Hejlová, Hana

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Hana Hejlova

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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The Role of Covered Bonds in Explaining House Price Dynamics in Spain

Hana Hejlova[a]

[a]Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague, Smetanovo nábreží 6, 111 01 Prague 1, Czech Republic
Email (corresponding author): hejlova.hana@gmail.com

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Abstract:
This paper tries to explain different nature of the dynamics during the upward and downward part of the last house price cycle in Spain. Covered bonds are introduced as an instrument which may accelerate a house price boom, while it may also serve as a source of correction to overvalued house prices in downturn, where important rigidities may be present In a serious economic stress, lack of investment opportunities motivates investors to buy covered bonds due to the strong guarantees provided, which may in turn help to revitalize the credit and housing markets. To address such regime shift, house price dynamics is modelled within a framework of mutually related house price, credit and business cycles using smooth transition vector autoregressive model, in which volume of covered bonds issued is included. Linear behaviour of such system is rejected, indicating the need to model house prices in a nonlinear framework. Also, importance of modelling house prices in the context of credit and business cycles is confirmed and causality from issuance of covered bonds to house price dynamics is found in this nonlinear structure. Finally, potential threat to financial stability resulting from rising asset encumbrance both in the upward and downward part of the house price cycle is identified. It is suggested that the collateral valuation used for the dynamic adjustment of the cover pool is done using forward looking predictions of house prices and that the rate of asset encumbrance is monitored jointly with stress testing the house prices.

Keywords: House price dynamics, credit cycle, asymmetric behaviour, rigidities on housing market, covered bonds, smooth transition vector autoregressive models
JEL: E32, G21, G23, E44, E58, C32

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Introduction

In many domestic housing markets, behaviour of house prices around the last financial crisis revealed important rigidities on the downward part of the house price cycle, with different speed of adjustment across countries. While part of these differences may be explained by distinct indebtedness of households and subsequent deterioration on credit markets, adjustment mechanism in those countries where the indebtedness grew the most still remains largely unexplained.

One of the explanations of the different dynamics of house price adjustment across countries may be the different to which covered bonds were used along the cycle. Their possible enhancement effects on the upward part of the house price cycle have been neglected in light of extensive use of mortgage backed securities, which were typical of the U.S., but less of some European countries like Spain, for example. Their possible corrective effects on the downward part of the house price cycle have been recently discussed on theoretical grounds, but they have not been empirically examined yet.

Although the use of both securitization instruments – the mortgage backed securities and the covered bonds – were in many countries associated with house price bubbles, nature of the underlying mechanism between use of these instruments and house prices seems to be different in light of development after the house price reversal. While in the past, covered bonds played an important role in several countries only, the new liquidity regulatory regulation based on the Basel III framework may extend issuance of them to other economies. For this reason, empirical investigation of potential effects of the covered bonds on house prices should be getting more attention.

There are several features that make Spain a convenient country to address such question. The housing market in Spain experienced an unprecedented upswing in house prices in years preceding to the financial crisis, with household indebtedness rising sharp. Despite a significant excess of dwellings, however, house prices long hesitated to fall after the bubble burst. At the same time, both sides of these cycles, the peak and the trough, were accompanied by significant issuance of covered bonds. Should therefore the covered bonds had some impact on the house price dynamics, its importance for credit financing in Spain makes this country a unique case to study this effect.

Regardless of the source of potential rigidities in the market with housing, different dynamics on the upward and downward part of the house price cycle showed that modelling house prices using linear models may not always give valid results. Despite this, existing attempts to put house prices into nonlinear models have been limited to univariate or uniequational framework, most of all. In the theoretical literature, some authors nevertheless argue that given the interrelations between house prices and business cycle, nonlinearities in house prices might well explain nonlinerities in macroeconomic variables like the output, which have been largely modelled apart. (Balcilar et al., 2012)

To address these issues, Part 2 reviews house prices in Spain in the context of mutually reinforcing powers between business, credit and house price cycles and presents possible sources of rigidities on the downward part of the house price cycle. Part 3 introduces covered bonds, describes their importance for house price price dynamics and explains motivation for assuming them as a potential source of the corrective mechanism on the downward part of the house price cycle. Part 4 reviews procedure for estimating STVAR models and presents model for explaining house price dynamics in the framework of business and credit cycles, extended by the use of covered bonds.

The contribution of the present work is twofold. First, it tests the mechanism behind the use of covered bonds and development of house prices in an empirical way, which has not been done so far. Secondly, it models house prices in a nonlinear framework extended to a vector of variables, where one of them is the covered bonds.

2. House prices and the last financial crisis in Spain

House prices, real economy and financial system

The last boom phase of the Spanish economy was not only of higher amplitude, but also of a longer duration than the booms previously experienced. Significant growth of gross domestic product was accompanied by an increase in real wages. Growing incorporation of women into labour market and better conditions for employability of young workers accounted for an increase in disposable income of households, the basic unit for decision making about housing purchase. Since there has always been a high propensity to primary home ownership in Spain and popularity of secondary housing, the favourable economic development lead to increased number of purchases of housing of both types.[2] Positive price signals from the real estate market then translated into economic

[2] For an overwhelming discussion of housing demand and supply determinants in Spain, see Esteban and Altuzarra (2008).

activity through increased activity in the construction sector, which turned to be the most dynamic part of Spanish economy and helped to boost the real economy even more.

In a situation of rising house prices, decreasing nominal interest rates combined with high average inflation in Spain and tax deductibility of mortgage interest payments made financning house purchases more affordable. Moreover, "*credit is not only procyclical in Spain, but actually amplifies the cycle.*" (Herrero and de Lis, 2008) Upswing in real estate prices caused that value of the mortgage collateral raised and allowed for further increase in mortgage lending. Similarly, income conditions of borrowers were significantly improved due to the booming phase of the economy, what lead to general over-optimism of banks at the time of mortgage granting. Banks were strongly motivated to lend by increasing profitability, since there were both lower loan loss provisions and loan losses incurred. The surge in credit was also significantly allowed for by recourse to foreign funding, which also made it less anticipated by the national authorities. (Jimeno and Santos, 2014)

With purpose of increasing bank resilience, reducing procyclicality of lending and eliminating feedback effect from the credit granting to the real economy, dynamic provisioning was introduced in 2000 by the Bank of Spain. It was designed on the premise that lending mistakes (such that materialize in the downturn) are prevalent in the upturn. In this way, it complemented the already existing general and specific provisioning by a statistical component, counting with losses that "*have not yet been identified in specific loans*".[3] (Saurina, 2009)

Modelling house prices in Spain: Literature review

Existing research on house price dynamics in Spain has been twofold. One stream of investigators follow asset market approach and base their approach on microeconomic decision making between purchasing housing as an asset and paying for it as a service.

Ayuso and Restoy (2006) use inter-temporal asset pricing model where housing services and consumption are allowed to interact. Equilibrium house prices are then estimated on a dataset until the first half of 2003 using VAR model

[3] To gain approval of the IFRS, statistical provisions became a part of the general provisions fund in 2005. However, until the proposal of the Basel III, which introduced countercyclical tools, Spain was the only example in the world of application of such anticyclical regulatory tool. (Hilbers et al., 2005)

for three countries including Spain. They find that the degree of house price overvaluation was about 20% and attribute this to the sluggishness of supply to demand shocks and slow adjustment of rents.

