1	1
France	2	1	2
Germany	1	1	1
Ireland	1	1	2
Italy	2	1	2
Netherlands	1	1	2
Portugal	1	1	1
Spain	1	1	2

Table 3. Test for unit root

Unit Root Tests for the Domestic Variables at the 5% Significance Level. Statistics are based on ADF from the sample period 1999Q1-2011Q4 with p ≤ 5 using Schwatz Bayesian information criteria. Test statistics are based on regression including trend och intercept. Unit Root Tests for the Foreign Variables at the 5% Significance Level. Statistics are based on Im-Pesaran-Shin from the sample period 1999Q1-2011Q4 with p ≤ 5 using Schwatz Bayesian information criteria. Test statistics are based on regression including trend and intercept. The critical values are -3,45 and -2,89 for differences.

Country	*GLOBAL*	*AUT*	*BEL*	*FIN*	*FRA*	*GER*	*IRL*	*ITA*	*NED*	*PRT*	*ESP*
hpi		-1,01	-1,70	-0,88	-0,17	-1,94	-2,12	-0,63	-0,54	-3,23	-0,14
Δhpi		-13,52	-3,90	-6,34	-3,26	-6,55	-7,13	-1,95	-2,99	-3,32	-2,01
Δ^2hpi		-5,85	-7,71	-8,07	-2,99	-10,55	-7,30	-4,79	-6,12	-6,10	-3,12
i		-0,52	-2,97	-1,90	-1,50	-1,55	-2,58	-0,48	-2,44	-2,95	0,41
Δi		-4,79	-2,32	-5,42	-3,29	-5,61	-6,82	-2,91	-5,84	-7,44	-4,15
Δ^2i		-7,04	-9,22	-7,75	-7,76	-7,33	-7,66	-8,67	-7,42	-5,63	-6,78
hpis*		3,71	3,48	3,30	2,98	3,58	3,28	3,10	3,07	4,16	2,97
Δhpis*		-7,48	-10,34	-10,43	-11,62	-10,34	-12,27	-12,22	-11,31	-11,25	-12,15
Δ^2hpi*		-23,86	-22,97	-22,84	-24,90	-21,79	-18,94	-23,15	-21,58	-22,17	-24,77
is		1,11	1,26	1,00	0,72	1,47	0,26	0,68	1,22	1,22	-0,72
$\Delta$is*		-20,05	-19,75	-17,21	-19,12	-17,21	-17,90	-19,86	-16,86	-13,76	-16,63
Δ^2i*		-23,73	-23,12	-23,69	-23,80	-24,02	-24,02	-23,44	-23,89	-24,68	-19,17
mir	-2,74										
Δmir	-5,16										
Δ^2mir	-6,82										
PHILLIPS-PERRON											
hpis*		-1,62	-0,41	-0,49	0,12	-0,01	-0,61	-0,68	-1,12	0,27	-0,69
Δhpis*		-6,10	-4,56	-5,42	-5,11	-4,29	-5,22	-4,70	-5,62	-3,38	-4,37
Δ^2hpi*		-16,88	-15,24	-16,23	-17,35	-29,54	-20,58	-15,90	-19,20	-10,42	-14,21
is*		3,86	-2,44	-2,29	-0,93	-1,16	-2,02	-2,71	-2,53	-2,36	-3,97
$\Delta$is*		-11,47	-10,54	-9,86	-9,37	-8,98	-8,44	-10,19	-9,79	-11,20	-13,06
Δ^2i*		-20,99	-21,72	-20,11	-17,19	-16,68	-19,79	-22,38	-21,93	-24,14	-13,54

Table 4. Cointegration Rank Statistics

Detailed Cointegration Results for the Trace Statistic at the 5% Significance Level

Country	*# endogenous variables*	*# foreign (star) variables*	*r=0*	*r=1*	*r=2*
Austria	3	2	85,85	35,06	4,64
Belgium	3	2	78,25	25,65	10,37
Finland	3	2	61,59	24,35	10,23
France	3	2	82,80	27,87	10,67
Germany	3	2	65,78	27,92	7,80
Ireland	3	2	87,41	41,07	11,88
Italy	3	2	120,78	50,70	11,99
Netherlands	3	2	136,21	40,06	14,74
Portugal	3	2	90,70	28,77	7,22
Spain	3	2	86,30	46,71	10,13

