UNIVERZITA KARLOVA V PRAZE

FAKULTA SOCIÁLNÍCH VĚD

Institut ekonomických studií

Ondřej Tobek

Was improper monetary policy the cause of real estate bubbles in Eurozone peripheral countries? Implications for future policy

Bakalářská práce

Praha 2014

Autor práce: **Ondřej Tobek**

Vedoucí práce: **PhDr. Mgr. Michal Hlaváček, Ph.D.**

Rok obhajoby: **2014**

Rozsah: **72 000 znaků**

Bibliografický záznam

Tobek, Ondřej (2014). *Was improper monetary policy the cause of real estate bubbles in Eurozone peripheral countries? Implications for future policy.* Bakalářská práce. Univerzita Karlova, Fakulta sociálních věd, Institut ekonomických studií. 48 s.

Abstract

This study is concerned with two interconnected issues. First, the suitability of interest rate chosen by ECB is assessed in individual Eurozone countries using seven versions of Taylor rule. The methodology primarily emphasizes robustness by employment of various measures of inflation and output gap. The policy rates were found to be too low in all Eurozone's peripheral countries for prolonged period of time. Second, the sensitivity of real estate prices to a change in interest rate in Greece, Ireland, Italy, Portugal, Spain and UK is estimated using VAR, VECM, BVAR and Panel VAR. The prime concern is whether the low policy rates can be the cause of housing bubbles. The housing prices respond most vividly to interest rate in Ireland, Spain and UK (approximately 3.5% increase in the price as a response to 1% decrease in interest rate) which are also the countries where flexible interest rate mortgages are dominant. Monetary policy is shown to be an important determinant of housing prices but it is not the sole reason for the bubbles.

Keywords

Monetary policy, ECB, interest rate, real estate, Greece, Ireland, Italy, Portugal, Spain, UK, VAR, BVAR, PVAR, VECM

Abstrakt

Nejprve je vhodnost úrokové míry nastavené ECB hodnocena v jednotlivých zemích Eurozóny pomocí sedmi verzí Taylorova pravidla. Zvolená metodologie je zaměřena především na robustnost použitím různých měr výstupové mezery a inflace. Úrokové míry zvolené ECB byly identifikovány jako příliš nízké ve všech periferních zemích Eurozóny po mnoho let. Následně se studie zabývá citlivostí cen nemovitostí na úrokovou míru v Řecku, Irsku, Itálii, Velké Británii, Portugalsku a Španělsku, která je odhadnuta pomocí VAR, VECM, BVAR a Panel VAR. Hlavním záměrem je určit, jestli nízké úrokové míry mohly stát za realitními bublinami. Ceny nemovitostí reagovaly na úrokovou míru nejprudčeji v Irsku, Španělsku a Velké Británii (jako reakci na zvýšení úrokové míry o 1% odpovídá zhruba 3.5% zvýšení ceny nemovitostí), což jsou také země, kde je největší podíl hypoték s variabilní úrokovou mírou. Monetární politika se ukázala jako důležitý faktor působící na ceny nemovitostí, ale nemůže být označena za jediný důvod tvorby bublin.

Klíčová slova

Monetární politika, ECB, úroková míra, nemovitosti, Španělsko, Irsko, Řecko, Itálie, Velká Británie, VAR, VECM, BVAR, PVAR

Prohlášení

1. Prohlašuji, že jsem předkládanou práci zpracoval/a samostatně a použil/a jen uvedené prameny a literaturu.
2. Prohlašuji, že práce nebyla využita k získání jiného titulu.
3. Souhlasím s tím, aby práce byla zpřístupněna pro studijní a výzkumné účely.

V Praze dne 15.5.2014 Ondřej Tobek

Poděkování

Rád bych poděkoval PhDr. Michalu Hlaváčkovi, Ph.D. za jeho ochotu, čas, odborné rady a inspiraci při vedení této práce.

Institut ekonomických studií
Projekt bakalářské práce

Název v anglickém jazyce:	Was improper monetary policy the cause of real estate bubbles in Eurozone peripheral countries? Implications for future policy
Klíčová slova:	monetární politika, ECB, úroková míra, nemovitosti, Španělsko, Irsko,VAR
Klíčová slova anglicky:	monetary policy, ECB, interest rate, real estate, Spain, Ireland, VAR
Akademický rok vypsání	2012/2013
Typ práce:	bakalářská práce
Jazyk práce:	angličtina
Ústav:	institut ekonomických studií (23-IES)
Vedoucí / školitel:	PhDr. Michal Hlaváček, Ph.D.
Řešitel:	Ondřej Tobek - zadáno vedoucím/školitelem
Datum přihlášení:	07.03.2013
Datum zadání:	07.03.2013

Seznam odborné literatury

Dokko, Jane K., Doyle, Brian M., Kiley, Michael T., Kim, Jinill, Sherlund, Shane M., Sim, Jae and Van den Heuvel, Skander (2011) “Monetary Policy and the Global Housing Bubble,” Economic Policy, Vol. 26, No. 66, pp. 233-283, Available at SSRN: http://ssrn.com/abstract=1801026 or http://dx.doi.org/10.1111/j.1468-0327.2011.00262.x

Ahrend, Rudiger, Cournede, Boris and Price, Robert (2008) “Monetary Policy, Market Excesses and Financial Turmoil,” OECD Economics Working Paper No. (2008)5. Available at SSRN: http://ssrn.com/abstract=1302789 or http://dx.doi.org/10.2139/ssrn.1302789

Berlemann, Michael & Freese, Julia (2010) "Monetary Policy and Real Estate Prices: A Disaggregated Analysis for Switzerland," Working Paper 105/2010, Helmut Schmidt University, Hamburg.

Taylor, John B. (1993) "Discretion versus policy rules in practice," Carnegie-Rochester Conference Series on Public Policy, Elsevier, vol. 39(1), pages 195-214, December.

Taylor, John B. (2009) “The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong,” Rock Center for Corporate Governance Working Paper No. 30; NBER Working Paper No. w14631 . Available at SSRN: http://ssrn.com/abstract=1341170 or http://dx.doi.org/10.2139/ssrn.1341170

Cihák, Martin, Iossifov, Plamen K. and Shanghavi, Amar (2008) “Interest Rate Elasticity of Residential Housing Prices,” IMF Working Papers, Vol. , pp. 1-32, 2008. Available at SSRN: http://ssrn.com/abstract=1316715

Předběžná náplň práce

Nejprve je určena senzitivita cen nemovitostí na změny v úrokové míře pomocí VAR. Vhodnost monetární politiky ECB v periferních zemích eurozóny je hodnocena porovnáním skutečných úrokových měr a úrokových měr, které by odpovídaly Taylorovu pravidlu. Použitím rozdílu mezi úrokovými mírami a senzitivitou cen nemovitostí se snažíme odhadnout, jak by se vyvíjely ceny při optimální úrokové míře v jednotlivých zemích. Dále je odhalen vztah mezi krátkodobou úrokovou mírou a hlavními ekonomickými indikátory pomocí VAR. Nakonec jsou odhadnuty náklady na boj s rostoucími cenami nemovitostí pomocí monetární politiky a porovnány s možnými zisky, z toho jsou vyvozeny implikace pro budoucí politiku.

Předběžná náplň práce v anglickém jazyce

At first the sensitivity of real estate prices to a change in interest rate is estimated using VAR. Optimality of monetary policy of ECB in Eurozone countries is assessed by comparison of actual interest rate and interest rate suggested by Taylor rule. Using the difference of interest rates and the sensitivity of real estate prices we try to estimate how the prices would behave under optimal policy for each country. Next the relation between interest rate and key economic variables is established by VAR. Finally the costs of fighting with rising real estate prices by monetary policy is estimated and compared to potential gains. Policy implications are drawn.

V Praze dne 7.5.2013

Contents

1 INTRODUCTION

In economics it is customary for new phenomena to be put under scrutiny only after they have risen to awareness through a crisis of some sort, this work is not an exception to this rule. The financial crisis of 2008, followed by a sovereign debt crisis in some Eurozone countries, was accompanied, perhaps even triggered, by housing bubble. The housing bubble was not present only in America, but also in many European countries – UK, Ireland and Spain to name a few. There are always many factors contributing to asset booms. One did, however, stand above others because of recent structural developments – monetary policy. There were many critics of FED for keeping the interest rates too low for too long even before the financial crisis erupted. Taylor (2007) suggests that improper monetary policy was the cause of housing prices boom in 2003-2006 in the US market.

Much of the literature is focused on the developments in USA, but the similar situation in Eurozone is often neglected. Fixing of exchange rate mechanism and the adoption of common currency has led to one common interest rate throughout the group of heterogeneous countries, an interest rate that was unprecedentedly low for countries in Eurozone's periphery. This warrants serious questions: Could it be that introduction of Euro has contributed to or even caused the housing booms in some countries? Is it true that converging countries with high inflation faced lower real interest rates and thus were more vulnerable to bubbles?

Studies that try to judge the suitability of monetary policy often use Taylor rule as a benchmark for interest rate. I also adhere to this methodology in this work as it allows quantifiable result. While performing the analysis I employ various versions of Taylor rule and also various measures for inflation and output gap. The unique aspect of this thesis is the use of wider sample of Eurozone countries than in any other study to my knowledge. As a method to insulate the role of monetary policy on housing prices VAR was chosen; a method widely adopted by other studies.

The thesis is structured as follows. There are two large sections; the first is concerned with monetary policy in Eurozone. There I try to determine whether the policy was well fitted for all Eurozone countries or whether there were some countries where interest rate deviated severely from ideal rate. Second section builds on these findings and tries to show how they influenced the developments of housing prices. This section includes general overview of housing market, literature review and empirical analysis itself.

2 MONETARY POLICY IN EUROZONE COUNTRIES

An introduction of common currency in Europe caused unprecedented changes in economies of participating countries. The once diverse economies with different interest rates, inflation, growth rates and business cycles were forced to converge by exogenous choice of governments and subsequent arbitrage opportunity in markets if they did not. This has meant a sharp drop in inflation and nominal interest rates in peripheral countries such as Spain or Ireland where high values, a status quo, were breached by a need to satisfy Maastricht criteria and ensuing outsourcing of monetary policy to more credible institution with different policy targets.

One difficulty the common currency brings is the loss of differentiable monetary policy in each country. Impossible trinity dictates that there can be only two of following at the same time: independent monetary policy, free capital flow and fixed exchange rate. When sovereign states entered Eurozone they effectively established a regime of fixed exchange rate and one of the four fundamental freedoms in Eurozone is free flow of goods and capital. This in turn makes a choice of optimal monetary policy for all member states untenable. In this section of the thesis I will try to determine how the common monetary policy in Eurozone fared in the last decade. That is, whether it was too loose in some countries or too tight in others. I will put most focus on peripheral countries as their housing market is later further analyzed. The list of countries includes Spain, Portugal, Greece, Ireland and Italy.

The above mentioned circumstances are well documented in literature. Aspachs-Bracons and Rabanal (2011) suggest that since Spain lacks its own monetary policy, it cannot be used as the first line of defense while responding to negative sector and country specific shocks. It means that the large decline in interest rates during the convergence to and adoption of euro (1996-2007) could not be addressed by standard policy tools. It could well contribute to increased residential investment and house price growth rates.

This section first starts with presentation of the basic needed theoretical underpinnings. Then, after the literature is reviewed, my analysis can finally follow.

2.1 THEORETICAL CONCEPTS

2.1.1 Taylor rule

Taylor (1993) proposed a simple versatile mechanical rule for monetary policy:

$$\boldsymbol{r_T} = \boldsymbol{\pi} + \boldsymbol{r}^* + \sigma(\boldsymbol{\pi} - \boldsymbol{\pi}^*) + \mu(\mathbf{y} - \mathbf{y}^*) \quad (1)$$

where $\boldsymbol{r_T}$ is a proposed optimal real interest rate, $\boldsymbol{\pi}$ rate of inflation over the previous four quarters – Taylor uses GDP deflator in his original paper –, $\boldsymbol{\pi}^*$ inflation target, $\mathbf{y} - \mathbf{y}^*$ is output gap – the difference between current real GDP and its long term trend –, and $\boldsymbol{r}^*$ is a real equilibrium interest rate.

The rule offers large flexibility. The importance between attaining GDP growth and price stability targets can be shifted by choosing σ and μ parameters. In the original article Taylor proposed σ, μ = 0.5 based on data from US economy. An extensive literature on policy rules has suggested a range of alternative coefficients. Other authors have proposed larger weight on output gap by setting μ equal to 1 (Taylor [1999]). Although the rule is simple, it can cover much of policy response function variation. Taylor (1998) concludes from his analysis that rules with only two factors – a nominal factor like the inflation rate and a real factor like real GDP – come very close to the fully optimal rule, which would include all possible variables in the model.

Sometime exchange rate parameter is added to the rule to cope with the changes in foreign trade. Taylor (1998) asserts that it is effective mostly only in small open economies. Such a rule for the ECB can improve performance in some countries, however, the differences with respect to two factor model are fairly small and neither rule strictly dominates the other according to his models. Another possible extension is a reaction to cyclical component of real estate prices (housing bubbles). Eurozone is, however, very diversified in this respect with no to little price growth in core countries but abrupt changes in periphery. The economies of countries where these abrupt changes occurred are too small with respect to whole Eurozone for ECB to set policy according to them. Including this variable would probably just result into spurious regression problems given small sample size.

The parameters that are hardest to measure are real equilibrium interest rate and output gap as these two variables are not observable, and estimates can be challenged (Ahrend et al. [2008]). Taylor (1993) proposes the equilibrium interest rate to be 2 – close to assumed steady state growth rate 2.2%. Gerlach and Schnabel (2000), while applying Taylor rule in the EMU countries in 1990–98, use a weighted average of ex post real interest rates. Specifically, they calculate the average realized real interest rate — computed as the three-month nominal interest rate minus the rate of CPI inflation over the past year — over the period 1982–97. They further use classical OLS regression of real interest rate on currency depreciation because the studied period was a turbulent time in foreign exchange markets for some countries. This is not needed in my analysis because I only cover period where exchange rates are already fixed. Ahrend et al. (2008) think that it is likely, and it is supported by evidence for some countries, that real neutral rates have been time-variant, and may have come down somewhat over recent decades.

2.2 LITERATURE REVIEW

Hayo (2006) tries to answer the question whether interest rate paths in the current member countries of EMU would differ from that chosen by ECB had they not given up their independence. To do this he estimates monetary policy reaction functions of individual central banks over the 20 years preceding the formation of EMU using General Method of Moments (GMM). The form of response functions is similar to Taylor (1993) but uses expected one-year-ahead inflation rate. These functions are next used to derive simulations of counterfactual interest rate paths over the time period from January 1999 to December 2004, which are in turn compared to actual interest rates. He finds that: "for almost all EMU member countries euro area interest rates tend to be below the national target interest rates, even after explicitly accounting for a lower real interest rate in the EMU period, with Germany being the only exception." The analysis is not flawless, even the author admits that the estimations are sometimes not robust or even plausible. Indeed in Ireland, Portugal and Greece the proposed interest rate targets are as high as 20% above observed rates. That is, the analysis is almost useless in the countries I am most interested in. It could be attributed to unprecedented stabilization of economies following the introduction of common currencies. Estimation of reaction functions based on past data and its interpolation into the future is therefore not of much use in my analysis.

Gerlach & Schnabel (2000) demonstrate that average interest rates in the EMU countries in 1990–98 copied very closely trajectory suggested by the Taylor rule via average output gaps and inflation. Seyfried (2010) examines the impact of monetary policy on housing prices in various European countries and USA in recent years. Using Taylor's rule as a benchmark, the ECB policy was found to be appropriate or slightly restrictive for France and

Germany, but too loose for Ireland and Spain. Dokko et al. (2009) found that many central banks in OECD countries were “too loose” relative to what the policy rule would imply. This difference was, however, usually very small and some foreign countries were at times even above, what the rule would imply. This disparity is further weakened when one takes into account the effect of real-time measurement, the choice of price index, and the parameterization of the policy rule.

Critics

Gerlach-Kristen (2003) argues that the works using Taylor rule in Eurozone have ignored the non-stationarity of the data. She then shows that traditional Taylor rules display signs of instability and appear mis-specified for euro area data over the period 1988 to 2002. To derive this, she uses vector error-correction (VECM) technique. It is, however, not very useful in my case as it focuses solely on optimal policy responses in immediate time rather than ex-post analysis and comparability across countries.

Bernanke (2010) offers some critics of over-relying on simple Taylor rule. His argument is that monetary policy works with a lag, effective monetary policy must therefore consider the forecast values of economic variables, not their current ones. Policymakers respond less to temporarily elevated inflation than to increases that are thought to be long-lasting. Standard Taylor rule, however, makes no similar distinction. Predictions from a Taylor rule accustomed to these consideration changes only little. In Bernanke (2010) this means a 1 percent lower interest rate target, a rate that is still above the observed values. In this work, I deal only with much more severe dislocations from the rule. These propositions are not, in turn, alone enough to explain the observed deviations.

2.3 ANALYSIS

One way to approach the comparison is by estimation of policy reaction functions before the introduction of common currency and using it on data after. This is not very useful in peripheral countries of Eurozone - see my critics of Hayo (2006) above. Next, one can estimate reaction functions in core countries, Germany for example, and apply it in others. As will be evident from the results, these reaction functions would be fairly similar to the ones I am using because my estimated target rates fit the data rather well in these countries. I have instead chosen to employ as many different measures of used variables as possible in the standard Taylor rule model. I will show that even this can cause large fluctuations in results while maintaining as robust approach as possible.