The second stream of research, which also this work belongs to, cover more macroeconomic type of models, which often include indicators of house prices, real economy and credit market and usually lead to autoregressive models.

Gimeno and Martínez (2006) and (2010) model house prices using loans on house purchase and nominal interest rates in a VECM model covering period until 2004 and 2009, respectively. They find that in the long run, house prices depend positively on income and level of credit financing. By imposing restriction of zero coefficient to the nominal interest rates in the house price equation, so that changes in financing costs are only reflected in volume of mortgage loans, they find that level of indebtedness depends positively on income and negatively on nominal interest rates. House prices then tend to adjust when the level of indebtedness exceeds its equilibrium value, with significant corrective power of nominal interest rates.

Esteban and Altuzarra (2008) provide broad discussion of macroeconomic determinants and analyse house price dynamics until the first half of 2006 using cointegration analysis. Compared to other works, they also include determinants of housing supply. They find that number of housing starts is positively explained by the number of households, house prices and real residential investment, while the effect of mortgage rate is negative. They conclude that house price increase in Spain was mainly demand driven, but, they did not attribute these dynamics to a speculative bubble.

Valverde and Fernández (2010) broaden the set of variables used in Gimeno and Martínez (2006) by adding real interest rates and inflation to capture effect of membership in the EMU and price-to-rent ratio. They also try to avoid problem of omitted variable bias by including proxy for credit quality using mortgage credit default rates. By employing VECM on period until 2010, they confirm results reached by Gimeno and Martínez (2006) but they suggest presence of structural shock in lending before 2001, when legislation on securitization was adopted and real interest rates dropped significantly. By estimating the model on two subsamples, they also find that house prices and interest rates had stronger effect on mortgage lending after credit conditions were eased.

Hejlová (2011) then aims at capturing mutually reinforcing powers between real economy, housing and credit market as described earlier and assessing the role of anticyclical prudential tools within this framework. It proposes simple model where the three markets are represented by gross domestic product, volume of credit on housing and house prices (in both real and nominal terms). Limited by short time span of publicly available data, it employs less variables than the previous models, but takes advantage of including volume of dynamic provisioning and foreign investment in real estate as endogenous and exogenous variable, respectively. The time series used cover the period between 1996 and 2010, and thus offer additional information about the adjustment process. In such setting, cointegration analysis was first carried out. It was found that when the sample is restricted to the period covering the house price increase, more cointegrating relationships are found in the data. This suggests that mutually reinforcing powers between the real economy, credit and housing market function correctly in the upturn, whereas in the downturn, rigidities may be present.

Rigidities on the downward part of the house price cycles

Rigidities on housing market, which may cause asymmetric behaviour of house prices on the downward side of the cycle, have been recently widely addressed on theoretical grounds. The main motivation for research is the so called house price puzzle, when there has been found "*a strong positive correlation between house prices and sales volume.*" (Genesove and Mayer, 2001) There have been two main theoretical contributions explaining such rigidity: the equity constraint and aversion to loss. On one hand, households tend to buy their own housing when they expect prices to rise and so avoid paying more in the future. (Balcilar et al. (2012) from Abelson et al. (2005)) On the other hand, general unwillingness of sellers to realize nominal losses by selling their housing bellow the initial purchase price has been noticed during the downward part of the house price cycle, called aversion to loss. (Genesove and Mayer, 2001) One may argue that the asking and bidding prices should always meet, so that the adjustment of both should happen. In reality, only a small correction of the original asking prices is documented by the final transaction prices. Instead, "*homes tend to sit on the market for long periods of time with asking prices, and many sellers eventually withdraw their property without sale.*" (Genesove and Mayer, 2001) Special case of aversion to loss called equity constrain has then been identified for mortgage financed housing, where accepting lower price might leave debtor with negagive equity. (Engelhardt, 2003)

In the particular case of Spain, mortgages were often used to finance not only primary, but also secondary housing or purchases which were motivated by speculative reasons.

As a result of these rigidities, households are less likely to transact, causing stickiness on the downward part of the house price cycle. Therefore, modelling house price dynamics must be done in a nonlinear framework, using different regimes along the house price cycle. To this end, researches should better know mechanism which underlies the house price reversal. In what follows, covered bonds are introduced as a potential source of such correction.

3. Covered bonds and house price dynamics

Selected features of the covered bonds

Covered bonds (CBs) are debt instruments secured by underlying pool of assets (cover pool) and characterized by strengthened protection of investors. Although specific arrangements differ considerably across countries, there are several features which are common for CBs in general.[4] First, the CB holders have preferential claim on the cover pool over unsecured investors in case of the issuer´s bancruptcy. Secondly, the issuer has to maintain required value of the cover pool all the time, i.e. to adjust assets in the pool dynamically according to changes in value. Minimum quality standards may also be required of these assets by law or contract governing the issuance. To ensure sufficient value under stress, overcollateralization is often mandatory or is held voluntarily by the issuer. Third, the double recourse guarantees that when the value of the cover pool is not sufficient to cover the incured loss, CB holders may also proceed to the issuer´s insolvency estate. CBs are most typically used for financing mortgage loans, but issuing CBs for funding public debt is also common.

The main differences between CBs, ordinary secured debt and asset or mortgage backed securities are the balance sheet treatment of the underlying assets and the investor's recourse in case of issuer's default. Being "*a form of secured debt that also shares some characteristics of securitized products, in some sense covered bonds could be interpreted as a mixed instrument between both classes of debt securities.*" (Martín et al., 2013)

[4] See for example ECBC (2014) (ECBC is an organization that serves as a platform for participants in the CB market, representing interests of the cover bond issuers. To our limited knowledge, it serves as source of data for all cross country comparisons of the CBs.)

Both CBs and other secured bonds are subject to a balance sheet treatment. However, while assets underlying the CBs are fenced into the pool on an individual basis, the pool for secured bonds may be any assets on the balance sheet of given minimum value. Contrary to this, the cover pool is sold together with the asset backed securities as a part of the special purpose vehicle (SPV) created for this purpose, which means that it gets off the balance sheet. To remove the assets, special purpose vehicle is usually created[5]. This leaves the CBs the only instrument for which collateral pool may be adjusted subject to its value. Guarantee of sufficient value of the CBs collateral pool is further strehghtened when overcollateralization is in place.[6]

In case of bankruptcy, investors in CBs not only have a claim on the issuer like in case of ordinary secured bonds, but this is not either limited solely to the collateral pool like in case of ABSs. In the latter case, the recourse of the investor is constrained by the cash flows from the securitized portfolio of assets, performance of which is not further guaranteed by the issuer. (ECBC, 2014) When the default rate of the pool underlying securitization exceeds the expected rate, the resulting loss is borne by the investor. In case of CBs, such an access to the issuer's proceeds is ensured even in cases when securities are issued by a special purpose entity, which further claims the proceeds upon the originating credit institution.

Following from the different treatment with regards to the balance sheet, both the principal and interests are paid out from the pool of assets in case of ABSs. On the contrary, the cover pool behind the CBs only serves as collateral, when it stays on the issuer's balance sheet, with instalments paid out from the cash flows of the bank. This applies for both CBs and other secured bonds. Moreover, while these payments usually have fixed interest rates for CBs, they are often floating for the ABSs (Packer et al., 2007), which may further be a source of interest rate risk (however, considering such risk is not straightforward when the underlying mortgages are of variable interest rate).