Critical Values for Trace Statistic at the 5% Significance Level (MacKinnon, Haug, Michelis, 1999)

Country	*# endogenous variables*	*# foreign (star) variables*	*r=0*	*r=1*	*r=2*
Austria	3	2	57,45	36,09	18,26
Belgium	3	2	57,45	36,09	18,26
Finland	3	2	57,45	36,09	18,26
France	3	2	57,45	36,09	18,26
Germany	3	2	57,45	36,09	18,26
Ireland	3	2	57,45	36,09	18,26
Italy	3	2	57,45	36,09	18,26
Netherlands	3	2	57,45	36,09	18,26
Portugal	3	2	57,45	36,09	18,26
Spain	3	2	57,45	36,09	18,26

Table 5. Contemporaneous Effects of Foreign Variables on Domestic Counterparts

Robust t-ratios, computed using White's heteroscedasticity-consistent variance estimator

		hpi	*i*
Austria	Coefficient	-0,300	-0,258
	Standard error	0,491	0,009
	t-Ratio	-0,577	-2,880
Belgium	Coefficient	1,413	-0,245
	Standard error	0,338	0,075
	t-Ratio	2,698	-2,811
Finland	Coefficient	0,760	-0,020
	Standard error	0,245	0,154
	t-Ratio	3,347	-0,147
France	Coefficient	0,524	1,016
	Standard error	0,150	0,243
	t-Ratio	2,857	5,327
Germany	Coefficient	0,294	0,049
	Standard error	0,118	0,064
	t-Ratio	2,894	0,924
Ireland	Coefficient	0,935	0,217
	Standard error	0,247	0,346
	t-Ratio	2,558	0,455
Italy	Coefficient	0,030	1,397
	Standard error	0,044	0,227
	t-Ratio	0,780	5,762
Netherlands	Coefficient	0,307	0,391
	Standard error	0,058	0,253
	t-Ratio	3,303	1,322
Portugal	Coefficient	0,174	0,052
	Standard error	0,058	0,025
	t-Ratio	3,303	1,322
Spain	Coefficient	0,925	0,167
	Standard error	0,167	0,178
	t-Ratio	6,988	1,168

Table 6. F-Statistics for testing the weak exogeneity of the foregin variables.

Based on a model containing unrestricted intercepts and restricted trend coefficients with I(1) endogenous varaibles on the 5% Significance Level

Country	*F test*	*Fcrit 0.05*	*hpis*	*is*
AUT	F(1,42)	4,073	1,625	3,854
BEL	F(1,42)	4,073	1,559	2,278
FIN	F(1,42)	4,073	0,100	0,388
FR	F(2,38)	3,245	1,691	2,040
GER	F(1,42)	4,073	0,647	0,580
IRL	F(2,41)	3,226	1,536	0,203
ITA	F(2,38)	3,245	0,929	1,613
NED	F(2,41)	3,226	0,642	0,249
PRT	F(1,42)	4,073	0,175	1,119
ESP	F(2,41)	3,226	1,303	4,149