2.3.1 Data

My sample of selected countries in Eurozone includes those that are in periphery as well as those in the core. That is: Germany, France, Netherlands, Italy, Ireland, Portugal, Greece, and Spain. United Kingdom is also included for sake of comparison because it is an example of a country that experienced housing bubble but did not have improper monetary policy.

The main source of data was OECD Economic Outlook No. 93 database – harmonized consumer price index (HCPI), GDP deflator, core CPI, real GDP, output gap, short-term (3M) and long-term (10Y bonds) interest rate. Real GDP in Greece was not complete; data from Eurostat were therefore adopted instead. In all countries, except for UK, ECB Marginal lending rate is used; computed as average in a given quarter from ECB database data. For UK I use quarterly Official Bank rate directly from Bank of England database.

2.3.2 Models

In the case of Eurozone, the larger weight should be given to deviation from inflation target because it is the main stated objective of the European Central Bank. As written in Article 127(1) of the Treaty on the Functioning of the European Union: "The primary objective of the European System of Central Banks shall be to maintain price stability." Sheller (2006, p. 81) suggests that in October 1998 the Governing Council of the ECB explained price stability as "a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the euro area of below 2%" and added that price stability "was to be maintained over the medium term". The council confirmed this definition in May 2003 and clarified that "in the pursuit of price stability, it aims to maintain inflation rates below but close to 2% over the medium term". I therefore use 1.9% inflation as a target for ECB, a value commonly applied in the reviewed studies. Where needed, it is assumed that central banks pursued the same inflation objectives in past as they do today.

ECB explicitly states that it uses HICP in monetary policy considerations. I will therefore primarily treat it as a measure of inflation in Taylor rule. For the sake of comparison, results with GDP deflator are also included.

The ECB has no official method to compute potential output; it rather chooses methods according to the policy areas. European Commission utilizes production function approach for country assessments (Cotis et al. [2004]). For this reason I have included output gap based on structural model from OECD Outlook 93 (the methodology is clarified in Johansson et. al. [2013]). It is available only as annual series; to transform it into quarterly data Cubic Spline

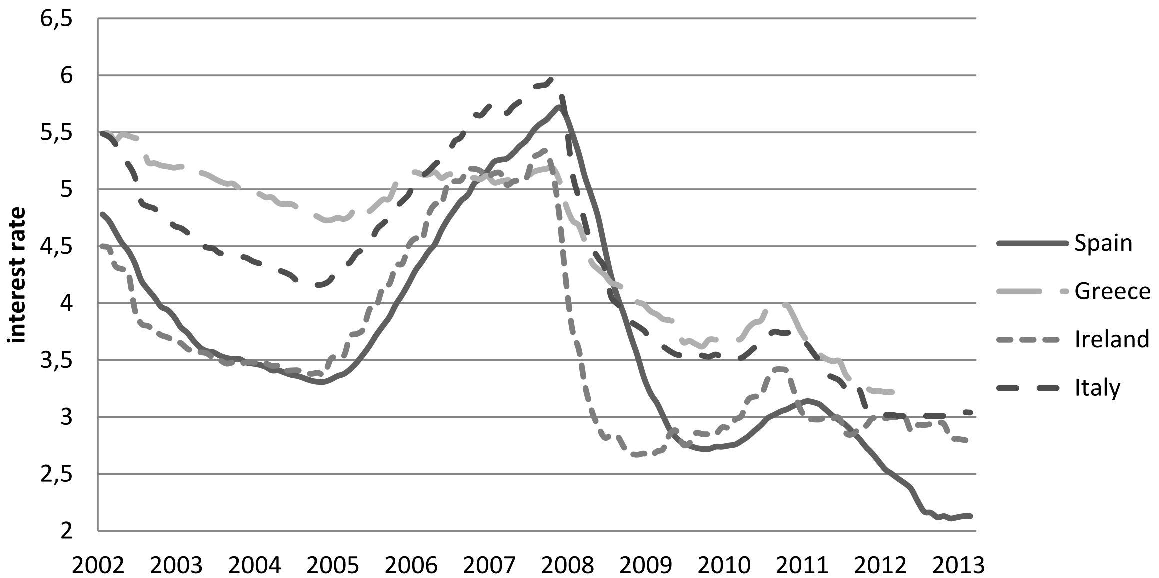
Interpolation in Stata was applied. Furthermore, output gaps were also estimated with Baxter-King (BK) and Hodrick-Prescott (HP) filters. For HP standard coefficient for quarterly series – 1600 – were utilized. This value is quite arbitrary as Giorno et al. (1995, p. 9) write: “Later, Prescott and Kydland (1990) justified their choice of λ as producing a trend that most closely corresponded to the line that students would fit through GDP by hand and eye.” There is no rule (and there even cannot be) how to choose this coefficient but the value 1600 became “industry standard”. In Baxter-King filter the authors’ recommend setting of 6 and 32 quarters (1.5–8 years) was adopted.

Table 1: used real interest rate

Greece	Portugal	Spain	Ireland	Italy	Germany	France	UK	Netherlands
1.27	1.46	1.73	1.65	2.31	2.1	2.18	2.1	1.68

The estimation of real interest rate was done by averaging ex-post real interest rate from 1999Q1 to 2013Q1; computed as 10 year government bond interest rate minus HCPI inflation. Government bond yields, however, are not pure risk free rate as was evident in sovereign debt crisis of 2010 (see CNB Financial Stability Report 2011/2012 p.48 for more detail). To remedy this problem German bonds yield is applied in Ireland, Portugal and Greece from 2010Q2. German bonds, on the other hand, have witnessed flight to safety in these years and are thus probably implying too low risk free interest rates. The impact of this whole change is, however, only cosmetic and does not influence the results much. For the effect of the crisis on costs of borrowing for housing purposes see Graph 1b.

Graph 1a: Annualised agreed rate (AAR), Lending for house purchase



source: ECB Statistical Data Warehouse

In Spain, the rise in interest rates was only modest so it did not affect real interest rate significantly. The real interest rate in core Eurozone countries was around 2.1%, a value very similar to that proposed by Taylor (1993). In periphery countries, it was lower at around 1.5%. The lower real interest rates can be partly explained by higher inflation. For precise numbers see *Table 1*. These values, however, get lower – to around 0.5% – if we apply short-term interest rate instead of long-term one. The role of real interest rate in TR is to shift the proposed policy rate upward or downward. As the rate should be positive, it is safe to say that in worst case scenario the target rates would be shifted down by 1%.

A total of 7 model specifications were adopted: 5 with various measures of inflation and output gap, one with larger emphasis on deviation of output, and last one with one t+4 inflation instead of present one. Future measure of inflation was stressed throughout literature (e.g. Bernanke [2010]) because the monetary policy has certain lag. The prediction of inflation at the time of decision making should be used instead of real observed data but this should not cause any serious problems because under rational expectations the decision makers should be "on average" correct. See *table 2* for full specifications. GDP deflator in Ireland was omitted because it was of poor quality - sudden jumps as high as 25% in one quarter – and it did not add any valuable information about trend. In Greece, the deflator was not available. BK filter (model 4) requires long period on both sides to compute; the timespan is therefore shortened to 1999Q1 – 2010Q1. The lower bound for interest rates was set as 0 because it is not possible to set interest rates lower than 0.

Table 2: specification of models

	model 1	model 2	model 3	model 4	model 5	model 6	model 7
Infl. measure	GDP def.	HCPI	HCPI	HCPI	core inf.	HCPI	HCPI t+4
Ouput gap	Structural	Structural	HP	BK	Structural	Structural	Structural
a	0.5	0.5	0.5	0.5	0.5	0.5	0.5
b	0.5	0.5	0.5	0.5	0.5	1	0.5

2.3.3 Results

The results are not surprising but rather support what intuition suggests. The monetary policy was well suited for core European countries. The target rate closely follows the actual one in Germany from 2001 to 2010. The same is true for Netherlands with an exception of two years following 2001 where the policy was too loose. In France, on the other hand, the policy was too relaxed from 2003 to 2007. In UK, the proposed rate was strikingly similar to the rate

Bank of England has chosen; hinting that the chosen policy rule can approximate decision process in a country with independent monetary policy rather well.

In the peripheral countries the situation was not as simple. The policy was too loose for all the countries in the beginning of 2000s but not to the same degree. In Portugal, this deviation of interest rate from Taylor rule of about 3% occurred only in three years following 2001. In Italy, the 2% disparity stayed for 5 years after 2003, whereas in Spain, Greece, and Ireland it existed for almost a decade. The difference was most severe in Ireland with 5% misfit. In Greece, this disparity increased to 5% by 2008. In Spain, the monetary policy was too eased from the outset of monetary union up to 2008 at about 2% below proposed optimal rate. See *table 3* for suggested divergences.

After 2010, there are apparent large divergences among countries. With policy being too loose in the center of Eurozone, on one hand, and being too tight in periphery, on the other hand. This posed a dilemma for ECB how to choose accommodative policy – not to cause large inflation in the center but at the same time not to exacerbate the economic problems of the periphery.

The sharp peaks in the graph – hinting either much higher or lower target rate than in the previous period – are mostly caused by highly fluctuating GDP deflator, attributed probably to poor data measurement or no adjustments between quarters (no smoothing used). This could be dealt with by smoothing the data with a filter, such as HP. In Greece and Ireland, the rates do not include these peaks because the GDP deflator was omitted. After 2009 at least some versions of TR have hit the limit of 0 in all countries, that is the suggested rates were lower than 0. This suggests that the countries were in severe economic downturn where monetary policy alone in not enough and other remedy in needed. The impact of drop in GDP on TR is further multiplied by the subsequent deflationary pressures.

Table 3: deviation from Taylor rule rate

	Greece	Portugal	Spain	Ireland	Italy	France
TR rate - ECB rate	3.31	2.83	2.63	5.18	1.97	1.64
period start	2002Q1	2000Q3	1999Q2	1999Q3	2001Q4	2003Q3
period length	36Q	14Q	38Q	35Q	26Q	13Q

where ECB rate is Marginal lending rate, TR rate is a mean of all rates proposed by respective Taylor rule models (see Table 2 for specifications); the period is specified as the time when ECB rate was below the predictions of all models (except the one using GDP deflator as it fluctuates too much)

To conclude, one of the findings of my analysis is that the type of variables used crucially determines the target rate. There is noticeable difference between GDP deflator and HICP. In other words, the reported divergences in some countries disappear altogether when other measures of inflation or output gap are used. This impreciseness does not, however, hamper the approach employed in this study. Deviations of target optimal rates in peripheral countries are persistent throughout all versions of TR used. The analysis thus bears persuasive argument that sub-optimality of monetary policy was a real phenomenon and the next section about housing price bubbles is justified. See Graphs 2a, 2b and 3 for better description of the rates.

2.3.4 Fit of the model and the problems

Serious flaw to my analysis is that TR based policy response function does not actually fit the data since 1999. Its match before this period was tested with positive results in Gerlach and Schnabel (2000) but there seems to be break in trend since then. TR is easily testable by a linear regression – shifting expected constants one gets:

$$r - \pi = r^* + a(\pi - \pi^*) + b(y - y^*) \qquad (7)$$

where constant is r*, expected coefficient of target rate adjusted inflation is $a = 0.5$, expected coefficient of output gap is $b = 0.5$ and r is observed policy rate.

The results from OLS estimation using the aggregate data on EU15, HP estimation of output gaps and dummy variable 1 and 2 to control for extraordinary periods of 2007Q1 – 2008Q4 and 2010Q4 – 2013Q1, respectively:

$$\widehat{r - \pi} = \underset{(.088)}{1.891} - \underset{(.148)}{0.770}\,(\pi - \pi^*) + \underset{(.076)}{0.615}\,(y - y^*) - \underset{(.324)}{0.6273}\,dummy1 - \underset{(.215)}{2.246}\,dummy2 \qquad R^2 = 0.819$$

All variables are significant at 5% level even with heteroskedasticity robust standard error. The Breusch–Pagan test for heteroskedasticity rejects homoscedasticity at 0.0473% level. Output gap fits the hypothesis remarkably well (b=0.5) but the coefficient on inflation (a) is either insignificant or even negative (should be 0.5) depending on which dummy variables and measures of output gap are employed. Using lagged or forward values of inflation is not helpful either. Generally, the TR fits the data rather well before 2008 but after that there are sharp divergences.

If panel data are employed instead of aggregated ones we arrive at the same conclusion. The results from fixed effect method using the 8 countries that were included in our previous analysis are following:

$$\widehat{r - \pi} = \underset{(.046)}{1.356} - \underset{(.0421)}{0.879}(\pi - \pi^*) + \underset{(.013)}{0.209}(y - y^*)$$

All variables are significant at 0.01 level and the reported standard errors are heteroskedasticity robust. The 8 countries make substantial part of Eurozone and the rest of old member states – Austria, Belgium and Finland – would not significantly change our results. The fixed effect estimator was chosen because we expect that there is some correlation between explanatory variables and fixed effect errors but the results from other estimators are nonetheless very similar. It is evident that the results deviate significantly from the assumed values of *a* and b. Panel data methods are therefore no remedy to our problem.

In recent years non-linear least squares became a very frequent estimation method (Hofman & Bogdanova [2012], Gerlach-Kristen [2003]). It allows for interest rate smoothening which is often observed in real data. The estimated coefficient b is still significantly different from the value implicitly used in Taylor rule – 0.41 with SE 0.31 vs. its theoretical value of 1.5.

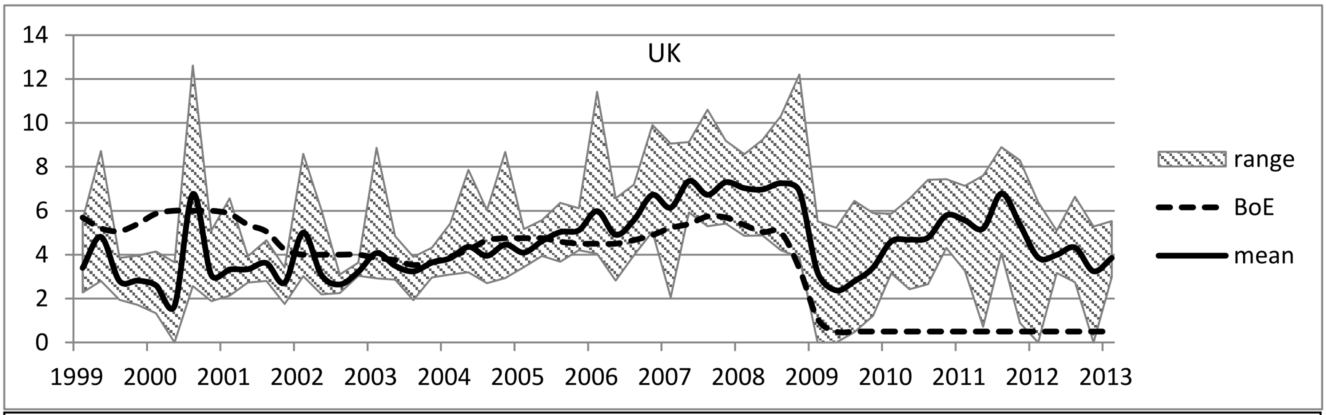
$$r = (1-d)(c + a(\pi - \pi^*) + b(y-y^*)) + dr_{t-1}$$

These results hint for possible omitted variable bias. There are compelling reasons to assume that both inflation and output gap are endogenous variables and thus results of OLS are biased and inconsistent. The frequent method to remedy this problem is to use 3SLS which is far beyond the ambitions of this text. For studies where this method is applied please see the literature review section. Building 2SLS model with 3 quarters lagged inflation and output gap as instrumental variables does not improve the results. The motivation behind the use of lagged values of endogenous variables is that the policy-makers consider only present value of these variables and so all the information in lagged values is already included in present values. Another way to remedy endogeneity is to include enough lags of the variables in vector auto-regression model (For description of the method see next section). In a model with 2 lags of the variables an effect of a shock to inflation is roughly equivalent to a = 0.5 after 2 quarters, this further increases over time.

The results do not impair my analysis as seriously as it seems. In order for monetary policy to decrease inflation the interest rate hike must be higher than the inflation increase.