The covered bonds have historically been typical of the European markets, while asset backed products have been associated with the US. The first covered bond type of products can be dated back to the 18th century. The first "modern

[5]Although a purposefully created SPV may serve for putting the cover pool by in case of covered bond contracts, too, which is typical of the U.K. (Rosen, 2008), it still belongs to the issuing entity.

[6]Spain has the tightest overcollateralization limit implied by the LTV limit on issuance, which is 25% for CBs backed by mortgage loans; this should mitigate the risk that may potentially arise from higher LTV mortgages in the pool. (Martín et al., 2013)

type" CB legislations are those of Switzerland (1931), Denmark (1951) Spain (1981) and Germany (1990). The widespread use of CB is associated with the introduction of euro, when the first CBs in benchmark format (Jumbo) called Pfandbrief were issued in 1995. The biggest CB markets have created in Germany, Denmark, France and Spain, while the most dynamic markets are nowadays is that of Sweden. As of 2013, almost 90% of CB volume was issude in the EU. Around 20% of the European issuance was made in Germany, while in Denmark and Spain it was 16 and 14% respectively. Mortgage backed CBs represented 100% of mortgage volume in Denmark and around 60% in Spain and Sweden. (based on ECBC (2014))

For an issuer, CBs represent a way of obtaining relatively cheap long-term financing, since guarantees provided by the double recourse make the interest payments demanded by investors effectively lower compared to both secured and unsecured instruments. (Ergungor, 2008) Currently, the generally low interest rate environment have made it difficult to attract sufficient volume of deposits, what makes the importance of CBs increasing. With the differential treatment introduced by the liquidity regulation under the Basel III (BCBS, 2013), CBs have also become an important tool for an efficient asset-liability management. (IMF, 2006) For reasons of the strengthened guarantees provided, CBs are on the other hand attractive among conservative and long-term oriented investors (Martín et al., 2013), interested in the highest quality instruments (Packer et al., 2007) with hold-to-maturity strategies. From the investor's point of view, such security bears higher yield than other safety investments like the government bonds. This in turn creates another advantage for the issuer, since such an investor base is different to the one attracted by ABSs for example, what further helps to diversify their portfolios. (Ergungor, 2008) Finally, CBs may represent an easy way of recourse to substantial amount of repo liquidity, since they are eligible as collateral in some of the central banks (e.g. the ECB). In these cases, regulatory standards of CBs like requirement for overcollateralization may play an important role (see for example EC (2014) for coditions of CBs eligibility for the ECB).

Valverde, Rosen and Rodríguez (2011) examine whether the systematic use of MBSs and covered bonds vary across banks depending on their characteristics related to their performance and risk profile in six countries including Spain, U.K. and the U.S. Authors find that banks issue covered bonds in times when they mostly need to raise liquidity, which is not the case of the MBSs. They also confirm that issuing covered bonds is a successful strategy in meeting such goal across banks. Cardone et al. (2010) address motivation behind the excessive use of securitization directly, confirming that liquidity has been the driver of CB issues.

Due to the enforced protection of investors embedded in the regulation, CBs were often regarded as close substitute to government bonds. Prokopczuk, Siewerty and Vonhoff (2013) point out that "*yield spread with respect to government securities has often been interpreted as pure liquidity premium.*" However, they show on data from Germany that credit risk was also embedded in the CB pricing, when diference between the risk premia of CBs backed by mortgage loans and government bonds varied during different phases of the last financial crises. Prokopczuk and Vonhoff (2012) also show that risk premia of mortgage backed CBs differes across countries depending on the conditions of real estate markets. These differences tend to be minor during normal times and tend to grow up to significant levels during periods of financial stress.

Covered bonds and house prices

On one hand, favourable terms provided by the investor to CBs translate to lower interest rates on housing credit offered to the households, which may tend to borrow more than they would otherwise do. For this reason, CBs may serve as an important fuelling factor during the initial part of the house price upswing, while home proprietorship is becoming accessible and the boom starts to build up. On the other hand, the Banking Supervision Committee of the ECB in 2011 reported about CBs as an alternative for typical instruments of securitization, which might be particularly useful in the downturn. (ECB, 2011) In line with need to ensure access to financial resources, which is needed to restore equilibrium on market with housing, there has been hope that CBs might represent new sources of mortgage financing. (Rosen, 2008) To address such question, I analyzed behaviour on the covered bond markets under market stress.

Recently, there have been two such episodes of stress – the financial and the subsequent sovereign crisis in the EU and the rest of the world. During the initial period of the financial crisis, the volume of unsecured bonds fell notably except for the government bonds, while the amount of securitization of the ABS type even rose on global level. Compared to these dynamics, market with CBs showed high stability when measured by the change in spreads. Prevailing sources of uncertainty were predominantly linked to valuation of assets that serve as collateral. The most significant increase in spreads was realized in countries where house prices were believed to be overvalued the most, with expectations of their correction (Spain and the UK). (Martín et al., 2013)

CBs then did not get into more severe troubles until the deterioration of the financial crisis after September 2008, when the hardship mainly concerned issuance on the primary markets. These fell to the pre-crisis levels, accompanied by rising spreads. To boost activity on the secondary market, the ECB launched the first wave of the Covered Bond Purchase Program in 2009.

When the sovereign crisis aggravated problems arising from the financial crisis itself, reaction of the national markets with CBs sharply diversified. Issuance in the Eurozone as a whole dropped, while the activity shifted to other countries, like the north-European ones, Canada or Australia. Within the Eurozone, countries split along the peripheral and non-peripheral countries, when "*the market almost closed for Irish and Portuguese investors and issuance weakened in Italy and Spain.*" (Martín et al., 2013) That polarization was also evident from the data on maturity profile of the issues, with decreasing length in countries from the periphery as a result of increased uncertainty. This lead to the second CBPP by the ECB in 2011. While it had not been seen before that rating of the CBs would accede that of the sovereign bonds, dramatic deterioration in some of the economies connected with worsening of the sovereign crisis made this relation reverse. Accidentally, Spanish CBs started to trade within the government bonds.

Possible explanation may be that at the beginning of the turnaround, extensive stock of CBs previously used for financing may in fact cause the credit market even more stuck. When the overall conditions deteriorate, the seeming protection provided by the CBs makes them a relatively favourable instrument for investors, what then implicitly helps the credit market get back to equilibrium. For this reason, the house price decrease in Spain may have been found limited due to the initial deterioration on the credit market resulting from high share of CBs in banks' portfolios. As the crisis proceeded and the sovereign conditions deteriorated, CBs might have become an increasingly popular investment and became one of the sources of adjustment.

CBs can then help to revitalize the credit market for two reasons. First, their issuance simply makes the mortgage financing possible. Secondly, relatively favourable terms under which CBs are issued even in more turbulent times make mortgages more attractive to households in a situation when house prices are expected to fall, which would otherwise press them to postpone the house purchase to a later moment in time. Investors into CBs, on the other hand, take advantage of getting higher interest compared to its levels in more normal times, while they still believe that the guarantees provided safeguard them from any potential loss connected to the fall in house prices. Inherent prerequisite for such an assumption is that the security provided by CBs to investors reduces uncertainty which would persist with use of any other instrument in times when general conditions significantly deteriorate. Guarantees provided with CBs may be able to maintain confidence among investors even when the market turns over, including likely deterioration in the collateral value.