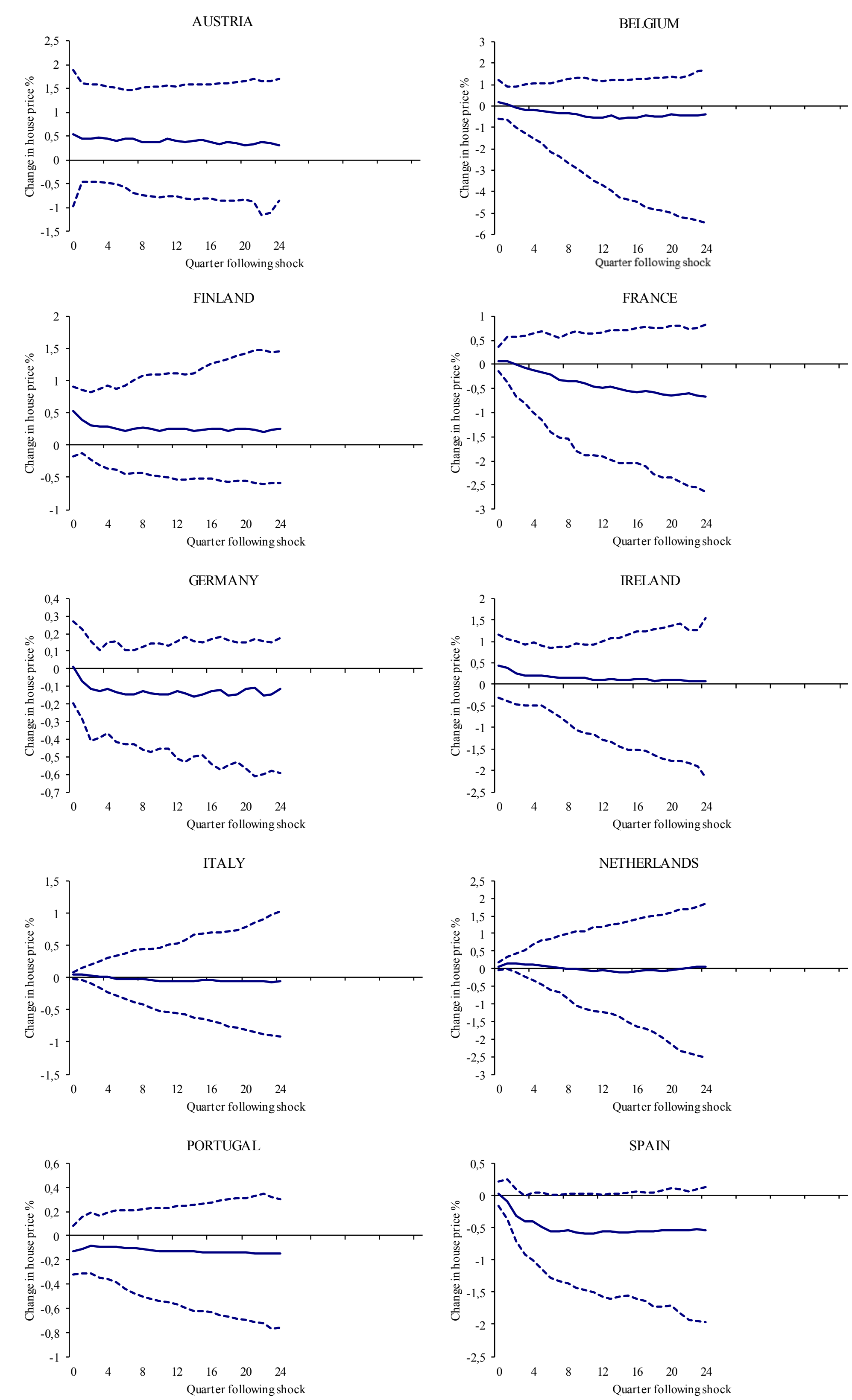
Trade weights

Source: The World bank Wolrd Integrated Trade Solution (WITS) - The UN COMTRADE data on exports and imports by commodity and partner country

Country	AUT	BEL	FIN	FRA	GER	IRL	ITA	NED	PRT	ESP
AUSTRIA	0	0,0138	0,0294	0,0193	0,1221	0,0124	0,0556	0,0200	0,0099	0,0170
BELGIUM	0,0293	0	0,0770	0,1575	0,1248	0,2601	0,0786	0,2130	0,0469	0,0550
FINLAND	0,0113	0,0102	0	0,0120	0,0256	0,0144	0,0124	0,0209	0,0082	0,0102
FRANCE	0,0692	0,2448	0,1246	0	0,2392	0,1605	0,2486	0,1461	0,1565	0,3017
GERMANY	0,6583	0,3065	0,4046	0,3292	0	0,2407	0,3501	0,4273	0,2080	0,2521
IRELAND	0,0088	0,0479	0,0232	0,0250	0,0341	0	0,0185	0,0233	0,0107	0,0211
ITALY	0,1362	0,0721	0,1066	0,1797	0,1625	0,0960	0	0,0806	0,0785	0,1621
NETHERLANDS	0,0435	0,2482	0,1531	0,0882	0,1757	0,1266	0,0913	0	0,0641	0,0712
PORTUGAL	0,0073	0,0099	0,0160	0,0234	0,0203	0,0113	0,0182	0,0118	0	0,1095
SPAIN	0,0360	0,0466	0,0654	0,1656	0,0955	0,0780	0,1268	0,0570	0,4172	0

Generalized Impulse Responses of the Euro area house prices - excluding the crisis years

A positive unit (1 s.e.) shock to the mortgage rate



Generalized Impulse Responses of the Euro area house prices - excluding Austria and Germany

A positive unit (1 s.e.) shock to the mortgage rate