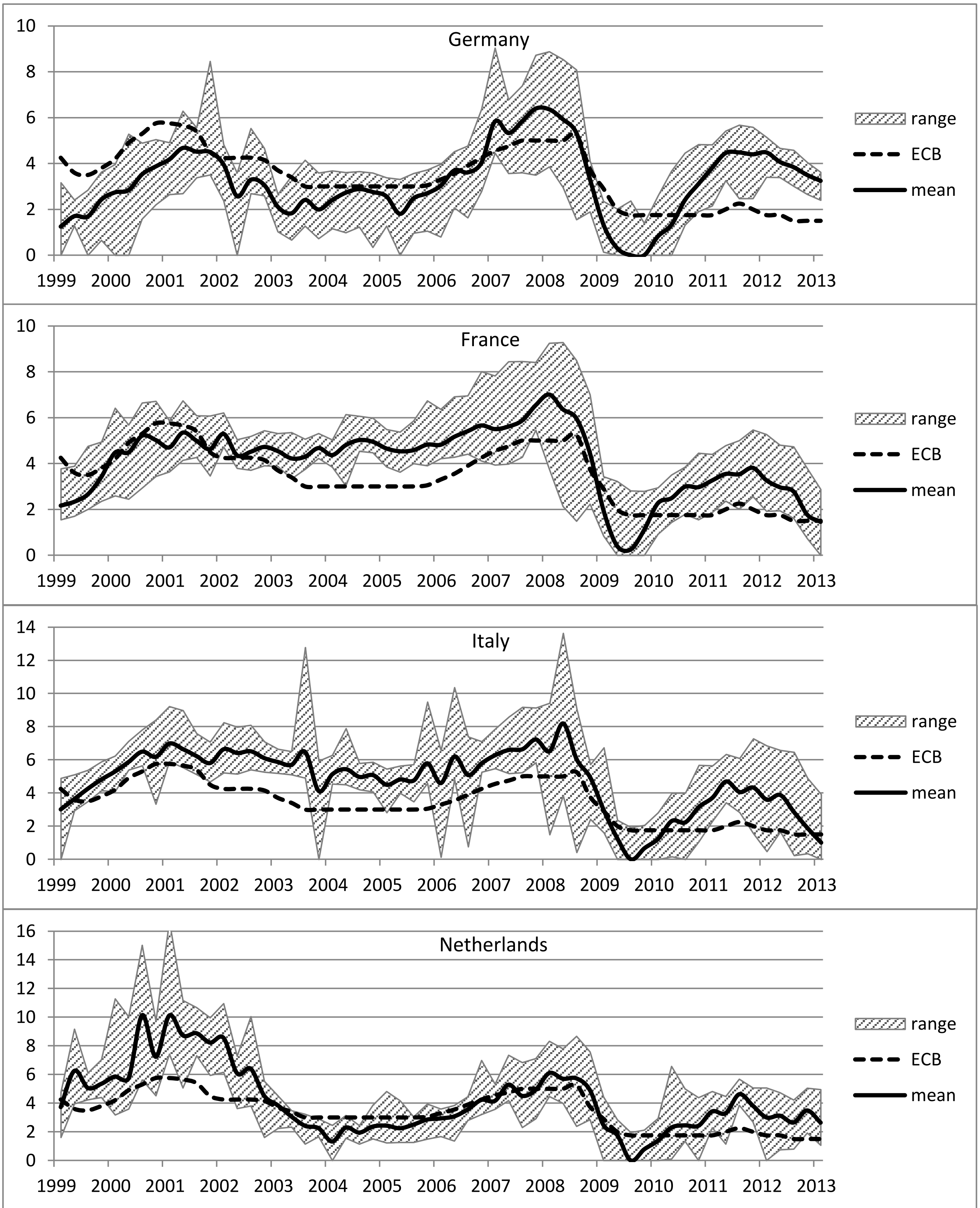
That is, given the policy goals of ECB, coefficient *a* has to be larger than 0 by definition and the predictions of TR for 2000 – 2007 fit the policy rate rather well in core countries (*graph 1b*).

Graph 1b: Implied interest rate from original version of Taylor rule (dark black) for EU15 and ECB marginal lending rate (grey)



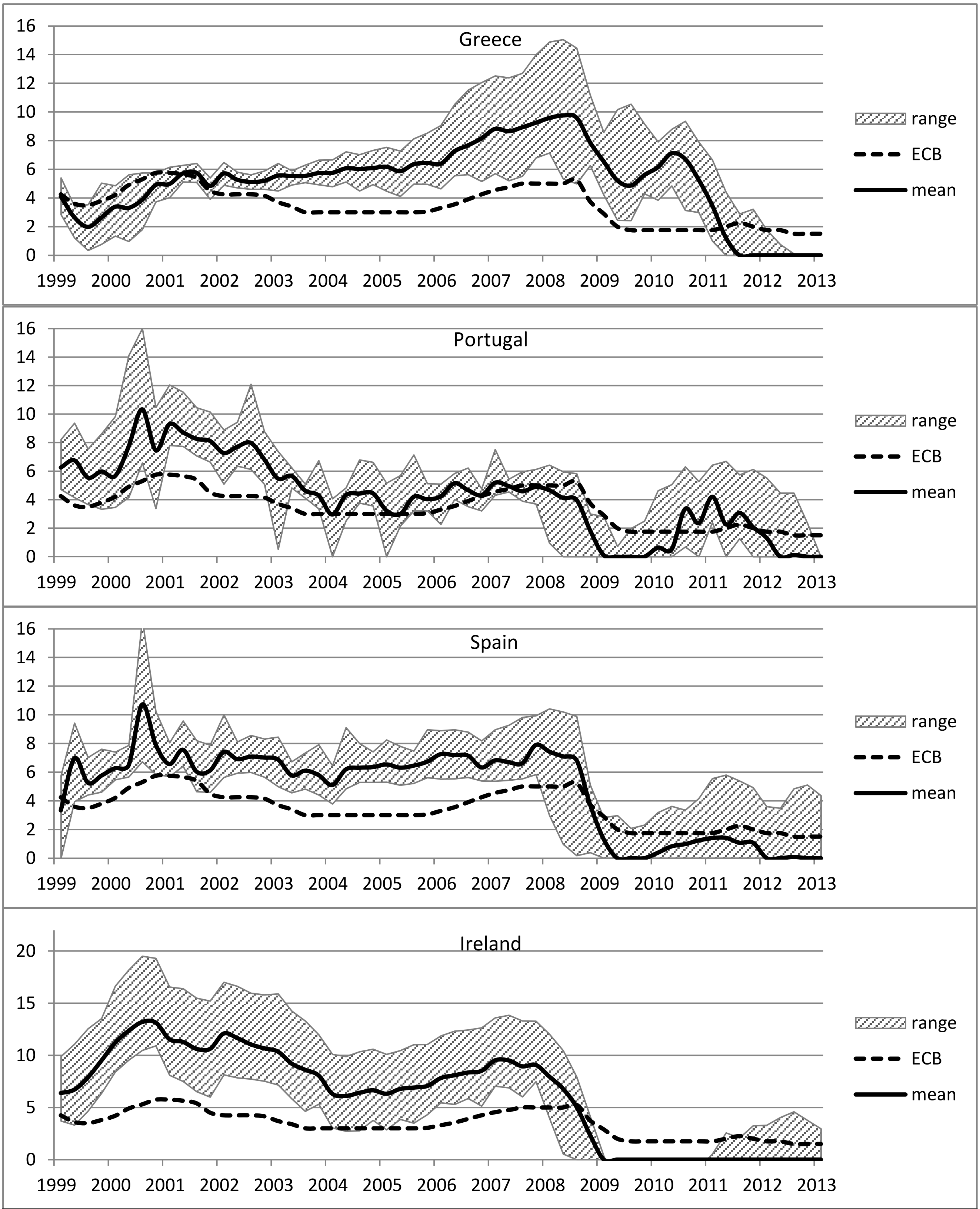
Graph 2a: ECB marginal lending rate (dashed line called ECB) together with 7 versions of Taylor rule (see table 2), mean is the average of all predictions of Taylor rules, range in is an interval covering all the predictions; the results are cut at 0 because it is not possible to set negative rates.

Source: author's computations



Graph 2b: ECB marginal lending rate (dashed line called ECB) together with 7 versions of Taylor rule (see table 2), mean is the average of all predictions of Taylor rules, range in is an interval covering all the predictions; the results are cut at 0 because it is not possible to set negative rates.

Source: author's computations



Graph 3: ECB marginal lending rate (dashed line called ECB) together with 7 versions of Taylor rule (see table 2), mean is the average of all predictions of Taylor rules, range in is an interval covering all the predictions; the results are cut at 0 because it is not possible to set negative rates.

Source: author's computations

3 DEPENDANCY OF REAL ESTATE MARKET ON INTEREST RATE

Having drawn conclusions from the previous section, second part of my analysis focuses on effects of monetary policy on housing market. John Taylor (2007) provides an early example of a study ascribing a large role of "too loose" monetary policy in USA in spurring housing activity after the 2001 recession. Spain, Ireland and UK all witnessed housing bubbles in the last decade and my goal is to determine whether low interest rates were the main force behind them.

In this section, I will discuss primarily residential housing; other segments are omitted for the sake of simplicity. For treatment of other segments and the differences see e.g. Berlemann & Freese (2010). What makes housing different from other goods? Residential housing is a durable good that produces service streams satisfying the basic human needs for shelter while simultaneously serving a role of store of purchasing power. Households choose to either buy the whole asset or just the service streams it yields. This distinction is crucial in the analysis of the housing market because increase in housing prices can be either completely normal and healthy – higher demand for housing increases the value of rents and thus is sustainable in the long run (an example of increasing housing costs in UK) – or benign and unhealthy – buying houses only because the price is increasing in expectations that it will continue to do so.

Tsatsaronis and Zhu (2004) offer overview of factors affecting housing market. A key distinction in the demand and supply factors is between those with longer-term influence and those that stir shorter-term dynamics. Factors influencing the demand for housing over long run include the average level of interest rates, shifts in household disposable income, gradual shifts in demographics, and permanent features of the tax system that might encourage home ownership as opposed to other forms of wealth. Long-term housing supply is determined by the availability and cost of land, the cost of construction, and quantity of investments into already existing housing stock.

In the short run, the housing supply responds only sluggishly and prices are therefore determined primarily by demand factors. Decisions about the housing investment depend markedly on the availability, cost and flexibility of debt financing. These factors are likely to steer changes in housing demand in the short-term together with returns on alternative assets, which imply the opportunity cost of real estate investments. Housing prices generally depend on the yield curve, inflation and availability of bank credit, but national differences in the mortgage markets are important nonetheless.

Elbourne (2008) suggests that elasticity of housing prices with respect to short-term interest rates crucially depends on the proportion of variable rate mortgages and renegotiable rate mortgages to total mortgages. The shorter the duration of the fixed period the sooner interest rate changes are going to affect household's decisions. Housing prices are therefore more sensitive to the short-term rates when floating rate mortgages are more widely used and more aggressive lending practices are associated with stronger reaction from prices to bank credit (Tsatsaronis and Zhu [2004]).

Calza et al. (2013) offer information about financing specificities of national housing markets. They differentiate mortgages into three categories: fixed (more than 5 years of fixed interest), mixed (between 1and 5 years of fixed interest) and variable with interest rate fixed up to one year. Countries with mostly variable-rate mortgages include Greece, Ireland, Spain, Luxembourg, Portugal, Finland, Australia, and the United Kingdom. Fixed-rate and mixed-rate mortgages are prevalent in Belgium, Denmark, Germany, France, the Netherlands, Austria, and Canada. Notably, in Spain more than 75% of mortgages are with variable interest, the rest mainly mixed. Similarly in Ireland variable-rates are dominant (70%), the rest is again mainly composed of mixed loans. In both these countries the typical loan to value ratio is around 70%. These statistics hint that the interest rate in peripheral countries has larger impact on prices of housing than is typical.

Housing is a complex sector with many factors at work at any time. Malzubris (2008), for example, finds that much of the upsurge in house prices in Ireland from 1992 to 2006 can be explained by low interest rates, tax treatment of housing, demographics, increased disposable income and a rise in ownership of houses for investment purposes. I will, however, focus only at monetary policy and I will try to abstain from analysis of other factors.

3.1 TRANSMISSION MECHANISMS

Before I can begin with empirical part, it is important to review how monetary policy influences house prices. Elbourne (2008) suggests that it can affect both the supply of and the demand for houses. As was already mentioned above, supply is one of factors determining price of housing in the long run, so monetary policy can have effect even beyond short run.

By managing short-term interest rate, monetary policy affects the housing demand directly through changes in (1) the user cost of capital, (2) expectations of future changes in house-price, and (3) the return available on other financial assets. User cost of capital is important determinant of the demand for residential capital even in standard neoclassical models. Mishkin (2007, p. 5) describes the role of interest rate in the neoclassical model as: “The user cost of capital (uc) takes account of several factors and can be written as

$$uc = ph\,[(1\text{-}t)i - \pi_h^e + \delta] \qquad (8)$$

where ph is the relative purchase price of new housing capital, i is the mortgage rate, π_h^e is the expected rate of appreciation of housing prices, and δ is the depreciation rate for housing.” Monetary policy therefore directly affects user cost of capital by lowering or raising mortgage rate as these are dependent on short-run interest rates. The equation can be further rewritten to show that the user cost of capital depends on real interest rates $[(1\text{-}t)i - \pi^e]$, and the expected real appreciation of housing prices $[(\pi_h^e - \pi^e]$, where π^e is the expected rate of inflation:

$$uc = ph([(1\text{-}t)i - \pi^e] - [\pi_h^e - \pi^e] + \delta) \qquad (9)$$

A shift in these expectations can thus have serious effects on the user cost of capital and housing demand. These effects are emphasized in Case and Shiller (2003).

The next determinant of demand for housing is the return on alternative assets. That is, the substitution effect when monetary policy changes relative prices (returns). Elbourne (2008) suggest that: “If the return available from holding bonds increases (interest rates rise) asset holders will transfer some of their portfolio into bonds and away from other assets including housing. This will lower house prices until the returns from holding the different asset classes is equalized after accounting for differing risks.”

Finally, there are also supply factors affecting housing activity, as I have already mentioned. Mishkin (2007) argues that construction of houses is relatively quick therefore the cost of financing house construction depends primarily on short-term interest rates. Higher short-term rates, which raise the cost of producing new housing, reduce construction activity. These supply effect of short-term interest rates on housing construction are supported in empirical research, such as that by McCarthy and Peach (2002).

3.2 LITERATURE REVIEW

The literature covering the effects of monetary policy on housing sprung up over the last decade with the emergence of housing bubbles in developed economies. It can be differentiated by methodology into three major groups. First, the largest group, using various versions of vector auto-regression models (VAR). These versions include Structural VAR (SVAR), Bayesian VAR (BVAR), factor-augmented-VAR (FAVAR), and simple reduced-form-VAR. For review of VAR studies see Appendix II or Cihák et al. (2008). Second group is utilizing structural models of whole economies, such as DSGE or FRB/US. The last group is characteristic with use of panel data analysis. The countries covered in these studies are predominantly UK and USA. Studies covering European counties of my interest (Spain, Italy and Ireland) utilize primarily panel data analysis.

The use of vector auto-regression with Choleski decomposition is probably the most frequent methodology. Applying this method Aspachs-Bracons and Rabanal (2011) found that an increase in interest rate by 25 basis points in USA leads to a decline of real house prices of 2 percent after 7 quarters. Vargas-Silva (2007) came to similar conclusion: contractionary monetary policy shocks cause negative responses of housing starts and residential investment. His identification procedure imposes sign restrictions (i.e. SVAR) on the response of some variables for certain time (not on response of housing variables). The extent of the impact is, however, sensitive to the selection of the horizon for witch the restrictions are applied. Iacoviello (2005) estimates a VAR in inflation, detrended output, house prices, and interest rates using US quarterly data from 1974 to 2003. In Choleski decomposition the interest rate is ordered first. He concludes that the policy shocks have a significant effect on house prices.

Using UK data and SVAR technique Elbourne (2008) finds that 100 basis points positive shock to short-term interest rates lowers house prices by 0.75%. Aoki et al. (2002) use recursive VAR and get larger effect: UK house prices are 0.8% lower five quarters after a 50 basis points interest rate shock. Another study with VAR methodology is Giuliodori (2005). He finds a range of responses with house prices decline between 1.5% and just over 2% following a 100 basis points shock. For an open economy specification he finds the response to be smaller at about 0.7%.

Iacoviello and Minetti (2008) utilize VARs to examine the credit channel of monetary policy through the housing market. They use multiple vector error correction models (VECM) and a VAR for Finland, Germany, Norway and UK. Some of their models try to look at the external finance mix of households, that is, the proportion of the relative supply of loans from banks and non-banks. They find that housing prices drop by 0.7–1% following a 70 basis points interest rate shock and conclude that there is also some evidence of a bank-lending channel and maybe a balance-sheet channel.

Jarocinski & Smets (2008) tried to model US economy using the Bayesian VAR. They use conditional forecasts based on observed real GDP, short and long-term interest rate, and prices developments in order to see whether it would fit the real world scenarios or if there were other factors contributing to the housing boom and bust. They have found that there is evidence that "easy monetary policy designed to stave off perceived risks of deflation in 2002 to 2004 has contributed to the boom in the housing market in 2004 and 2005."

Negro and Otrok (2007) employed FAVAR because: "[It] yields a parsimonious model that allows us to study the effects of national shocks on regional economies." They can thus combine a small number of national level variables with a wide selection of regional variables, capturing local economic conditions, without losing too many degrees of freedom. Their analysis again suggests that the impact of monetary policy shocks on housing prices is non-negligible but generally fairly small in comparison to the size of the price increase over the five year period from 2002 to 2007. The employment of FAVAR in monetary policy analysis is also emphasized by Bernanke et al. (2003, 2005). It is praised because decision makers can take into account great variety of factors – far more than a simple model with few variables (even more than the number of observations). The method thus produces better forecasts than classical methods.

Structural models of economy, such as U.S. DSGE model used at the Federal Reserve Board, EDO, attribute only a small portion of the strength of residential investment over 2003 through 2006 to monetary policy (Edge et al. 2009). Dokko et al. (2009) come to similar results using different structural macro-econometric model (FRB/US). They also ascribe some of the strength in housing markets to the low interest rates and accommodative monetary policy that followed the 2001 recession. The impetus from monetary policy to housing markets was, however, only a small factor. DSGE macroeconomic models explicitly state causal links, expectations, and thereby provide coherent framework for analysis (Stock & Watson [2001]). It is also their greatest weakness as they stand and fall with this time-variant body of knowledge they are based upon.

Other method, simple yet beneficial to some extent, is a linear regression of house price changes on Taylor rule residuals (the difference between observed interest rates and Taylor rule consistent rates) in multiple countries. The regression is, however, usually found to be insignificant; hinting that monetary policy is not the sole reason for housing bubbles but a contributing factor nonetheless. Ahrend et al. (2008) use panel of EU and other OECD countries and find that: "The available evidence suggests that periods when short-term interest rates have been persistently and significantly below what Taylor rules would prescribe are correlated with increases in asset prices, especially as regards housing."