Under such hypothesis, relationship between covered bonds and house prices is both positive and negative depending on the phase of the house price cycle. This would suggest that modelling house prices in linear framework does not work and confirm the need to model dynamics on the upward and downward part of the house price cycle differently. To address such concern, I approach to modelling house prices using smooth transition vector autoregressive model.

4. Empirical analysis

Motivation

Abrupt rise in house prices prior to 2008 and their sluggish adjustment thereafter raises questions about ways of modelling such asymmetric behaviour. As was found in Hejlová (2011) after splitting the sample around the turning point, there are relations between housing prices, credit and business cycle which tend to function smoothly during the boom periods, but cease to exist during recessions. Valverde and Fernández (2010) then find evidence of structural break in credit financing of housing before 2011, pointing at the fact that this occurred at the time when "*mortgage credit securitization substantially grew.*" (Valverde and Fernández, 2010)

To address this problem, first, CBs have been introduced as a potential source of change in the underlying mechanism between house prices and credit. In the following part, differences in mechanism behind the dynamics between both sides of the cycle are tested and modelled using a smooth transition vector autoregression model. Such model assumes existence of two linear regimes, governed by values of the so called transition variable vis-a-vis some threshold value, with smooth transition between these regimes. Such transition then depends on the size of departure of this threshold variable from the threshold value.

Using ST(V)AR models

Currently, the most comprehensive STVAR model is that of Camacho (2004), which is a vector extension of previous STAR models as developed by Granger et al. (1993) and Terasvirta (1994). The model takes form of:

$$y_t^1 = \beta_{y1}^t A_t + \left(\tilde{\beta_{y1}^t} A_t\right) F_{y1}\left(D_{t,y1}\right) + \alpha_{y1} e_{t-1} + u_{y1,t}$$

$$\vdots$$

$$y_t^n = \beta_{yn}^t A_t + \left(\tilde{\beta_{yn}^t} A_t\right) F_{yn}\left(D_{t,yn}\right) + \alpha_{yn} e_{t-1} + u_{yn,t},$$

where y_i are n endogenous variables ($y = 1, ..., n$, n$\in N$),A=$\left(1, X_t'\right)'$ is the vector of constant and lagged variables until the lag p ($p \in N$),β_{yi} and $\tilde{\beta_{yi}}$ are vectors of coefficients and F is a transition function, where $D_{t,i} = z_{t,i} - g_i$, i.e. departure of of the transition variable z_i from the threshold g_i. e_t is the equation error included in case of cointegrated variables and t denotes time ($t = 1...T$). The series of errors, u_i, are assumed to be serially uncorrelated. (Rewritten from Camacho (2004) for case of n variables.)

When the value of the transtion function F (governed by departure of of the transition variable z_i from the threshold g_i) approaches zero, the system reduces to VAR with coefficients β_{yi}. When its value approaches one, the system reduces to another VAR with coefficients $\beta_{yi} + \tilde{\beta_{yi}}$.

The standardized procedure to estimate STAR models proposed by Terasvirta (1994) consists of the following steps:

1. Specifying linear VAR with maximum lag length determined using linear estimation techniques.

2. Suggesting whether nonlinearity is present in the time series by the means of testing for linearity of the system of equations.

3. Estimating parameters of the model; estimating parameters of the transition function is done a priori using two-dimensional grid search.

4. Evaluating the model and retrieving impulse responses.

5. Evaluating predictive power of the model by the means of comparing forecasts of alternative models.

For testing nonlinearity, Camacho (2004) introduces vector extension to test for nonlinearity as developed by Luukkonen et al. (1988). Such test may be used to test for nonlinearity of a system as a whole or each equation separately. It takes form of:

$$y_1 = \varepsilon_{y1,0} + \sum_{h=0}^{3} \xi'_{y1,h} X_t w^h + u_{y1,t}$$

$$y_2 = \varepsilon_{y2,0} + \sum_{h=0}^{3} \xi'_{y2,h} X_t w^h + u_{y2,t},$$

where y_i $(i = 1, 2)$ are endogenous variables, X is the vector of lagged variables until lag p $(p \in N)$, $\varepsilon_{yi,0}$ and $\xi_{yi,h}$ are vectors of coefficients, u_i are series of errors and t denotes time $(t = 1...T)$. The null hypothesis of linearity is equal to $H0 = \xi_{i1} = \xi_{i2} = \xi_{i3} = 0$. For testing linearity of the system, LR statistic is used in a form of $LR = T\,(|\sum_R| - |\sum_U|)$, where $|\sum_R|$ and $|\sum_U|$ are determinants of the estimated variance-covariance matrix of the restricted and unrestricted model, respectively, and T is the number of observations in each equation. Distribution of the statistic is with χ^2 with degrees of freedom equal to number of the restrictions. For testing individual equations, LM statistic is used, in a form of $LM = (SSR_0 - SSR)/\hat{\sigma}^2$ with asymptotic $\chi^2(3p)$ degrees of freedom, where SSR_0 and SSR is the sum of squared residuals of the restricted and unrestricted model, respectively.

Additionally, Camacho (2004) also assumes situation when threshold variable is exogenous to the autoregressive system. In such case, the Taylor approximation reduces to:

$$y_1 = \sum_{h=0}^{2} (\varepsilon_{y1,h} w^h + \xi'_{y1,h} X_t w^h) + u_{y1,t}$$

$$y_2 = \sum_{h=0}^{2} (\varepsilon_{y2,h} w^h + \xi'_{y2,h} X_t w^h) + u_{y2,t},$$

with the same notation. The null hypothesis of linearity here is equal to $\varepsilon_{i1} = \varepsilon_{i2} = 0$, $\xi_{i1} = \xi_{i2} = 0$.

For modelling of the smooth transition between the regimes, two concrete functions have been widely assumed:

Logistic function $F_i(D_{ti}) = \frac{1}{1+e^{-\gamma_i D_{ti}}}$, where again $D_{t,i} = z_{t,i} - g_i$ and

exponential function $F_i(D_{ti}) = 1 - e^{-\gamma_i D_{ti}}$, where $D_{t,i} = (z_{t,i} - g_i)^2$.

The type of the transition function has a key role in the interpretation of the model. The logistic function is suitable for modelling economic relations in which different regimes – higher and lower – are associated with values of the transition variable below and above certain threshold, respectively. The exponential function is, on the other hand, only governed by the size of deviation from such threshold, offering one outer regime for deviations from the threshold which are more significant, and one inner regime for deviations which are smaller. (Terasvirta and Anderson, 1992). For this reason, use of one of these functions for modelling the transition may be often relatively straightforward.

However, to decide between these two model specifications in more rigorous way, Terasvirta (1994) proposes series of nested hypothesis testing using simple F-tests, which result from the Taylor series approximation of the functions as in the linearity tests alternative. In the multivariate extension, Camacho (2004) again proposes using the two modifications for case when transition variable does and does not to the vector of explanatory variables, respectively.

To limit the number of possible values of the threshold and smoothness parameters, two ways of dealing with the grid search may be particularly helpful. First, dividing the exponent by standard deviation of the transition variable makes the threshold roughly scale free, so that an arbitrary number of values of the transition parameter ranging from 0 to 100 may be used in searching for the most appropriate value. Secondly, the set of the threshold values may be narrowed by taking sample percentiles of the transition variable and searching through these (from Dijk et al, 2002 and Tsay, 1989). To ensure enough observations in both regimes, which are split by the value of the threshold value that is being looked for, such value may not be close to the 0th and 100th percentiles. The respective parameter values are then found using a grid search, by choosing the model with the best fit measured, i.e. for which the sum of squared residuals, or logarithm of their determinant, is minimized. With large values of the parameter, the transition function becomes very steep and the model approaches the simple TAR model with sharp switch between regimes.

When threshold and transition parameters are searched for value by value as in the grid search, the model is linear for each of this particular combination of parameter values and ordinary least squares may be used for estimating. (Weiss, 1999)

Finally, Skalin and Terasvirta (1999) developed a way of testing for pairwise non-granger causality in a nonlinear framework, when they again use the suitable Taylor series expansion of the variable which is tested for having causal effects. With use of the previous notation, such test takes form of:

$$y_1 = \left(\phi_0 + \sum_{i=1}^{p} \phi_i y_{1,t-i}\right) + \left(\rho_0 + \sum_{i=1}^{q} \rho_i y_{1,t-1}\right) F_{y1}\left(D_{t,y1}\right)$$

$$+ \sum_{i=1}^{q} \delta_i y_{2,t-i} + \sum_{i=1}^{q} \sum_{j=1}^{q} \gamma_{ij} y_{2,t-i} y_{2,t-j} + \sum_{i=1}^{q} \psi y_{t-i}^{3} + \varepsilon_t$$

where ϕ_0, ϕ_i, ρ_0, ρ_i, δ_i, γ_{ij}, ψ_i are coefficients. The null hypothesis of variable y_2 non-granger causing variable y_1 is equal to $\delta_i = \gamma_{ij} = \psi_i = 0$, which is tested using F-statistic.

Turning to the scarce empirical implementations of these models, from the univariate models, Terasvirta and Anderson (1992) apply STAR to quarterly logarithmic production indices for 13 countries and Europe. Camacho (2004) applies the multivariate extension to assess predictive power of the Composite Leading Indicators (calculated as weighted average of 10 macroeconomic leading variables) to forecast both output growth and business cycle phases. Koop et al. (1996) demonstrate the use of generalized impulse response functions using bivariate model of U.S. output and unemployment rate. Weiss (1999) uses generalized impulse responses to assess symmetry of monetary policy in a model that includes output, money supply and prices. From the models that also contain an error correction term, Escribano and Mira (2002) apply VECM on money demand in the UK. Mendoza (2003) use smooth transition VECM (STVECM) to assess relationship of real interest rates and credit supply on private investment in Venezuela, while Kavkler et al. (2007) use STVECM to model components of the real exchange rate between Slovenia and Slovakia. As an improvement to previous works, they also allow for different transition variables and transition functions in different equations of the system.

As for the examples of nonlinear models applied to market with housing, the existing application of STAR models was on regional housing prices in the U.S. Kim and Bhatacharya (2009) model dynamics of home prices, which depend on the sign and size of its own lagged values. They also explore the causal relationship between the growth in house prices and the mortgage rate in this nonlinear framework. The results strongly reject the null hypothesis of no Granger causality in the nonlinear framework, whereas the same hypothesis was not rejected in the linear model.

Model of house price dynamics with covered bonds

Ambition of the model is to stay within the framework of mutually enhancing powers between house prices, credit and business cycle, described in part 2 and investigated in Hejlová (2011). Practical advantage of such an approach is that variables which are used to proxy these three cycles (house prices, credit on housing and GDP) tend to contain information about most of the variables which are frequently used in models of house price determinants, like real wages, unemployment or even interest rates. Compared to a situation when all these relevant variables individually were included in a model, choosing the three cycle proxies saves a lot of degrees of freedom and makes the estimation on small samples technically possible. It also allows to model these cycles so as they affect each other, so that it well captures the overheating nature of the economy.

In the following empirical analysis, it is approached to testing for nonlinearity and estimating logistic STVAR models for a sequence of different sets of variables. Besides deciding whether nonlinear framework is needed to estimate these models, such an approach allows to test whether additional variables, i.e. proxies of credit and business cycle and the CBs, should be included in the model explaining the house price dynamics. Finally, it is approached to testing about the non-granger causality between house prices, credit on housing and the covered bonds in a nonlinear structure.

The basic variables which are assumed as proxies of house price, credit and business cycles are:

House prices

Prices of general dwellings, both new and existing. In euro per squared metre and of quarterly frequency. Collected by the Spanish Ministry of Housing and reported by Bank of Spain.

Credit on housing

Sum of both mortgage and general credit on housing for households and non-profit organizations. By including mortgages, which are allowed to back the CBs, as well as general credit on housing, both direct effects of relatively favourable terms of financing via CBs and secondary effects of increased banks' liquidity on general credit market are assumed. Measured in thousand euros of stock outstanding, of monthly (mortgages) and quarterly (credit) frequency. Collected and reported by Bank of Spain.

Covered bonds

Volume of new issues of covered bonds. New issues are included to capture the possible incremental effects on credit and house prices. Since such data abstract from the effect of the maturity profile of the last issues, they provide more accurate information about conditions under which mortgages are granted at each point in time, and thus also the easiness of repaying the debt. In thousand euros, of monthly frequency. Obtained from AHE, which compiles this dataset from information on individual issues of CBs by institutions from Comisión Nacional del Mercado de Valores.

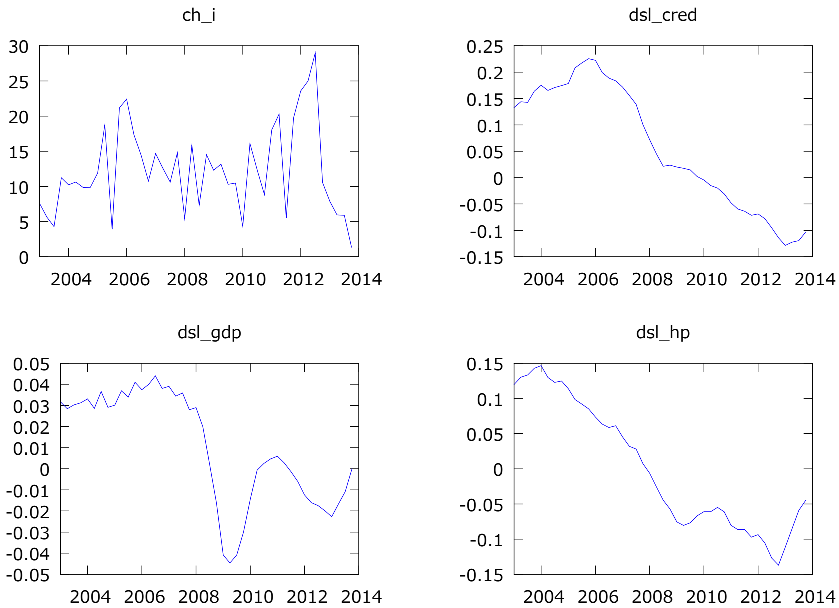
Gross domestic product

In thousand euros, of quarterly frequency. Collected by Instituto Nacional de Estadística.