Another alternative method is a fundamental analysis of trends and behavior of people. As Shiller (2007, p. 35) brilliantly argues: „Monetary policy is in an important sense concentrated on the extreme short-term. The fundamental target variable in the U.S. is the federal funds rate, an overnight rate. And yet, economic decision makers are focused on a lifetime decision problem. Economic decision makers have to decide on the long-term, 50-year-plus, value of their investments. The difference of maturities is a factor on the order of 10,000 to one. Using monetary policy to manage such decisions is a little bit like adding a grain of sand a day to a scale that is weighing a car."

It is hard to synthesize any consensus about the precise size of the elasticity of residential housing prices with respect to short-term interest rates. A review of many other studies can be found in Cihák et al. (2008). They suggest that there are two potential causes of the wide variance in estimates: unsuitable estimation techniques; and differences in the estimates derived from cross-country panel and single-country datasets, likely caused by incomparability of housing price data among countries. The reported elasticities vary from zero to minus 8. Panel data studies report very small elasticities, typically between zero and minus one, whereas single-country study estimates are usually in the range of minus 3 to minus 8. To bridge these differences Cihák et al. (2008) applied 3SLS. Their best estimate is minus 3.6. Even better suited econometric techniques are not, however, enough to explain the differences and do not lead to any consensus.

3.3 EMPIRICAL ANALYSIS

The empirical analysis is concerned with countries that are often omitted in similar studies – Portugal, Greece and Italy – and countries that experienced housing bubbles in 2000s – Spain, Ireland and UK. UK, in spite of not being a member of Eurozone, is included for a handy comparison – it is a country with sovereign monetary policy that has also experienced housing bubble. The goal is to estimate the response of housing markets to changes in monetary policy (interest rates). In order to produce a robust estimate a broad spectrum of methods is included.

3.3.1 Data

Due to availability, the quarterly frequency of data was chosen. As recent data as possible are employed – up to 2013Q2 – while the timespan of data is limited to 1990s in order to prevent the structural differences of economies, before introduction of common currency, to have significant role. This is very important e.g. in Greece where interest rates were as high as 20% in early 1990s. The main source of data is the same as in the first part of my analysis. That is, OECD Economic Outlook No. 93 database for harmonized consumer price index (HCPI), real GDP, short-term (3M) interest rate, GDP deflator. Short term interest rate is chosen instead of policy interest rate because of establishment of ECB and different policy tools of individual former central banks. It should not cause any serious problems as the two interest rates mostly closely copy each other – a correlation of 98.2% for period 1999Q1 – 2013Q3 (See appendix IV. for the graph). Real GDP in Greece was not available for the whole period; where needed, data from Eurostat were adopted instead. GDP deflator was often offered in longer series, it had to be therefore used where HCPI was not available. Because of the change in currency it is not possible to use standard M3 for each individual country. A common consolidated statistics from OECD main economic indicators, however, offer similar information. The database was also a source of data on share prices, permits issued for dwellings, work started for dwellings, private final consumption expenditure (measured in volume), and capital formation in housing (Gross fixed capital formation, housing, volume). For UK, M4 from Bank of England was adopted as a measure of broad money.

The source of housing price indexes differs among countries. For Greece the statistics are prepared by Bank of Greece and time series start in 1993Q4 - Other Urban Areas (Urban areas other than Athens). For Italy, Ireland, Spain, and Portugal the data comes from ECB’s data warehouse: Residential property prices, New and existing dwellings. All the datasets go at least to 1990. Data on UK housing prices were taken from compiled dataset from Bank for International Settlement (Property price statistics). See appendix I for more information.

Unit roots of time series are tested by augmented Dickey–Fuller (ADF) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. These tests complement each other because H_0 for ADF states that the process is I(1), whereas in KPSS it is stationarity of time series. For results see Appendix III. Number of lags is approximated by Schwert's rule of thumb formula p = $\text{integer}\{12(\frac{T}{100})^{\frac{1}{4}}\}$. In Spain the only stationary variable is inflation (infl) - I(0). Housing starts (starts) and interest rate (i) are I(1), whereas log of real GDP (lgdp), log of real M3 (lrm3) and log of real house price index (lrhp) are I(2). Similarly in Portugal inlf, lrhp, i are I(1), whereas lgdp, lrm3 and log of capital formation in housing (lcf) are I(2). In Greece the quality of time series is even worse – i and starts are the only I(1) series, the rest of the variables (infl, lrhp, lrhp2 – alternative index, lrm3 and lgdp) are I(2). The presence of I(2) series hints for severe problems with VAR estimation and the instability of results. In Ireland starts, infl, GDP and deflator are I(1). The rest of variables are I(2). This includes: lgdp, lrhp, lrhp using deflator, lrm3, lrm3 using deflator, and lcf. Similarly in Italy inf and i are the only I(1) the rest of variables are either I(2) – lgdp, lrm3, lrhp – or even I(3) lcf. In UK, the series are relatively well behaved – lgdp, starts, i, lcf, inf, GDP deflator are I(1), whereas lrm4, lrm4 using deflator, lrhp, lrhp using deflator are I(2). See appendix I for a list of abbreviations.

The number of co-integrating equations (r) is tested in Stata with method based on Johansen's maximum likelihood estimator (Johansen [1995]). It is based on three methods: Johansen's "trace" statistic method, "maximum eigenvalue" statistic method and the third method that chooses r to minimize an information criterion. Generally, all model specifications contain some degree of co-integration. Mostly n-2 co-integrating equations, where n is the number of variables. Specific values are given with individual models below.

3.3.2 Methodology

I follow vector auto-regression methods that are well established in this area of empirical research. When time series are non-stationary - I(1) - and co-integrated, the VAR is accompanied with bad asymptotic behavior and spurious regression problems - the biasness of estimates of relationships among variables with similar trend. If the variables are co-integrated the VAR in first differences is mis-specified because it excludes the error correction term. In order to cope with this problem vector error-correction approach has to be employed.

Other alternative, often preferred by similar studies (e.g. Berlemann & Freese [2010] and Elbourne [2008]), is to disregard this problem and accept VAR with some imperfections. This approach is not unwarranted; Sims et al. (1990) show that given proper number of degrees of freedom and size of dataset, the estimated parameters in VAR have asymptotically normal distribution converging at rate $\sqrt{T}$ even when co-integration is present, where T is the number of observations. This is valid in particular for short run simulations. Elbourne (2008, p.75) argues that "small mistakes in specifying the co-integrating relations will affect the short-run parameters, the safest approach appears to be estimating the model in levels and only focusing on the short horizon responses." That is, VECM is far more dependent on underlying specifications than VAR.

A word of caution is at hand; the authors relying on this concept usually devote only one sentence to these problems and do not cite Sims et al. (1990) at full. Sims et al. raise further assumptions such as: "The innovations in the VAR [*must*] have enough moments and a zero mean, conditional on past values of Y_t." The most important question is, however, how many observations are enough so that we can rely on consistency of the estimator. The data on housing are available usually with quarterly frequency and the most frequent timespan is two decades as larger period is either not available or includes some fundamental structural changes in economies. That is, the analysis has to do with about 80 observations which may prove too little.

To provide valuable comparison both VAR and VECM are used. Given the structure of data even this may not be enough. Usual advice from theory is to choose VAR for I(0) variables or I(1) nonintegrated variables and VECM for I(1) and co-integrated series. All of the presented models, however, include I(2) variables that are furthermore co-integrated. Employment of VAR is therefore somewhat controversial and yields very unstable results in some countries. Somewhat better results are achieved with BVAR and PVAR.

VAR and VECM description of methods

VAR framework is useful because it can deal with endogeneity problems. It was first introduced in Sims (1980). Recursive VAR, structural VAR (SVAR) and vector error-correction methods are of particular interest to my analysis. Overview of these methods can be found in Stock & Watson (2001).

To produce impulse response functions (irf) the errors must be uncorrelated across equations. Irf tracks the response of current and future values of the given variable to a one-unit increase in the current value of one of the VAR errors. Recursive VAR brings this about by including some contemporaneous values as regressors – the so called Choleski decomposition introduced in Sims (1980). The variable is always regressed on lags of all variables plus the current values of all other variables ordered before it. Stock & Watson (2001) add that because of this, "the results depend on the order of the variables: changing the order changes the VAR equations, coefficients, residuals, and there are n! recursive VARs representing all possible orderings." That is, the irf depends on ordering of variables which is arbitrary.

BVAR

Let us consider classical VAR model (for more details see Sims and Zha [1998] or Koop and Korobilis, [2009])

$$\mathbf{y}_t = \mathbf{a}_0 + \sum_{i=1}^{p} \mathbf{A}_i \mathbf{y}_{t-i} + \boldsymbol{\varepsilon}_t , \boldsymbol{\varepsilon}_t \sim N(0, \Sigma) \quad (10)$$

where y_t is a M × 1 vector of variables, $\mathbf{a_0}$ is a M × 1 vector of intercepts, $\mathbf{A}_1$–$\mathbf{A}_p$ are M × M matrices of parameters, and $\boldsymbol{\varepsilon}_t$ is a M × 1 vector of disturbances. The VAR can be generally written in matrix form in two different ways. Depending on how this is done the results are expressed either in terms of the multivariate Normal or in terms of the matric-variate Normal distribution. Let us define

$$x_t = (1, y_{t-1}^T, \dots, y_{t-p}^T) \quad (11)$$

$$X = \begin{bmatrix} x_1 \\ \vdots \\ x_T \end{bmatrix} \quad (12)$$

$A = (\mathbf{a_0}\ \mathbf{A_1} \dots \mathbf{A_p})^T$ and $\alpha = vec(A)$ then we can depict the VAR as either (13)

$$Y = XA + E, \qquad \text{where } E \sim N(0, \Sigma), \text{ or} \quad (14)$$

$$y = (I_M \otimes X)\alpha + \boldsymbol{\varepsilon}, \qquad \text{where } \boldsymbol{\varepsilon} \sim N(0, \Sigma \otimes I_M). \quad (15)$$

The likelihood function can be broken into two conditional parts: $\alpha|\Sigma, y$ and $\Sigma^{-1}|y$ with Wishart distribution, such that

$$\alpha|\Sigma, y \sim N(\hat{\alpha}, \Sigma \otimes (X^T X)^{-1}), \quad (16)$$

$$\Sigma^{-1}|y \sim W(S^{-1}, T - K - M - 1), \quad (17)$$

where K = 1+Mp, $\hat{A} = (X^T X)^{-1} X^T Y$ is OLS estimate of A, $\hat{\alpha}$= vec($\hat{A}$) and $S^{-1}=(Y - X\hat{A})^T(Y - X\hat{A})$.

The goal of Bayesian statistics is to estimate posterior density of coefficients using given data and prior density. In my analysis I will employ only Minnesota prior since it is frequently used in other studies and is fitted for estimation of macroeconomic models. The estimation of prior is simplified because Σ is replaced by its estimate and we are assuming that it is a diagonal matrix. Furthermore it is typical to assume that mean of prior distribution is 0 with exception of first own lags where 1 is chosen. This is important in our case because almost all (if not all) variables have unit roots and this specification of mean treats them as random walks.

If we use aforementioned models in a form

$$Y_t = x_t\beta + \boldsymbol{\varepsilon}_t, \quad t=1, \ldots, T \tag{18}$$

The prior for β is $\beta \sim N(\beta_0, V_0)$. Koop and Korobilis (2009) specified the prior covariance matrix V_0 as a diagonal matrix with its elements $v_{ij,l}$ $l = 1,\ldots,p$

$$v_{ij,l} = \begin{cases} \dfrac{a_1}{p^2} & \text{for coefficients on own lags} \\ \dfrac{a_2\sigma_i}{p^2\sigma_j} & \text{or coefficients on lags of variable } i \neq j \\ a_3\sigma_i & \text{for coefficients on exogenous variable} \end{cases}$$

where σ_i is i-th diagonal element of Σ. That is, we are imposing quadratic decay (p^{-2}) of importance of lags. The posterior densities can then be derived as

$$\hat{\beta}|\hat{\Sigma}, Y \sim N(\bar{\bar{\beta}}, \bar{\bar{V}}) \tag{19}$$

$$\bar{\bar{V}} = (V_0^{-1} + (\Sigma^{-1} \otimes X^T X))^{-1} \tag{20}$$

$$\bar{\bar{\beta}} = \bar{\bar{V}}(V_0^{-1}B_0 + (\Sigma^{-1} \otimes X^T X)\hat{A}) \tag{21}$$

where $\hat{A}$ is OLS estimate of A. The simplification is immense as you then have to choose only 3 parameters.

3.3.3 Specification of the models for VAR

The models always includes classical variables used for the study of monetary policy (MP) effect, housing price index and some measure of changes in housing supply and construction activity – either housing starts or fixed capital formation in housing, based on which data are available. Variables to specify MP are fairly standard (See appendix II) and include: (i) GDP, as a measure of income and state of the business cycle; (ii) the rate of inflation, measured as either HCPI (preferably) or GDP deflator; (iii) interest rate, main MP instrument in our case; (iv) M3 (M4 for UK). All variables except for inflation and interest rate are specified in log real term. Interest rate spread is not included because during the financial crisis its usual measure includes large risk premiums in some countries. The goal is to keep the number of variables maximally at 6 because this number is often stressed as the limiting factor of VAR.

The ordering of variables for Choleski decomposition to get orthogonalized impulse response functions is chosen in a standard way. The first is inflation followed by GDP. Next are the monetary policy variables – interest rate and M3 – which can react to underlying situations of the economy (infl, lgdp). The last are housing market statistics – housing price index, capital formation or starts of new constructions. Iacoviello (2002) similarly identified the recursiveness approach: “the monetary policy shock has no immediate effect on output and CPI inflation, but can contemporaneously affect real balances (by affecting liquidity supply), interest rates and real house prices.” So the real estate prices may react to immediate MP instruments, whereas inflation and GDP product react only with a lag to interest rate shocks.

Greece

There is no stable and plausible model for the whole period 1995Q1 – 2013Q1. The model is either unstable (oirf diverges) or gives only implausible results – the housing prices increase following an increase in interest rates. The only sensible results are obtained for VAR when the period is restrained to pre-crises years 1995Q1 – 2008Q1. The included variables in the model are infl, lgdp, i, lrm3, lrhp, permits. Two lags are chosen based on results of tests (FPE, AIC, HQIC, SBIC). Then the estimated response of housing prices to 100 basis points shock to interest rate is a drop of about 2% after 5 years. This effect, however, remains insignificant with asymptotic standard errors (SE) but turns to significant when using bootstrap SE with 500 repetitions. The asymptotic SE should play smaller role in our case since the size of the sample is relatively small. See appendix V for results of individual countries. This result is perhaps attributed to poor quality of the data. There is no nation-wide housing price index available so we have to rely on aggregation of data from only few largest cities which might reflect certain local dynamics that are not prevalent in the whole country and are not included in the model. The precision of all the data produced from Greek statistical office can questioned until late 2000s.

Portugal

The main models are based on data from 1988Q4 to 2013Q2. Again, there is no stable, plausible and significant result. Different specification of model and restriction of timeframe do not help. The main problem here is that housing prices did not change very much during the last decade (an increase of 7%) which in turn does not allow any significant results from the estimation. The result thus might be correct in that there is little relationship between interest rate and housing prices.

Spain

Some well-behaving models can be found but the choice of variables is quite arbitrary. The two models below include infl, lgdp, I, lrm3, starts, lrhp (ordered in this way, further on standard model SM) and they have two lags. The only difference between them is that the former does not include 3 last observations. That is, the former one uses data from 1999Q1 up to 2013Q1, whereas the latter one ends at 2012Q3. This arbitrary measure completely changes dynamics of model and makes it explode in the latter case. The same results apply to VECM results. Basic specifications of VECM are the same as above with 4 co-integrating vectors. The models are highly unstable. The same restriction of observations as above causes an increase in the effect of a 100 basis points shock to interest rate on housing prices from 13% to 20%. This instability can be akin to large convergence of the economy and sharp decline of housing prices after the burst of the bubble which has abruptly increased borrowing costs for Spanish home owners but is not reflected in Eurozone-wide interest rates. Specifying the VECM as having only 4 variables (infl, lgdp, i, lrhp) and one co-integration vector causes shocks to be permanent ones.

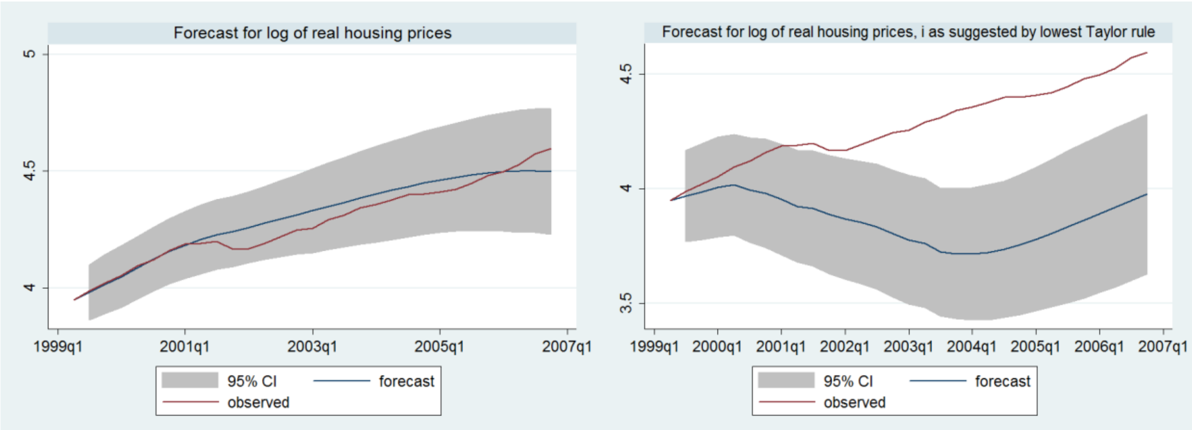
Italy

For the rest of the countries the data is not as hostile as in the previous ones given that they were countries with established market economies that did not witness sharp convergence period. For Italy, the SM is stable and gives plausible results for a period from 1990Q1 to 2013Q1. A one percent shock to interest rate decreases the price of housing by roughly 2.5%. By applying VECM with co-integration rank 2 the effects of shock on housing market turns to be permanent.

Ireland

The SM is once again with 2 period lags and with 1996Q2 - 2013Q1 period (limited due to availability of HCPI). The resulting response of housing prices to a 0.35% shock in interest rate is 2% in 3 years. The results from VECM exaggerate the effect and produce suspicious results.

Ireland, being a country that experienced housing boom and bust, a member of Eurozone and having the most stable results, is perfect for counterfactual approach. The question is: What would happen had the interest rates been at the levels suggested by Taylor



Graph 4: The conditional forecasts of housing prices for Ireland with observed interest rate (on the left) and the optimal interest rate from Taylor rule (on the right).

rule? The simulation is done by shifting interest rate (and its lags) to exogenous variables and running dynamic forecast with both the observed interest rate and with its TR suggested counterpart. The resulting trajectory of housing prices is indeed severely influenced by the change in interest rates suggesting that interest rates may not play such a minor role after all. See graph 4 for the results.

United Kingdom

Results for UK are the most stable ones from my sample. For SM with 2 lags and GDP deflator as measure of inflation, the response of housing prices to a 0.55% shock in i peaks at 3% after three years. The data sample span from 1985Q1 to 2013Q2. The VECM again shows that changes in interest rate have permanent effect. HCPI is available only for shorter period but its use does not significantly change the results.

Country	period	method	response	after
Greece	1995Q1 to 2008Q1	VAR	2%	5 years
Portugal	1988Q4 to 2013Q2	VAR & VECM	no stable model	
Spain	1993Q1 to 2013Q3	VAR	8%	5 years
	1993Q1 to 2013Q3	VECM	13%	5 years
Italy	1990Q1 to 2013Q1	VAR	2.5%	5 years
	1990Q1 to 2013Q1	VECM	2%	5 years
Ireland	1996Q2 to 2013Q1	VAR	6.6%	2.5 years
UK	1985Q1 to 2013Q2	VAR	5.5%	3 years
	1985Q1 to 2013Q2	VECM	5.8%	5 years

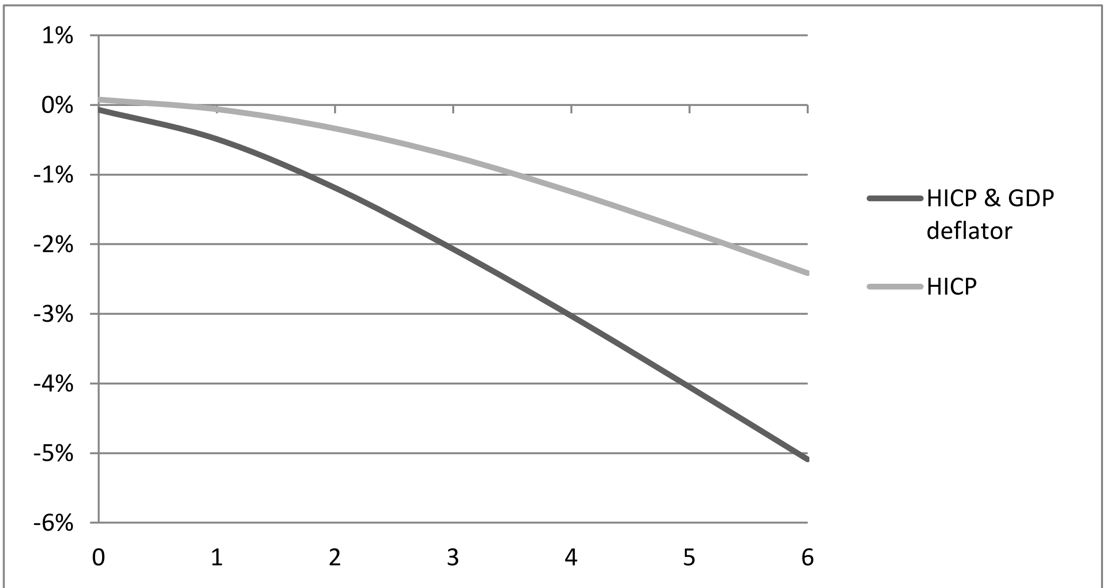
Table 4: Summary of the results, response stands for percentage increase in housing prices after 1% interest rate shock

3.3.4 Panel VAR

The panel VAR allows estimation with larger dataset and we can thus theoretically expect estimated coefficients closer to the true values (assuming consistency). The method is particularly helpful because it combines the ability to cope with endogeneity (the VAR part) while at the same time allowing for unobserved individual heterogeneity (the panel part). This section draws methodology exclusively from Love & Ziccino (2006) who in turn follow method developed by Holtz et al. (1988). Please refer to these papers for more technicalities.

Forward mean-differencing (Helmert procedure) is applied to the data in order not to cause bias that would be present if the standard mean-differencing was used to get rid of fixed effects. The coefficients are then estimated by system GMM.

There are two specifications of the models. Both of them include 6 countries (Ir, It, UK, Sp, Po, Gr) and 6 variables (as ordered for oirf: infl lgdp lrm3 i lcf lrhp) and two lags but the timespan and measurement of inflation differs. The first model is based solely on HICP across all countries, which results in somewhat shorter time series. In the second model the HICP is substituted for GDP deflator where the available time series are longer. The results of both models are consistent with the previous analysis and suggest that as a response to 1% shock to interest rate the housing prices increase by 2.5% or 5% for the two models respectively.



Graph 5: Impulse response functions from PVAR of housing prices to one percent shock to interest rate; horizontal axis shows quarters after the shock.

3.3.5 BVAR

Bayesian VAR proved to be the most suitable method for the estimation. It allows for larger number of lags and variables than simple VAR while retaining robustness. The identification procedure for individual countries is as follows: first, the 6 typical variables of standard model (see below) were applied with reasonable number of lags (mostly 5); second, if the severe collinearity was detected the least important variables were dropped; third, the robustness was checked by shifting the parameters of the VAR.

The standard model includes inflation, log of real GDP, interest rate, log of real M3, log of real housing index and log of real housing investment or log of housing starts based on availability of data. It is built with 5 lags, $a_1 = 1$, $a_2 = 0.5$ and prior mean 0. Changing a_1 and a_2 does not significantly influence the results in any of the models. Inclusion of more lags generally diminishes the size interest rate effects. The timespan of data is completely the same as in the VAR section. See appendix VI for all impulse response functions.

In Spain the model includes log of real GDP, inflation, interest rate and log of real housing index. Other variables were excluded because of collinearity. The effect of 1% increase in interest rate is a drop in real estate prices by 4.2% after 5 years. In Greece the model includes the whole set of the standard model variables (with permits issued for building of new housing). The effect of 1% increase in interest rate is a drop in real estate prices by 2.5% after 5 years.

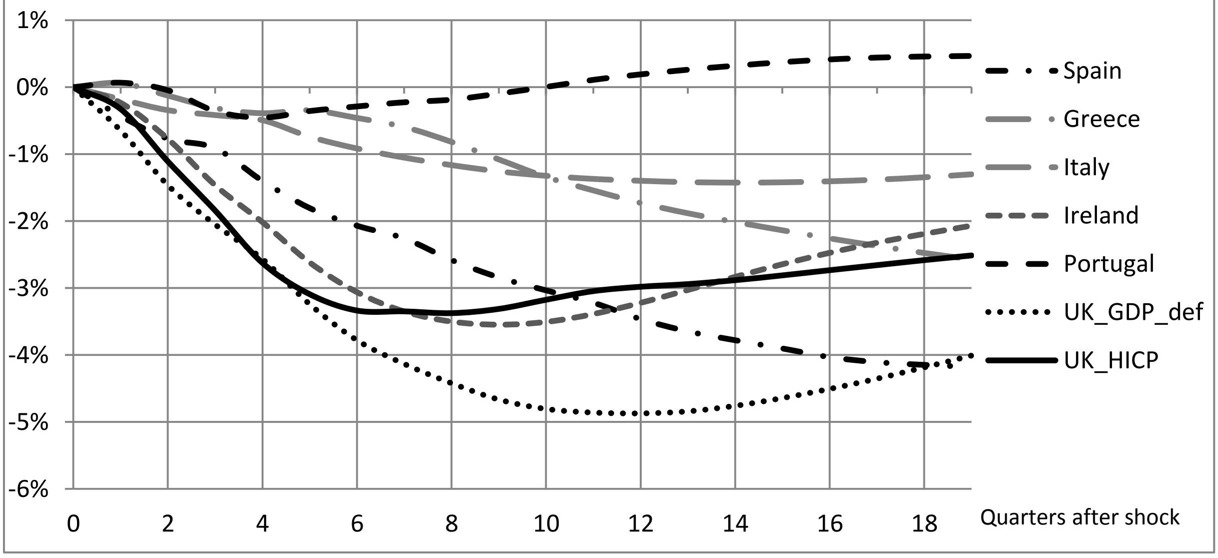
In Italy the model again includes the whole set of the standard model variables (with log of real housing investment). The effect of 1% increase in interest rate is a drop in real estate prices by 1.4% after 3 years. The rest of the models are the same as in Italy. In Ireland the effect of 1% increase in interest rate is a drop in real estate prices by 3.5% after 2 years. In Portugal there is only very weak relation between interest rate and housing prices which is in accordance with what the simple VAR has indicated above. The effect of 1% increase in interest rate is a drop in real estate prices by 0.5% after 1 year.

When using longer time series and GDP deflator in UK, the effect of 1% increase in interest rate is a drop in real estate prices by 4.9% after 3 year. When the HICP is employed instead (and the period therefore starts at 1993Q1 instead of 1985Q1) the effect decreases to 3.4% after 2 years.

Country	period	inflation	response	after
Greece	1995Q1 to 2013Q1	HICP	2.5%	5 years
Portugal	1988Q4 to 2013Q2	HICP	0.5%	1 year
Spain	1993Q1 to 2013Q3	HICP	4.2%	5 years
Italy	1990Q1 to 2013Q1	HICP	1.4%	3 years
Ireland	1996Q2 to 2013Q1	HICP	3.5%	2 years
UK	1985Q1 to 2013Q2	GDP defl.	4.9%	3 years
	1993Q1 to 2013Q2	HICP	3.4%	2 years

Table 5: Summary of the results of BVAR, response stands for percentage increase in housing prices after 1% interest rate shock

Graph 6: impulse response functions from BVAR, change in housing prices after 1% shock to interest rate



4 CONCLUSION

The first part of this study tries to determine whether the interest rate chosen by ECB was optimal for all Eurozone's countries in 2000s. Due to the nature of data and the fact that optimal rate cannot be observed even ex-post a simple but robust approach is adopted. The building block of my methodology is the standard version of Taylor rule which is shown to be quite effective by hundreds of studies. This is further accompanied by combination of various measures of inflation and output gap to make the approach even more robust.

The policy rates were found to be too low in all Eurozone peripheral countries for prolonged period of time. The most severe disparity was found in Ireland where the observed interest rate was on average 5.18% above what Taylor rule suggests over a period of 35 quarters. On the other hand the policy rate was well suited for core countries such as Germany or Netherland. This disparity has appeared once again in 2009 where the rate is too loose for Germany and France but too tight for peripheral countries. The target rate is critically dependent on specification of explanatory variables. The reported divergences in some countries disappear altogether when other measures of inflation or output gap are used. This impreciseness does not, however, hamper the approach employed in this study. Deviations of target optimal rates in peripheral countries are persistent throughout all versions of Taylor rule used. The analysis thus bears persuasive argument that sub-optimality of monetary policy was present for prolonged period of time.

The second part of this study is concerned with the effects that this loose monetary policy could have on housing prices in Greece, Ireland, Italy, Portugal, Spain and UK and its connection to housing bubbles. Again standard methodology is adopted utilizing VAR and its derivatives on quarterly series from the last two decades. This section is unique in the extent of methods and countries since it combines VAR, VECM, Bayesian VAR and Panel VAR for the six countries, which is more comprehensive than any other study to author's knowledge. This in turn allows for comparison across countries. The main problem encountered is with the characteristics of the time series. Most of the series are integrated of order two, some of order one and all are generally co-integrated. The typical advice for similar data is to drop it entirely. There were indeed some troubles with estimation (e.g. no stable VAR model for Portugal). In the simple recursive VAR the inclusion of different variables completely changes the results. BVAR proved to be much better than simple VAR when the underlying

VAR is quite unstable. The results from BVAR are much more econometrically clean and closer to the results that are commonly reported in the literature. Monetary policy often has many channels and has some impact only with severe lag. This is where BVAR is the most useful – the ability to include more variables and larger number of lags to the models.

The countries where the housing prices are most dependent on interest rate are Ireland, UK and Spain with approximately 3.5% increase in the prices as a response to 1% decrease in interest rate. The more vivid reactions can be perhaps attributed to speculative motive of buying a house. In these countries the housing prices grew rapidly and thus buying house in expectation to sell it later was very profitable strategy for a while. These speculative sales were often financed by banks and thus were more dependent on interest rate as a direct factor affecting the costs of holding the assets. The houses were not owner-occupied and thus again more sensitive to increases in interest during economic downturn. In Greece and Italy the response is only 2.5% and 1.4% respectively. In Portugal there appears to be little relationship between interest rate and housing prices. These results are fairly comparable across the countries because all the data was collected under unified methodology by Eurostat with the exception of housing price indices that were retrieved by various institutions under various methodologies. Given the results from the first part of my analysis the elasticities in Ireland and Spain translate to at least 15 to 20% increase in housing prices because of the shock to interest rates after adoption of common currency. The bubble in housing prices can thus be at least partly assigned to unanticipated costs of introduction of Euro.

The next large cause of concerns is the duration of misfit optimal interest rate. One can reasonably expect that estimation with VAR at least approximately works in the short run (2 years) but it is most certainly severely biased in almost a decade. It is therefore not (and present author thinks that it will never be) possible to precisely determine what was the impact of monetary policy. There are nonetheless several important conclusions to be made. First, in the countries where mortgages with flexible interest rates are dominant (Ireland, Spain) the housing prices respond more vividly to changes in interest rates. Second, there are large differences in housing prices determinants among European countries and it would be hard if not impossible to manage housing booms with monetary policy. Third, monetary policy is shown to be an important determinant of housing prices and cannot be underestimated or omitted as some authors do. It is not, nonetheless, the sole reason behind the housing bubbles but it could have served as a trigged for irrational exuberance to play its own part.

5 REFERENCES

Ahrend, Rudiger, Cournede, Boris and Price, Robert (2008) “Monetary Policy, Market Excesses and Financial Turmoil,” OECD Economics Working Paper No. (2008)5. Available at SSRN: http://ssrn.com/abstract=1302789 or http://dx.doi.org/10.2139/ssrn.1302789

Aoki, K., Proudman, J., Vlieghe, G. (2002) “Houses as collateral: has the link between house prices and consumption in the U.K. changed?” Fed. Reserve Bank New York Econ. Pol. Rev. 8 (1), 163–177.

Aspachs-Bracons, Oriol, Rabanal, Pau (2011) "The Effects of Housing Prices and Monetary Policy in a Currency Union," International Journal of Central Banking, International Journal of Central Banking, vol. 7(1), pages 225-274, March.

Berlemann, Michael & Freese, Julia (2010) "Monetary Policy and Real Estate Prices: A Disaggregated Analysis for Switzerland," Working Paper 105/2010, Helmut Schmidt University, Hamburg.

Bernanke, B., Boivin, J. (2003) “Monetary policy in a data-rich environment. Journal of Monetary Economics,” 50, 525–546.

Bernanke, B., Boivin, J., Piotr, E. (2005) “Measuring the effects of monetary policy: a factor-augmented vector autoregressive (FAVAR) approach,” Quarterly Journal of Economics 120, 387–422.

Bernanke, B. (2010) “Monetary Policy and the Housing Bubble,” Speech at the Annual Meeting of the American Economic Association, Atlanta, Georgia, January 3, 2010; available at: http://www.federalreserve.gov/newsevents/speech/bernanke20100103a.pdf

Calza, A., Monacelli, T. and Stracca, L. (2013) “Housing Finance and Monetary Policy,” Journal of the European Economic Association, 11: 101–122. doi: 10.1111/j.1542-4774.2012.01095.x

Karl E. Case & Robert J. Shiller (2003) "Is There a Bubble in the Housing Market?," Brookings Papers on Economic Activity, Economic Studies Program, The Brookings Institution, vol. 34(2), pages 299-362.

Cihák, Martin, Iossifov, Plamen K. and Shanghavi, Amar (2008) “Interest Rate Elasticity of Residential Housing Prices,” IMF Working Papers, Vol. , pp. 1-32, 2008. Available at SSRN: http://ssrn.com/abstract=1316715

CNB Financial Stability Report 2011/2012, Available at: https://www.cnb.cz/en/financial_stability/fs_reports/fsr_2011-2012/index.html

Cotis, J-P, J. Elmeskov and A. Mourougane (2004) “Estimates of Potential Output: Benefits and Pitfalls from a Policy Prospective,” in L. Reichlin (ed.), The Euro Area Business Cycle, Centre for Economic Policy Research, London.