All data series were transformed from nominal to real terms using Harmonized Index of Consumer Prices, as compiled and reported by Eurostat. House prices, credit on housing and GDP, which were found stationary in the first differences (Table 4), enter the models in rate of change to capture the dynamics of the system. For higher smoothness, yearly rate of changes calculated as seasonal logarithmic differences of the original time series were used. Issues of CBs, as already an incremental variable, are put into the model in levels (in billion of euros).

The dataset is of quarterly frequency and covers period between 2003 and 2013. While this is not a long timespan, it is still the largest data set on CBs available. Individual time series used in the models are described in Figure 1, with variable abbreviations and models summarized in Table 1.

Figure 1: Time series modelled



Source: Banco de Espana, Asociación Hipotecaria Espanola, Instituto Nacional de Estadística.

Table 1: Models and variable abbreviations used

Variable	Notation
dsl_hp	seasonal logarithmic differences of house prices
ch_i	issues of covered bonds (cédulas hypotecarias), in euro billion
dsl_cred	seasonal logarithmic differences of credit on housing
dsl_gdp	seasonal logarithmic differences of gross domestic product
Model	**Variables included, in notations**
Model 0	dsl_hp, dsl_cred
Model 1	dsl_hp, ch_i
Model 2	dsl_hp, ch_i, dsl_gdp
Model 3	dsl_hp, ch_i, dsl_cred

Source: Author.

To assess mutual relations between housing and credit market including the CBs, four simple STVAR models were proposed – two two-variable and two three-variable ones. These are:

- Models that explain dynamics of house prices and credit on housing (model 0) and dynamics of house prices and issues of CBs (model 1).
- Models that explain dynamics of house prices, credit on housing and issues of CBs (model 2) and dynamics of house prices, GDP and issues of CBs (model 3).

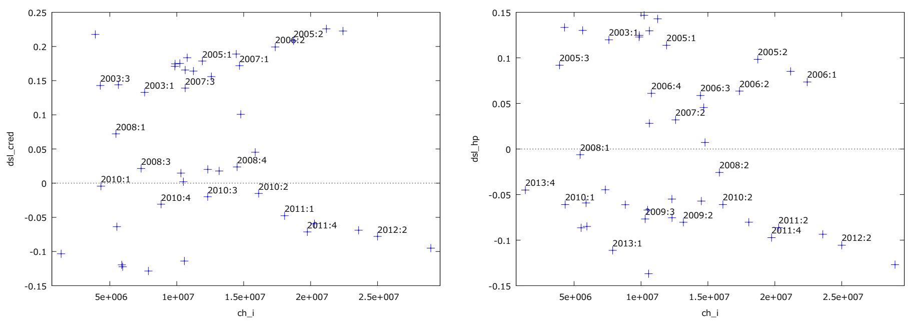
By comparing suitable pair of two- and three-variable model, it may be tested for variable inclusion in the sytem of equations. This is done using likelihood ratio test, since the two-variable models are submodels of the three-variable models, i.e. they may be both obtained from the three-variable models by imposing restrictions on some of their parameters.

By comparing model 3 with model 0, it may be tested whether adding issues of CBs is important for explaining the house price dynamics. Vice-versa, by contrasting model 3 with model 1, it may be tested whether assuming credit dynamics is important for explaining the house price dynamics. Finally, by comparing model 3 with model 1, it may be assessed whether the overall macroeconomic conditions are relevant for explaining the house price dynamics.

The most difficult task here was to choice the threshold variable. Suggested procedure of testing for choice of the transition variables within the test for linearity is complicated by the fact that there exist two alternatives of the corresponding test statistics, depending on whether the candidate variable is endogenous or exogenous to the model. In a situation of small sample and restricted models when some of the candidate variables are endogenous and others exogenous, choosing the threshold variables based on the lowest p-value is not possible, since p-values obtained from different alternatives to the test cannot be compared.

Therefore, it was approached to choosing the threshold variable based on theoretical discussion in part 3, which is also the approach preferred by Camacho (2004). As a result, change in credit on housing was chosen to govern the state of the system of equations. The main reason is that credit market is supposed to be an important environment for transmission of shocks between housing and CB markets, when frozenness of credit market was identified as one of the main reasons for assuming rigidities in the housing market, i.e. the different behaviour of house prices on upward and downward part of the cycle. To verify this choice on data, pairs of variables were plotted (Figure 2). From visual inspection of these plots, dependence is found between dynamics of credit and house prices (the first plot) and dynamics of house prices and issues of CBs (the second plot). The patterns seem to consist of two approximately linear relationships with opposite sign. These relationships are connected with higher and lower rates of growth in credit and house prices respectively. This means that the issuance of CBs increases with higher rate of both growth and fall in either house prices and mortgages. In other words, their issuance increases with more extreme values of both. With this choice, it is then statistically tested for the lag of the transition variable on equation by equation basis.

Figure 2: Dynamics of house prices, credit on housing and CBs



Source: Banco de Espana, AHE and author's computations.

Note: x-axis: yearly change in volume of credit on housing outstanding and house prices respectively, y-axis: volume of CBs issued, labels: year and quarter of observation.

In the first step, linear VAR was estimated for each model specification. Based on Hannan-Quinn information criterion, 2 lags of endogenous variables were included in each model. At the same time, no cointegration relationship was found between variables in levels in either of the four model specifications.

In the second step, it was tested for nonlinearity, which is accepted as a rejection of the null hypothesis of linearity. For each model, the test was conducted for two to five lags of the transition variable. Also, it was tested for both linearity of the system of equations and of individual equations. Tests for linearity of the system of equations reject the null hypothesis of linearity with high level of significance for all four models and all four lags of the transition variable considered. However, tests for linearity of the individual equations fail to reject the null hypothesis of linearity for some of the lags, and they even reject the null for all lags in equation describing the credit dynamics in model

0. That observed, it seems that the test of the nonlinearity of the system tends to be "spoiled" by evidence of nonlinearity in at least one of the equations. Actually, the null hypothesis is often rejected with high level of significance even when it is not rejected for some other equations and lags. Therefore, in model 0, only equation describing the house price dynamics is estimated for two regimes, while just one regime is assumed to describe the dynamics of credit on housing. Similarly, it is approached to choosing the lag of the threshold variable based on equation specific approach. This corresponds to the situation when it takes more time to certain variable to react.

Third, it was tested for specification of the regimes. Two transition functions were assumed, exponential and logarithmic, which lead to a model with inner and outer regime or high and low regime, respectively. Auxiliary regressions for nested hypothesis testing are estimated in two modifications corresponding to the situation when the transition variable is endogenous or exogenous to the system. Based on a sequence of F-tests on estimates of such auxiliary regressions, logarithmic function was suggested to approximate the regime switch for all models in which rate of change of credit is included as endogenous variable (models 0 and 1). In the rest of the cases, exponential function was suggested by the same sequence of tests. On one hand, it might be said that without including the CBs into the system of equations, rigidities are present in the market and for this reason house prices and credit on housing behave asymmetrically during booms and recessions (interpretation of model 0 with logistic function). On the other hand, it might be argued that when issues of CBs are included into the system together with house price dynamics, they may potentially help to correct these rigidities by increasing activity in the market in the downturn, so that inner and outer regimes, which are symmetric around the turnover, are found (interpretation of model 1 with exponential function). However, such conclusions might be misleading, since we do not a priori know which of the models is correctly specified. Instead, it seems that results of the tests are governed by the degree of the Taylor series approximation in the auxiliary regressions, determined by whether the transition variable is endogenous or exogenous to the system. To help to decide on the nature of the regime switch, linear VAR including rate of change of house prices and issues of CBs was estimated on full sample, as well as two subsamples corresponding to positive and negative growth rates of credit on housing. Then, impulse responses were analysed. While for the estimate on the full sample, response of house prices to shock in issues of the CBs evolves close to zero, for the positive and negative regimes of credit growth, the response of house prices in the first quarters is positive and negative, respectively. For this reason, logistic function is assumed to better approximate the change between two regimes in the relation of house price dynamics and issues of the CBs. The same is assumed for dynamics of credit on housing and GDP vis-a-vis both rate of changes in house prices and issuance of CBs, where such an assumption draws out of theory.