Dokko, Jane K., Doyle, Brian M., Kiley, Michael T., Kim, Jinill, Sherlund, Shane M., Sim, Jae and Van den Heuvel, Skander (2011) “Monetary Policy and the Global Housing Bubble,” Economic Policy, Vol. 26, No. 66, pp. 233-283, Available at SSRN: http://ssrn.com/abstract=1801026 or http://dx.doi.org/10.1111/j.1468-0327.2011.00262.x

Dokko, Jane K., Doyle, Brian M., Kiley, Michael T., Kim, Jinill, Sherlund, Shane M., Sim, Jae and Van den Heuvel, Skander (2009) “Monetary Policy and the Housing Bubble,” Finance and Economics Discussion Series, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Edge, Rochelle M., Michael T. Kiley, and Jean-Philippe Laforte (2009) “The Sources of Fluctuations in Residential Investment: Housing Markets: A View from a Policy-Oriented DSGE Model of the U.S. Economy,” Washington: Board of Governors of the Federal Reserve System, April 2Board, October.

Elbourne, Adam (2008) "The UK housing market and the monetary policy transmission mechanism: An SVAR approach," Journal of Housing Economics, Elsevier, vol. 17(1), pages 65-87, March.

Gerlach-Kristen, Petra (2003) "Interest rate reaction functions and the Taylor rule in the euro area," Working Paper Series 0258, European Central Bank.

Gerlach, Stefan & Schnabel, Gert (2000) "The Taylor rule and interest rates in the EMU area," Economics Letters, Elsevier, vol. 67(2), pages 165-171, May.

Giorno, C. et al. (1995) “Estimating Potential Output, Output Gaps and Structural Budget Balances,” OECD Economics Department Working Papers, No. 152, OECD Publishing. http://dx.doi.org/10.1787/533876774515

Giuliodori, M. (2005) “Monetary Policy Shocks and the Role of House Prices Across European Countries,” Scot. J. Polit. Economy 52 (4), 519–543.

Hofmann, Boris and Bogdanova, Bilyana (2012) “Taylor Rules and Monetary Policy: A Global 'Great Deviation'?” (September 1, 2012). BIS Quarterly Review September 2012. Available at SSRN: http://ssrn.com/abstract=2206331

Hayo, Bernd (2006) “Is European Monetary Policy Appropriate for the EMU Member Countries? A Counterfactual Analysis,” No 200610, Marburg Working Papers on Economics, Philipps-Universität Marburg, Faculty of Business Administration and Economics, Department of Economics (Volkswirtschaftliche Abteilung), http://EconPapers.repec.org/RePEc:mar:volksw:200610.

Holtz Eakin, D., W. Newey, and H. Rosen (1988) "Estimating Vector Autoregression with Panel Data," Econometrica, 56, 1371-1395. (http://www.jstor.org/stable/pdfplus/1913103.pdf)

Jarocinski, Marek & Smets, Frank (2008) “House Prices and the Stance of Monetary Policy,” ECB Working Paper No. 891. Available at SSRN: http://ssrn.com/abstract=1120167

Johansson et. al. (2013) "Long-term growth scenarios," OECD Economics Department Working Papers, no. 1000.

Love, Inessa & Ziccino, Lea (2006) “Financial Development and Dynamic Investment Behaviour: evidence from Panel VAR,” The Quarterly Review of Economics and Finance, 46, 190-210.

Iacoviello, M., Minetti, R. (2008) “The credit channel of monetary policy: evidence from the housing market,” Journal of Macroeconomics 30 (1), 69-96

Iacoviello, Matteo (2005) "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," American Economic Review, American Economic Association, vol. 95(3), pages 739-764, June.

McCarthy, J., and R. W. Peach (2002) “Monetary Policy Transmission to Residential Investment,” Federal Reserve Bank of New York Economic Policy Review 8, no. 1 (May): 139-58.

Malzubris, Janis (2008) “Ireland’s Housing Market: Bubble Trouble,” ECFIN Country Focus 5 (9).

Mishkin, Frederic S. (2007) “Housing and the Monetary Transmission Mechanism,” NBER Working Paper Series, Working Paper 13518, http://www.nber.org/papers/w13518

Negro, Marco Del & Otrok, Christopher (2007) “99 Luftballons: Monetary policy and the house price boom across U.S. states,” Journal of Monetary Economics, Volume 54, Issue 7, October 2007, Pages 1962-1985, ISSN 0304-3932, http://dx.doi.org/10.1016/j.jmoneco.2006.11.003.

OECD (2013) "OECD Economic Outlook No. 93," OECD Economic Outlook: Statistics and Projections (database). doi: 10.1787/data-00655-en

OECD (2013) "Finance," Main Economic Indicators (database). doi: 10.1787/data-00043-en (Accessed on 22 September 2013)

Seyfried, William (2010) “Monetary policy and housing bubbles: a multinational perspective,” Research in Business and Economics Journal, Volume 2 - March 2010, http://www.aabri.com/manuscripts/09351.pdf

Scheller, Hanspeter K. (2006) “The European Central Bank History, Role and Functions,” Second Revised Edition 2006, ISBN 92-899-0022-9 (print), ISBN 92-899-0027-X (online), http://www.ecb.europa.eu/pub/pdf/other/ecbhistoryrolefunctions2006en.pdf

Shiller, Robert J. (2007) “Understanding Recent Trends in House Prices and Home Ownership,” NBER Working Paper No. 13553, October 2007, JEL No. R0, http://www.nber.org/papers/w13553.pdf?new_window=1

Sims, C., Stock, J., Watson, M. (1990) “Inference in linear time series models with some unit roots,” Econometrica 58 (1), 113–144.

Sims, C.A., (1980) “Macroeconomics and reality,” Econometrica 48 (1), 1–48.

Stock, James and Watson, Mark (2001) "Vector Autoregressions," Journal of Economic Perspectives, American Economic Association, vol. 15(4), pages 101-115, Fall.

Taylor, John B. (1993) "Discretion versus policy rules in practice," Carnegie-Rochester Conference Series on Public Policy, Elsevier, vol. 39(1), pages 195-214, December.

Taylor, John B. (1998) “The Robustness and Efficiency of Monetary Policy Rules as Guidelines for Interest Rate Setting by the European Central Bank”, IIES Seminar Paper 649.

Taylor, John B. (1999). “An Historical Analysis of Monetary Policy Rules,” in John Taylor, ed., Monetary Policy Rules. Chicago: University of Chicago Press.

Taylor, John B. (2007) “Housing and Monetary Policy,” NBER Working Paper Series 13682. Cambridge, Mass.: National Bureau of Economic Research, December, www.nber.org/papers/w13682.pdf.

Taylor, John B. (2009) “The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong,” Rock Center for Corporate Governance Working Paper No. 30; NBER Working Paper No. w14631 . Available at SSRN: http://ssrn.com/abstract=1341170 or http://dx.doi.org/10.2139/ssrn.1341170

The Treaty on the Functioning of the European Union, retrieved on 18.9.2013 from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2008:115:0047:0199:en:PDF

Tsatsaronis, Kostas & Zhu, Haibin (2004) “What Drives Housing Price Dynamics: Cross-Country Evidence,” BIS Quarterly Review, March 2004. Available at SSRN: http://ssrn.com/abstract=1968425

Vargas-Silva, Carlos (2008) "Monetary policy and the US housing market: A VAR analysis imposing sign restrictions," Journal of Macroeconomics, Elsevier, vol. 30(3), pages 977-990, September.

Databases: Bank of England, Bank of Greece, Bank of Spain, Eurostat, OECD Economic Outlook, OECD Key economic variables, BIS property price statistics (http://www.bis.org/statistics/pp.htm)

6 APPEDICES

Appendix I: Data description

Table A1: Sources of housing data

Country	Source	Indicator
Greece	Bank of Greece	Other Urban Areas (Urban areas other than Athens)
	BIS	Residential property prices, All flats (Athens & Thessaloniki), per sq. m, Q-ALL NSA
France	BIS	Residential property prices, Existing dwellings, pure price, Q-ALL, NSA
Germany	BIS	Residential property prices, All dwellings, pure price, Q-ALL, NSA
Netherlands	BIS	Residential property prices, Existing houses, pure prices, Q-ALL NSA
	BIS	Residential property prices, Existing flats, pure prices, Q-ALL NSA
	BIS	Residential property prices, Existing dwellings, per dwel., M-ALL NSA
	ECB	Quarterly, Residential property prices, Existing dwellings, NSI, Residential property in good and poor condition
Portugal	ECB	Quarterly, Other, Residential property in good and poor condition"
Spain	ECB	Residential property prices, New and existing dwellings
UK	BIS	Residential property prices, All dwellings (ONS), per dwel., M, Q-ALL NSA
Italy	ECB	Residential property prices, New and existing dwellings
Ireland	ECB	Residential property prices, New and existing dwellings

Greece						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	73	25.7289	0.151237	25.46083	25.94301
inflation (HICP y-to-y)	infl	73	3.775628	2.049899	-0.00484	11.05425
interest rate (3M Euribor)	i	73	5.233711	4.502069	0.1951	17.12667
permits for new housing construction	permits	73	44.34658	24.54528	4.5	188.1
log of real housing price index	lrhp	73	5.419891	0.186859	5.122797	5.705568
log of real M3	lrm3	73	4.573374	0.158549	4.368271	4.821352
Ireland						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	93	25.42906	0.382621	24.77068	25.87903
inflation (HICP y-to-y)	infl	69	2.274718	1.865879	-2.73139	5.680543
interest rate (3M Euribor)	i	93	4.812566	3.804186	0.1951	24
starts of new housing construction	starts	77	56.00519	31.61786	6.1	113.4
log of real capital creation in housing	lcf	93	22.60301	0.484621	21.81124	23.41119
GDP deflator	def	93	0.890541	0.1601	0.633277	1.11756
log of real housing price index	lrhp	73	4.109419	0.350773	3.39285	4.608737
log of real M3 (deflated by GDP def.)	lrm3d	93	4.509185	0.242905	4.105902	4.94488

Table A2: Description of data for Ireland and Greece

UK						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	114	27.74521	0.215119	27.33503	28.03023
inflation (HICP y-to-y)	infl	82	2.192966	0.948026	0.625326	4.82536
interest rate (3M Libor)	i	114	6.487077	3.856995	0.489733	15.18557
starts of new housing construction	starts	94	80.76596	15.51045	38.7	110.1
log of real capital creation in housing	lcf	114	24.73399	0.231776	24.38433	25.24584
GDP deflator	def	114	3.065913	2.744284	-3.61137	10.61419
log of real housing price index	lrhp	94	4.749229	0.363625	4.255428	5.270913
log of real M4 (deflated by GDP def.)	lrm3d	114	13.84505	0.446399	12.99167	14.59023
log of real housing price index (deflated by GDP def.)	lrhp	114	4.693555	0.36509	4.074567	5.254347
log of real M4 (deflated by HICP)	lrm3d	94	4.749229	0.363625	4.255428	5.270913
Spain						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	81	27.51426	0.167876	27.21275	27.72198
inflation (HICP y-to-y)	infl	81	3.03695	1.235662	-0.95338	5.056098
interest rate (3M Euribor)	i	81	4.136752	2.9708	0.1951	14.293
starts of new housing construction	starts	81	54.69052	33.24774	4.631299	153.4641
log of real housing price index	lrhp	81	4.213321	0.285342	3.846236	4.659238
log of real M3	lrm3	81	4.644119	0.191367	4.391231	4.939003
Italy						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	93	27.92116	0.077989	27.78233	28.03481
inflation (HICP y-to-y)	infl	93	3.126504	1.52168	0.179125	7.587119
interest rate (3M Euribor)	i	93	5.415462	4.078108	0.1951	16.43
log of real capital creation in housing	lcf	93	24.99446	0.082377	24.8838	25.17747
log of real housing price index	lrhp	93	4.377331	0.120156	4.142143	4.57033
log of real M3 (deflated by GDP def.)	lrm3d	93	4.486002	0.229721	4.160445	4.850585
Portugal						
variable	acronym	observations	mean	std. dev.	min	max
log of real GDP	lgdp	102	25.66592	0.148342	25.32793	25.83404
inflation (HICP y-to-y)	infl	99	4.267243	3.627708	-1.45149	18.79248
interest rate (3M Euribor)	i	102	6.552423	5.530834	0.07	17.92667
starts of new housing construction	starts	78	98.34231	48.90423	10.2	186.6
log of real housing price index	lrhp	100	4.576519	0.050475	4.460973	4.676733
log of real M3	lrm3	99	4.536547	0.208853	4.30688	4.891266
log of real capital creation in housing	lcf	102	22.84058	0.341143	21.75432	23.35109

Table A3: description of data for UK, Spain, Italy and Portugal

Appendix II: Review of VAR studies

study	country	method	variables	frequency	timespan	result
Dokko et al. (2009)	USA	reduced-form VAR	real GDP, real personal consumption expenditures, nominal share of residential investment in GDP, real house prices, core PCE inflation, the unemployment rate, nominal federal funds rate	quarterly	1977Q1 to 2002Q4	simulation suggests that macroeconomic conditions did not drive the housing market developments in this period—at least not in a historically typical manner
Berlemann & Freese (2010)	Swi.	VAR & Choleski	three-month target libor rate, inflation, GDP, M3, Swiss Performance Index, Real Estate Performance Index	quarterly	1987Q4 to 2008Q4	whole real estate market reacts significantly to monetary policy
Giuliodori (2005)	UK	VAR & Choleski	CPI, GDP, consumption, RHPI, money market rate	quarterly	1979Q3 to 1998Q	decrease in prices betweeen 1.5% and just over 2% following a 100 basic points money market shock
Aoki et al. (2002)	UK	VAR & Choleski with policy rate last	output, inflation, oil prices, real broad money, short term interest rates, consumption, house prices, housing investment	quarterly	1975Q2 to 1999Q	house prices 0,8% lower 5 quarters after 0,5% interest rate shock
Iacoviello (2005)	USA	VAR & Choleski	interest rates, inflation, and detrended output and house prices	quarterly	1974 to 2003	policy shocks have a significant effect on house prices
Del Negro, Otrok (2007)	USA	factor-augmented-VAR	the house factor, total reserves, CPI inflation, GDP growth, the 30-year mortgage rate and the Federal Funds rate	quarterly	1986 to 2005	policy shocks have small effect relative to the size of the recent housing price increase in USA
Jarocinski & Smets (2008)	USA	Bayesian VAR	real GDP, the GDP deflator, commodity prices, the federal funds rate, M2, real consumption, real residential investment, real house prices and the long-term interest rate spread	quarterly	1987Q1 to 2007Q2	evidence that monetary policy has significant effects on residential investment and house prices and that easy monetary policy designed to stave off perceived risks of deflation in 2002 to 2004 has contributed to the boom in the housing market in 2004 and 2005
Vargas-Silva (2007)	USA	VAR & Choleski	housing starts, residential investment, real GDP, house prices, GDP deflator, commodity price index, total reserves, non-borrowed reserves and the federal funds rate	monthly	1965:1 to 2005:12	housing starts and residential investment respond negatively to contractionary monetary policy shocks, however, the magnitude of the impact is sensitive to the selection of the horizon for which the restrictions hold
Elbourne (2008)	UK	SVAR	prices, retail sales, a short term interest rate, money supply, the house price index, the nominal exchange rate, commodity prices, and the Federal Funds Rate	monthly	1987:1 to 2003:5	100 basis points positive shock to short term domestic interest rates lowers house prices by 0.75%.