Since the transition variables in each equation only differ in how much they are lagged, one common threshold value and transition parameter were estimated for all equations in the individual models. This is motivated by the assumption that if the house price, credit and business cycles are interconnected, the state which is implicitly determined by the threshold value of the switching variable should be common to the system. However, dynamics of each variable may still differ in how lagged their reaction is, which is controlled for by equation specific lag of the transition variables. Results of these tests as well as model specifications and estimates are reported in Tables 5 – 10 of the Appendix.

In the final step, models were estimated using a multivariate LSTVAR model. The grid search was conducted on 50% of the sample, excluding 25% of the observations with the lowest and highest values. It was allowed for 50 partitions of values of the potential threshold values over this interval and 200 values of the smoothness parameter. Having standardized the transition variable by its standard error, the smoothness parameter is scale free and it may run from 0 to 100.

Results of grid search reflect different specification of the models. When house prices dynamics are explained by dynamics of credit only (model 0), estimated transition into the second regime happens when credit on housing already falls by 5% anually. This possibly confirms the hypothesis that regime shift in house price dynamics right around the turnover may not be explained by credit dynamics only. When house prices dynamics are explained using issues of CBs (model 1 and 2), estimated threshold value (7% and 10% change in credit, respectively) suggests the system switches to the second regime around the moment when house prices start to fall. Finally, when house prices dynamics and explained using both credit dynamics and issues of CBs, the transition into the second regime happens when the credit dynamics turn into negative values (-2% change in credit).

Also, estimates of the transition parameter, which are very much close to zero for three models (7, 32.5 and 4 for models 0, 2 and 3 respectively), confirm appropriateness or using TVAR model with smooth transition between regimes. That is, values of the transition parameters are sufficiently far from the value of 100, for which transition function of LSTVAR would approach indicator function of the TVAR model with instantaneous switch between regimes, and thus simpler TVAR would be the preferred option.

Results

Based on these interim results about model specifications, it was approached to the hypothesis testing.

First, inclusion of variables into the system explaining house price dynamics was tested using likelihood ratio test. The null hypothesis of the submodel being better than the full model was rejected on high level of significance for all three cases assumed. This confirms the assumption that house prices, credit and business cycle are mutually interlinked and that CBs play an important role in these relations. (Table 2)

Table 2: Testing for inclusion of variables

	Model 3 vs. model 0:	Model 1 vs. model 2:	Model 1 vs. model 3:
H0:	ch_i shall be excluded	dsl_gdp shall be excluded	dsl_cred shall be excluded
LR test stat.	79.9387	489.3062	439.7871
DF	27	22	22
P-value	3.8580E-07	1.2368E-89	2.4206E-79
Selection	Model 3 with ch_i	Model 2 with dsl_gdp	Model 3 with dsl_cred

Source: Author's computations.

Secondly, pairwise Granger causality tests in a LSTVAR setting were conducted based on approach suggested by Granger and Swanson (1996). For this, the Taylor series expansion approximating the nonlinear behaviour of the variable, which is tested as a potential source of causality, was adjusted for these pairwise submodels to which the transition variable is exogenous.

The null hypothesis of non-Granger causality was rejected for the relation from volume of CBs issued to the house price dynamics, suggesting possible leading effects of the covered bonds. On the contrary, null hypothesis of no causality in the opposite relation was not rejected, corresponding to the fact that falling house prices may hardly lead to increased issuance of CBs.

The null hypothesis of non-Granger causality was then rejected for the relation from house prices to credit on housing. On the contrary, the null hypothesis of the opposite causal relationship failed to be rejected. This confirms results of many previous empirical studies, in which existence of the financial accelerator from credit to house prices is suggested, but not it fails to be empirically confirmed. Finally, this results points at the importance of CBs in Spain in leading the house price dynamics over the last cycle. (Table 3)

Table 3: Results of tests for non-Granger causality

	Model 1: dsl_hp, ch_i		Model 0a: dsl_hp, dsl_cred	
Pair of variables	ch_i – dsl_hp	dsl_hp – ch_i	dsl_hp – dsl_cred	dsl_cred – dsl_hp
H0	ch_i ↛ dsl_hp	dsl_hp ↛ ch_i	dsl_cred ↛ dsl_hp	dsl_hp ↛ dsl_cred
Test stat.	2.8447	1.4634	1.2359	1.9429
P-value	0.0316	0.2300	0.3158	0.0961
DF	5, 31	7, 29	7, 32	7, 32

Source: Author's computations.

Conclusion

The aim of the thesis was to explain different dynamics of house prices on the upward and downward parts of the last house price cycle in Spain, in a situation of overheated economy, indebtedness of households and unprecedented use of covered bonds for mortgage funding. It was suggested that covered bonds first helped to drive house prices up, but they might have also helped to drive them back to equilibrium when the credit market froze and transaction activity became limited.

Due to the interconnectedness of housing, credit and business cycle, significant house price correction may be accompanied by serious economic downturn with occurrence of financial or even sovereign crisis. In a situation of economic stress, lack of other investment opportunities with favourable risk-return characteristics turn investors to buy covered bonds, even when they may expect collateral value to decrease. Crucial condition to this are the strong guarantees provided to investors by law or special contracts governing the covered bonds.

To capture these potential effects, house price dynamics is modelled within the mutually related system of house prices, credit and business cycles, in which the covered bonds are assumed to play an important role. Presence of nonlinear regime switching behaviour between situations of credit boom and squeeze is tested within the framework of vector extension to the smooth transition VAR. In a sequence of models which represent various systems of equations explaining yearly rate of change in house prices, credit on housing, GDP and volume of covered bonds issued, linearity was rejected for these systems as a whole and also for most of the individual equations. This first confirms the need of modelling the house price dynamics in nonlinear framework. Estimate of the threshold parameter supports hypothesis that change in behaviour of the house prices and credit dynamics, as well as the issuance of covered bonds, happens around the credit and house price cycle reversal. Such shift, however, does not happen abruptly. That confirms appropriateness of modelling such relationships using smooth transition VAR. For explaining the house price dynamics, behaviour on market with credit and covered bonds, as well as dynamics of the real economy, are found important. Hypothesis of no causality was rejected in the relation from issuance of covered bonds towards house price dynamics when tested in the nonlinear way. On the other hand, hypothesis of no causality was not rejected in the relation from credit on housing to house prices. This finally gives importance to the covered bonds in leading the house price cycle in Spain.