Appendix III: Unit root tests

	Ireland					UK				
		ADF	11 lags	KPSS	3 lags		ADF	11 lags	KPSS	3 lags
diff		value	5%	value	5%		value	5%	value	5%
	starts	-0.959	-2.905	.449	0.146	starts	-1.272	-2.904	.308	0.146
	lgdp	-2.276	-2.905	.52	0.146	lgdp	-1.207	-2.890	.31	0.146
	lrm3	0.118	-2.905	.483	0.146	lrm4	-0.699	-2.904	.257	0.146
	i	-8.558	-2.905	.242	0.146	i	-0.483	-2.890	.0962	0.146
	lcf	-2.486	-2.905	.482	0.146	lcf	-1.308	-2.890	.215	0.146
	lrhp	-2.174	-2.905	.439	0.146	lrhp	-2.586	-2.904	.298	0.146
	inf	-1.190	-2.905	.194	0.146	inf	-0.962	-2.914	.372	0.146
	lrhp2	-2.178	-2.905	.396	0.146	lrhp2	-0.713	-2.890	.247	0.146
	lrm3d	0.118	-2.905	.483	0.146	lrm4d	-0.638	-2.890	.168	0.146
	infl2	-1.893	-2.899	.181	0.146	infl2	-1.998	-2.890	.211	0.146
F	starts	-1.973	-2.906	.0616	0.145	starts	-3.177	-2.905	.308	0.145
	lgdp	-1.383	-2.906	.268	0.146	lgdp	-3.164	-2.890	.114	0.146
	lrm3	-1.999	-2.906	.177	0.146	lrm4	-2.483	-2.905	.297	0.146
	i	-3.539	-2.906	.0245	0.146	i	-3.358	-2.890	.0375	0.146
	lcf	-1.627	-2.906	.197	0.146	lcf	-3.694	-2.890	.0686	0.146
	lrhp	-1.098	-2.906	.151	0.146	lrhp	-1.515	-2.905	.398	0.146
	inf	-3.821	-2.906	.0489	0.146	inf	-2.469	-2.915	.0305	0.146
	lrhp2	-1.327	-2.906	.363	0.146	lrhp2	-2.128	-2.890	.149	0.146
	lrm3d	-1.999	-2.906	.177	0.146	lrm4d	-2.842	-2.890	.151	0.146
	infl2	-3.506	-2.900	.0242	0.146	infl2	-3.354	-2.890	.026	0.146
S	lrhp	-2.534	-2.907	.0434	0.146	lrhp	-3.531	-2.906	.0362	0.146
	lrm3	-3.240	-2.907	.039	0.146	lrm4	-3.117	-2.906	.0339	0.146
	lgdp	-3.661	-2.907	.0262	0.146	lgdp	-4.165	-2.890	.0254	0.146
	lcf	-3.084	-2.907	.0294	0.146	lcf	-5.310	-2.890	.0245	0.146
	lrhp2	-2.965	-2.907	.0355	0.146	lrhp2	-3.769	-2.906	.025	0.146
	lrm3d	-3.240	-2.907	.039	0.146	lrm4d	-3.578	-2.890	.0352	0.146

Figure A1: tests for unit roots, where diff is degree of differentiation of the series - F first, S second

	Greece					
		KPSS		ADF	11 lag	3 lag
diff		value	5%	value	5%	
	lgdp	.374	0.146	-1.960	-2.921	
	lrm3	.194	0.146	-0.825	-2.921	
	i	.372	0.146	-2.717	-2.921	
	starts	.378	0.146	-0.557	-2.921	
	lrhp	.377	0.146	-1.440	-2.921	
	inf	.175	0.146	-1.699	-2.921	
	lrhp2	.43	0.146	-2.713	-2.921	
F	lgdp	.362	0.146	0.137	-2.922	n
F	lrm3	.234	0.146	-2.486	-2.922	n
F	i	.0853	0.146	-1.646	-2.922	-3.969
F	starts	.0323	0.146	-0.557	-2.922	-5.654
F	lrhp	.323	0.146	0.424	-2.922	n
F	inf	.046	0.146	-2.405	-2.922	-5.127
F	lrhp2	.258	0.146	-0.044	-2.922	n
S	lrhp	.0383	0.146	-3.696	-2.923	
S	lrm3	.0422	0.146	-2.901	-2.923	
S	lgdp	.0491	0.146	-2.419	-2.923	
S	lrhp2	.0527	0.146	-3.698	-2.923	
S	infl	.0448	0.146			

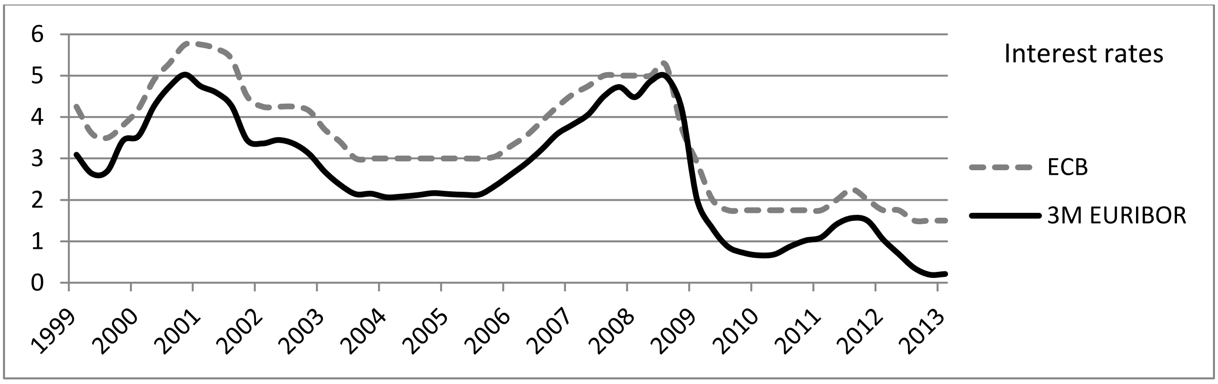
	Spain				
		KPSS	3 lag	ADF	11 lag
diff		value	5%	value	5%
	lgdp	.44	0.146	-2.517	-2.915
	lrm3	.22	0.146	-0.886	-2.915
	i	.285	0.146	-2.506	-2.915
	starts	.422	0.146	-1.596	-2.915
	lrhp	.308	0.146	-2.780	-2.915
	inf	.104	0.146	-2.956	-2.915
F	lgdp	.271	0.146	-0.422	-2.916
F	lrm3	.251	0.146	-2.471	-2.916
F	i	.0972	0.146	-2.496	-2.916
F	starts	.0751	0.146	-2.045	-2.916
F	lrhp	.476	0.146	0.043	-2.916
F	inf	.0269	0.146	-3.395	-2.916
S	lrhp	.0819	0.146	-2.096	-2.916
S	lrm3	.0331	0.146	-2.641	-2.916
S	lgdp	.0324	0.146	-2.787	-2.916

Figure A2: tests for unit roots, where diff is degree of differentiation of the series - F first, S second

	Portugal					Italy				
		ADF	11 lag	KPSS	3lag		ADF	11 lag	KPSS	3lag
diff		value	5%	value	5%		value	5%	value	5%
	lgdp	-1.430	-2.900	.526	0.146	lgdp	-2.246	-2.905	.463	0.146
	lrm3	-0.022	-2.900	.484	0.146	lrm3	-0.266	-2.905	.36	0.146
	i	-3.087	-2.900	.462	0.146	i	-1.847	-2.905	.361	0.146
	lcf	0.307	-2.900	.603	0.146	lcf	-2.093	-2.905	.253	0.146
	lrhp	-1.850	-2.900	.262	0.146	lrhp	-1.129	-2.905	.238	0.146
	inf	-2.901	-2.900	.41	0.146	inf	-2.176	-2.905	.329	0.146
F	lgdp	-1.455	-2.901	.138	0.146	lgdp	-1.595	-2.906	.115	0.146
	lrm3	-2.946	-2.901	.291	0.146	lrm3	-2.593	-2.906	.245	0.146
	i	-3.206	-2.901	.115	0.146	i	-2.998	-2.906	.0345	0.146
	lcf	-0.128	-2.901	.164	0.146	lcf	-1.121	-2.906	.228	0.146
	lrhp	-3.206	-2.901	.083	0.146	lrhp	-1.611	-2.906	.222	0.146
	inf	-2.938	-2.901	.0569	0.146	inf	-3.798	-2.906	.0266	0.146
S	lrhp	-3.274	-2.902	.0249	0.146	lrhp	-3.432	-2.907	.0662	0.146
	lrm3	-3.020	-2.902	.0245	0.146	lrm3	-3.024	-2.907	.037	0.146
	lgdp	-3.846	-2.902	.0302	0.146	lgdp	-4.418	-2.907	.0182	0.146
	lcf	-4.030	-2.902	.0222	0.146	lcf	-1.121	-2.907	.228	0.146

Figure A3: tests for unit roots, diff is differenciation of series - F first, S second

Appendix IV: Comparison of ECB rate and money market rate



Appendix V: The impulse response functions of real estate prices

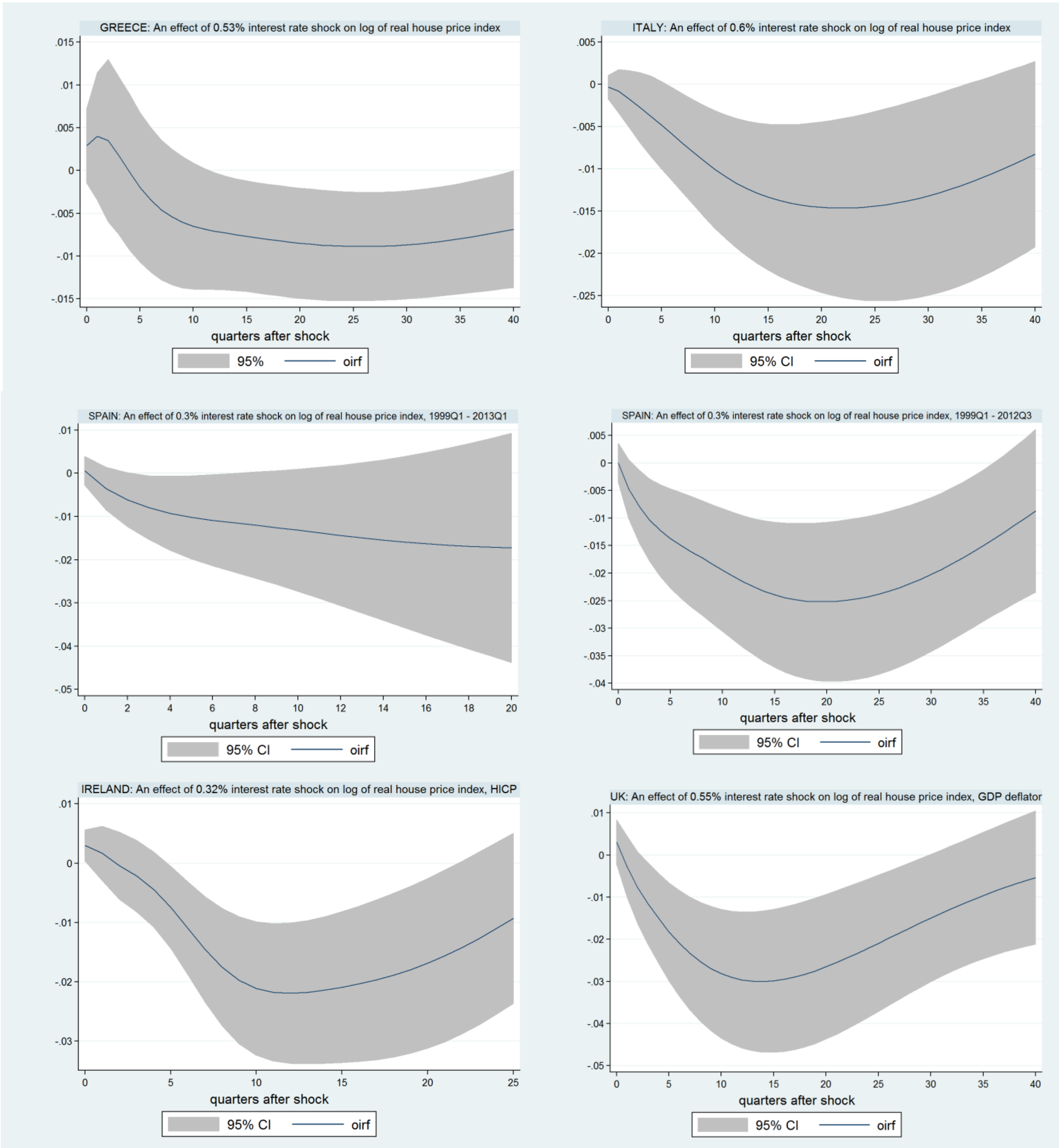


Figure A4: VAR orthogonalized impulse response functions

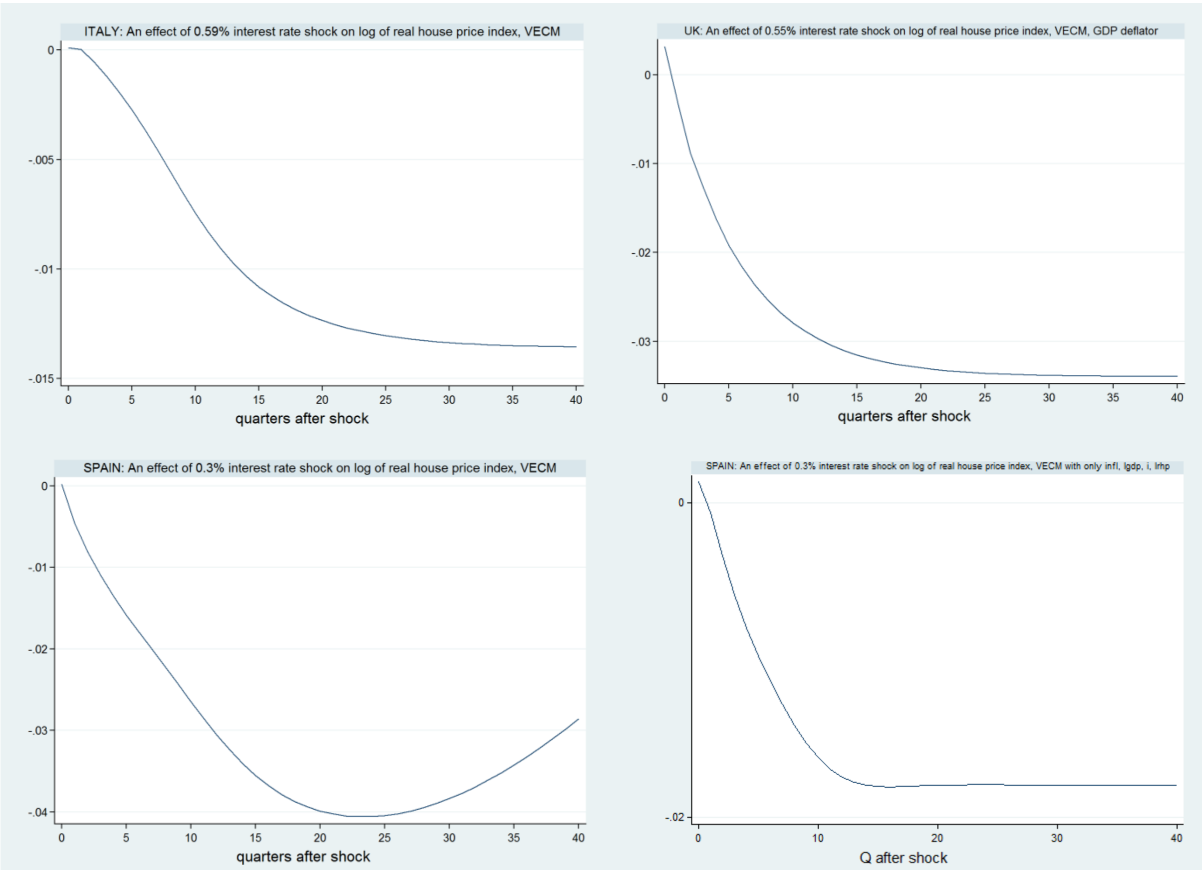


Figure A5: VECM orthogonalized impulse response functions

Appendix VI: Impulse response functions from BVAR

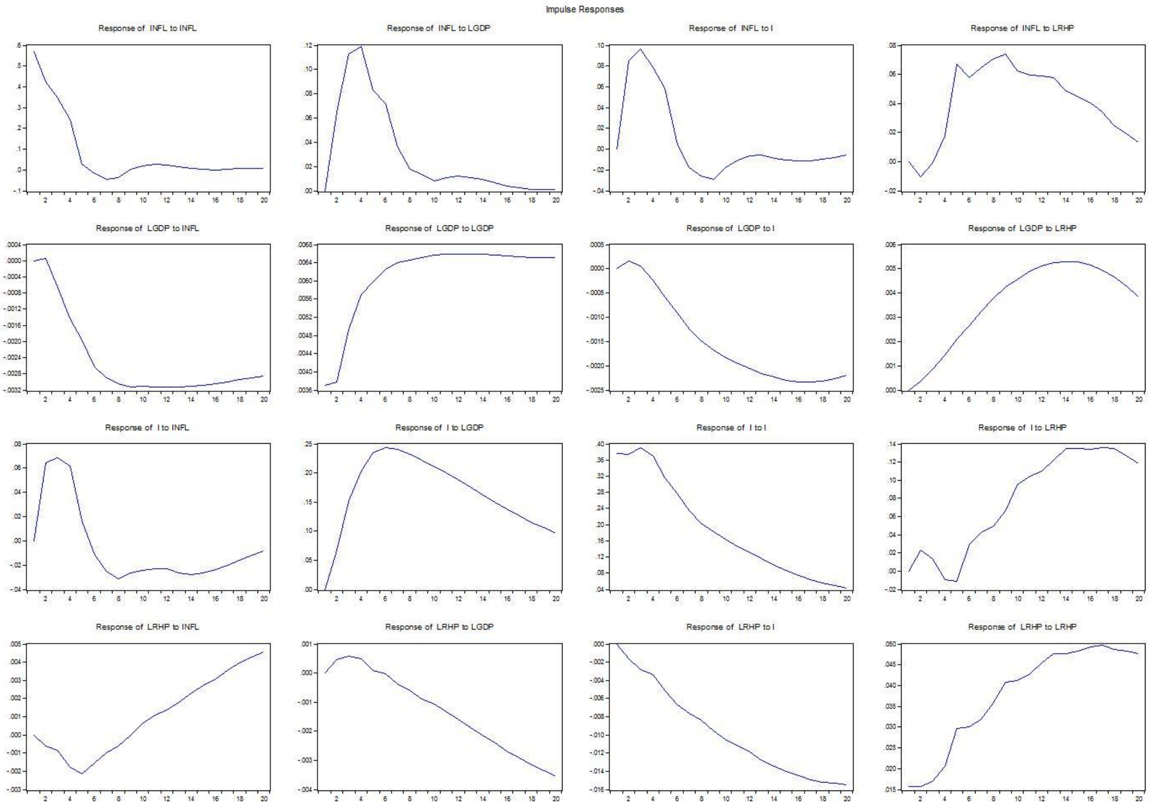


Figure A6: impulse response functions for BVAR model in Spain

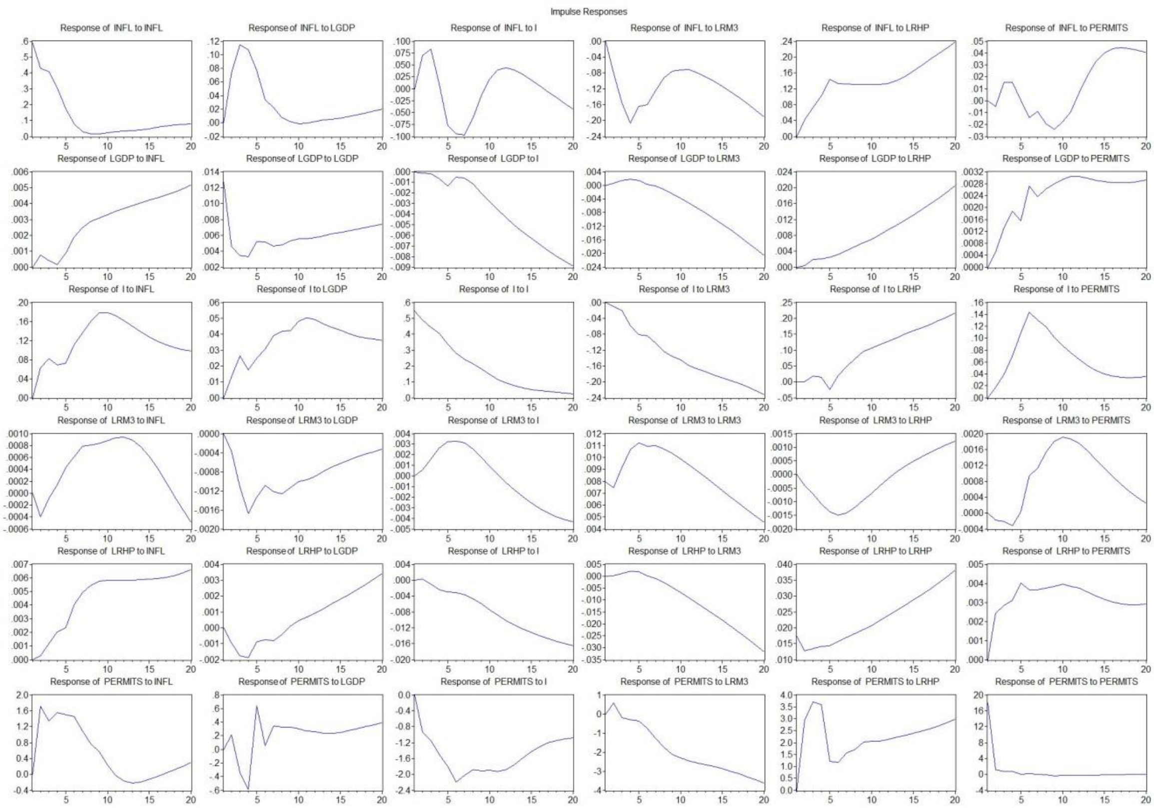


Figure A7: impulse response functions for BVAR model in Greece

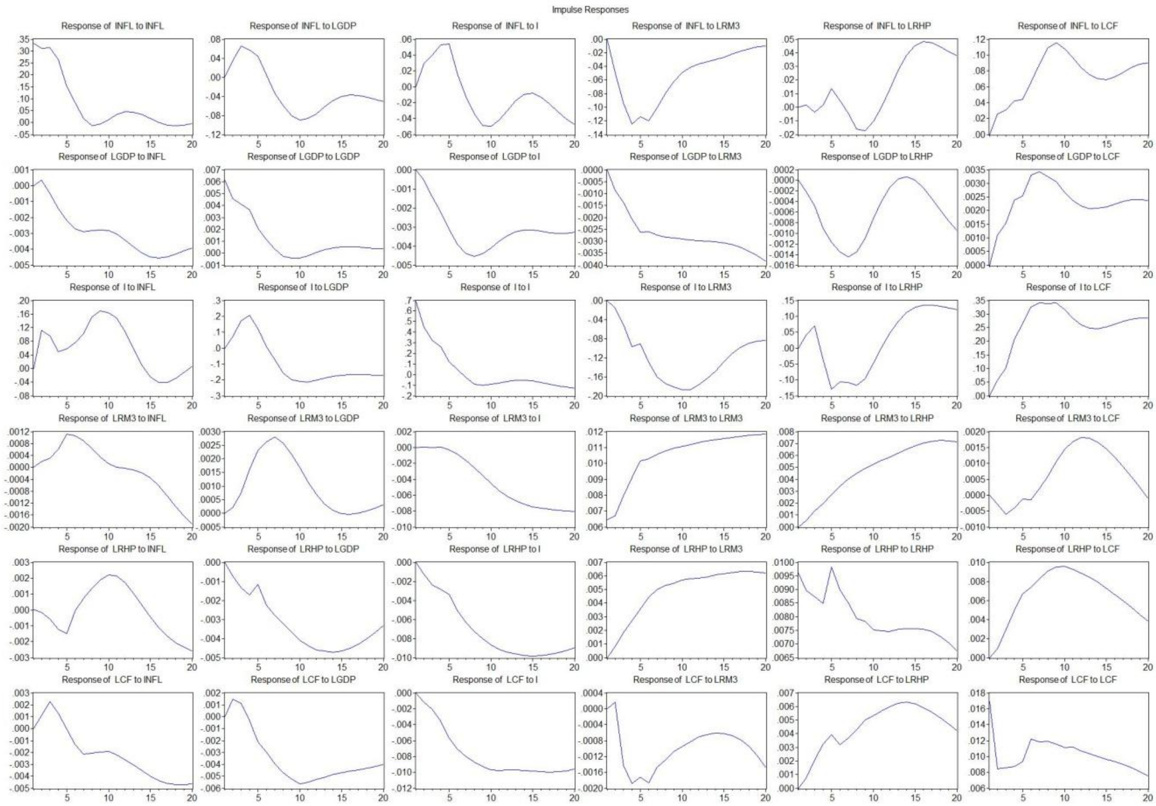


Figure A8: impulse response functions for BVAR model in Italy

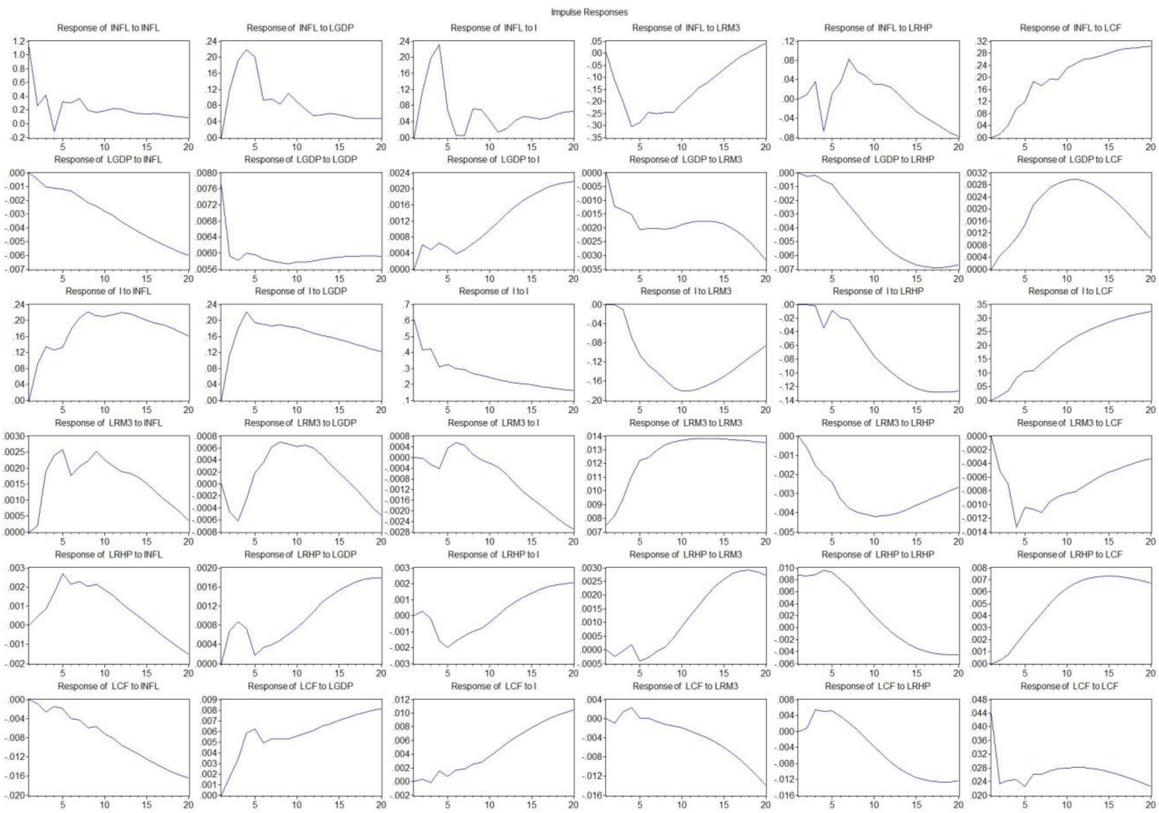


Figure A9: impulse response functions for BVAR model in Portugal

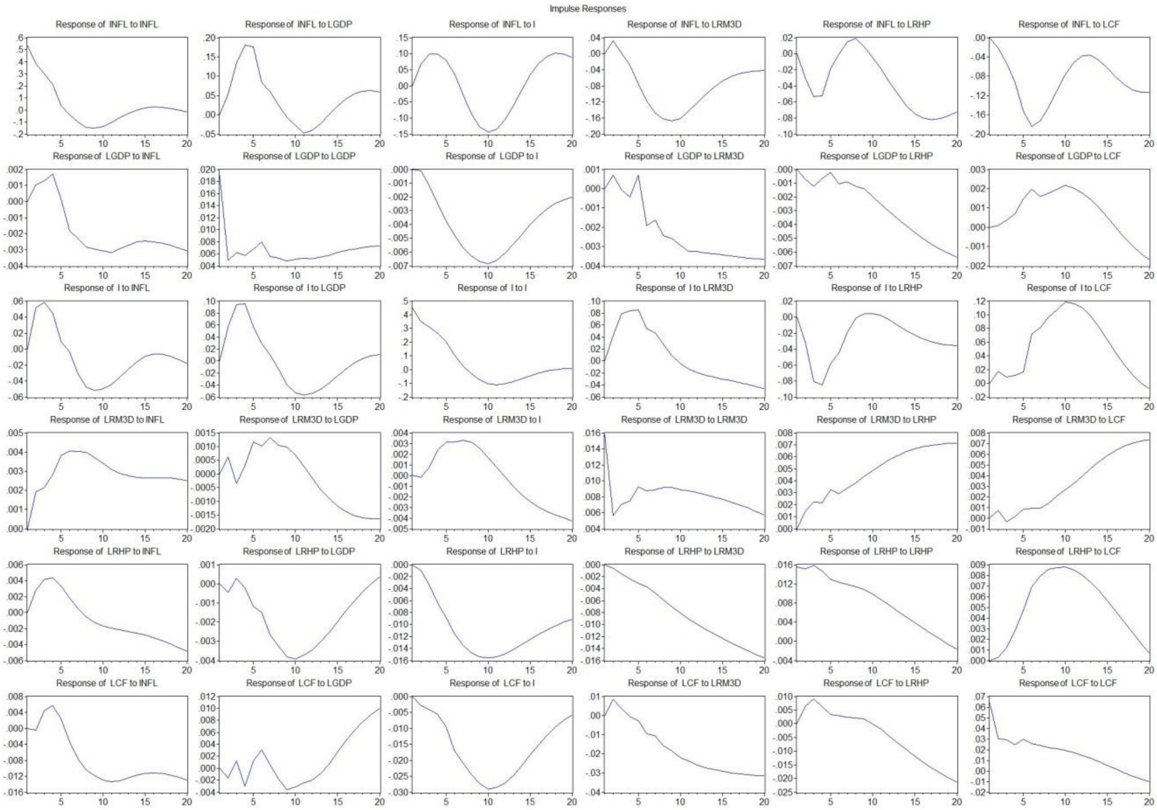


Figure A10: impulse response functions for BVAR model in Ireland

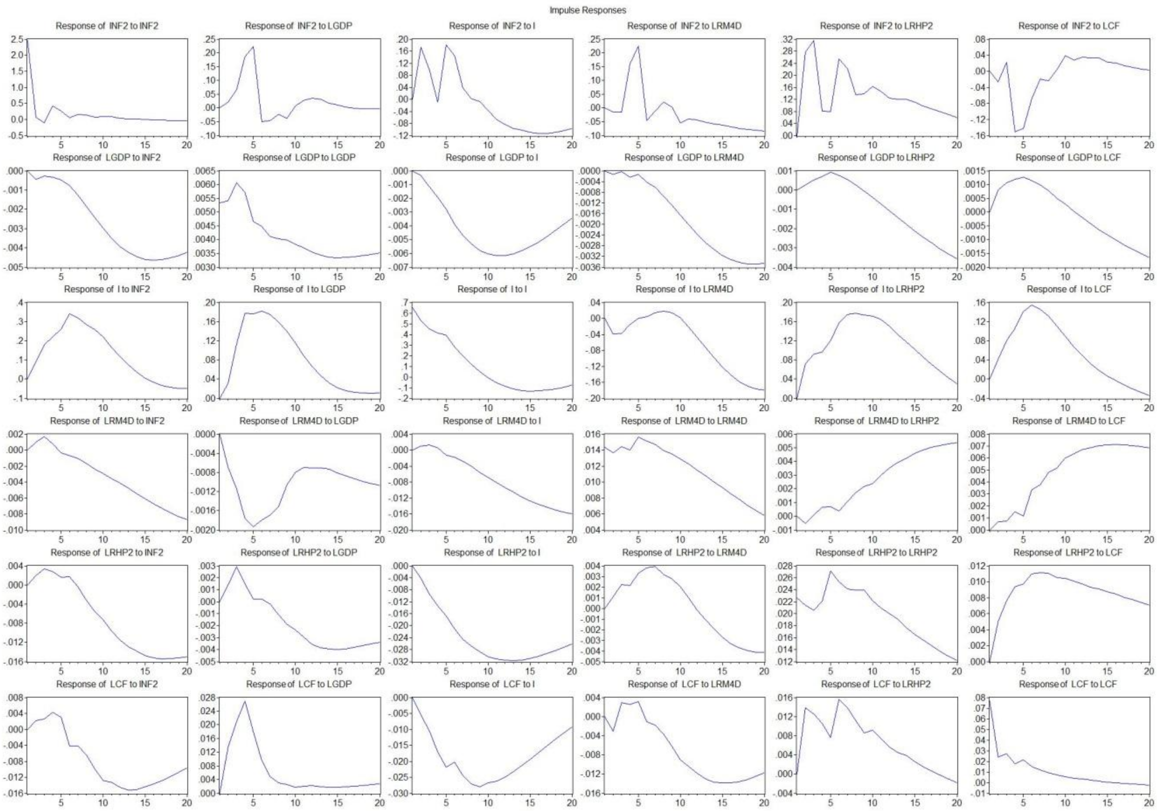


Figure A11: impulse response functions for BVAR model in UK, GDP deflator

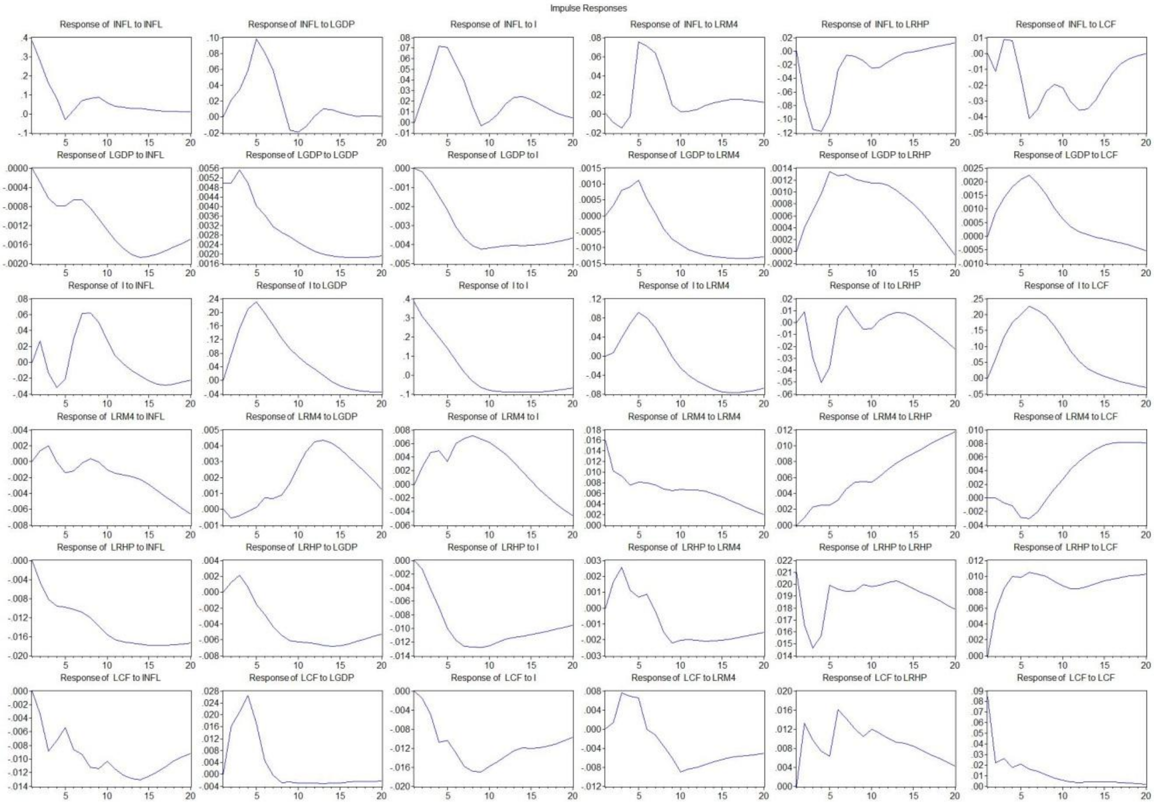


Figure A12: impulse response functions for BVAR model in UK, HICP