Data for Spain show that issuance of covered bonds tends to rise with both increasing rate of house price growth, as well as accelerating house price decline. This means that the asset encumbrance increases along the whole duration of house price and credit cycle, which may become source of risks to financial stability. With increasing asset encumbrance, sense of security related to covered bonds, which motivates buyers to invest into them, is increasingly illusionary. With some rate of asset encumbrance, decline in house prices may lead to losses which cannot be covered by the pool of assets, neither with prudent degree of overcollateralization. Moreover, increasing issues of the covered bonds may drive the prices down more rapidly, reducing further the safeguard of the overcollateralization. In this way, the danger connected to the covered bonds lies in the blind faith connected to the guarantees provided, leading to accepting latent risks, while at the same time contributing to the procyclicality of the house price and credit cycle.

Currently, the preferential treatment of the CBs under Basel III framework may lead to further significant preference for holding this instrument. Should the issuance of covered bonds rise in the future, there may be two potential actions to limit these risks. First, including forward looking predictions of house prices into the metod of the collateral valuation used for the dynamic adjustment of the cover pool might be helpful. Secondly, the rate of asset encumbrance should be monitored jointly with stress testing the house prices, since the excessive asset encumbrance may cause the danger of an abrupt fall in house prices more appealling.

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Appendix: Results of the empirical analysis

Table 4: ADF unit root test

Variable	Statistic	P-value
ch_i	-4.2783	0.0079
l_cred	-1.8238	0.6765
l_gdp	-1.5920	0.7805
l_hp	-2.8871	0.1762

* Results for test specification with intercept and trend. H0: The time series contains unit root.

Table 5: Lag lenght criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
Model 0: dsl_hp, dsl_cred						
0	113.8905	-	0.0000	-5.0859	-5.0048	-5.0559
1	277.8836	305.6235	0.0000	-12.3584	-12.1151	-12.2681
2	289.8299	21.1775*	0.0000*	-12.7195*	-12.3140*	-12.5692*
3	290.5953	1.2872	0.0000	-12.5725	-12.0048	-12.3620
4	293.7665	5.0451	0.0000	-12.5348	-11.8049	-12.2642
Model 1: dls_hp, ch_i						
0	-86.4508	-	0.2856	4.4225	4.5070	4.4531
1	0.4778	160.8179	0.0045	0.2761	0.5294*	0.3677
2	7.3442*	12.0163*	0.0039*	0.1328*	0.5550	0.2855*
3	9.1089	2.9118	0.0044	0.2446	0.8357	0.4583
4	15.2141	9.4630	0.0040	0.1393	0.8993	0.4141
Model 2: dls_hp, ch_i, dsl_gdp						
0	27.7198	-	0.0001	-1.2360	-1.1093	-1.1902
1	145.3982	211.8211	0.0000	-6.6699	-6.1632*	-6.4867
2	161.4477	26.4817	0.0000	-7.0224	-6.1357	-6.7018*
3	171.3561	14.8626	0.0000	-7.0678	-5.8011	-6.6098
4	184.0919	17.1934*	0.0000*	-7.254595*	-5.6079	-6.6592
Model 3: dls_hp, ch_i, dsl_cred						
0	-16.8044	-	0.0005	0.9902	1.1169	1.0360
1	130.6176	265.3597	0.0000	-5.9309	-5.4242*	-5.7477
2	144.9214	23.6012	0.0000	-6.1961	-5.3094	-5.8755*
3	149.6531	7.0976	0.0000	-5.9827	-4.7160	-5.5247
4	165.2254	21.0226*	0.0000*	-6.3113*	-4.6646	-5.7159

* Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 6: Linearity testing

Test stat.**/ Transition var.*	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
Model 0: dsl_hp, dsl_cred								
Endogenous	Eq. 1: dsl_hp		Eq. 2: dsl_cred				System	
dsl_cred(-2)	1.9111	**0.0741**	0.8288	0.6213			43.1770	**0.0095**
dsl_cred(-3)	1.0913	0.4016	1.0482	0.4341			31.4743	0.1406
dsl_cred(-4)	1.2881	0.2757	1.0196	0.4565			34.1760	0.0816
dsl_cred(-5)	0.9106	0.5479	1.6537	0.1291			38.3953	0.0316
dsl_hp(-2)	1.3511	0.2430	1.1341	0.3711			39.0137	0.0272
dsl_hp(-3)	1.2089	0.3219	1.5620	0.1569			39.7580	0.0227
dsl_hp(-4)	1.3445	0.2462	1.4481	0.1992			42.1431	0.0124
dsl_hp(-5)	1.1465	0.3626	1.5718	0.1537			48.1198	0.0024
Model 1: dls_hp, ch_i								
Exogenous	Eq. 1: dsl_hp		Eq. 2: ch$_i$				System	
dsl_cred(-2)	3.0885	0.0081	3.9038	**0.0018**			67.4460	0.0000
dsl_cred(-3)	3.0467	0.0088	3.5828	0.0032			73.2303	**0.0000**
dsl_cred(-4)	3.1025	0.0079	1.6860	0.1305			56.9202	0.0000
dsl_cred(-5)	3.8586	**0.0020**	1.2481	0.3024			60.1419	0.0000
Model 2: dls_hp, ch_i, dls_gdp								
Exogenous	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl$_g dp$		System	
dsl_cred(-2)	4.0687	**0.0010**	2.9731	0.0079	4.7583	**0.0003**	163.7855	**0.0000**
dsl_cred(-3)	2.6857	0.0142	3.0930	**0.0062**	3.6854	0.0020	150.5214	0.0000
dsl_cred(-4)	2.8379	0.0104	2.2473	0.0359	3.1949	0.0051	135.0466	0.0000
dsl_cred(-5)	3.3819	0.0035	2.1044	0.0489	2.8892	0.0094	133.5797	0.0000
Model 3: dls_hp, ch_i, dsl_cred								
Endogenous	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred		System	
dsl_cred(-2)	5.9952	**0.0001**	2.9224	0.0113	2.0498	0.0614	193.7746	**0.0000**
dsl_cred(-3)	2.5108	0.0245	3.1107	**0.0080**	2.1873	0.0465	184.7436	0.0000
dsl_cred(-4)	3.2793	0.0060	1.9333	0.0779	1.8446	0.0934	173.3336	0.0000
dsl_cred(-5)	4.3366	0.0011	1.9950	0.0686	2.9277	**0.0112**	209.8875	0.0000
dsl_hp(-2)	4.2967	0.0011	1.4261	0.2204	1.9927	0.0689	174.8981	0.0000
dsl_hp(-3)	2.4071	0.0301	2.7475	0.0156	2.5698	0.0219	180.2284	0.0000
dsl_hp(-4)	2.7648	0.0151	3.6051	**0.0034**	2.0447	0.0620	177.3910	0.0000
dsl_hp(-5)	2.5583	0.0224	2.0817	0.0575	1.9951	0.0686	172.6773	0.0000
ch_i(-2)	2.0426	0.0623	3.3675	0.0051	0.3404	0.9873	131.3640	0.0000
ch_i(-3)	2.7389	0.0159	3.7629	0.0026	1.9831	0.0703	168.5088	0.0000
ch_i(-4)	3.6248	0.0033	4.3229	**0.0011**	1.1404	0.3857	184.1717	0.0000
ch_i(-5)	2.3301	0.0350	1.6445	0.1410	0.8354	0.6470	131.8820	0.0000

* Number of lags in parenthesis
** Refers to specification of the test statistic for when transition variable is endogenous or exogenous to the system estimated
*** Transition variables the lowest p-values are in bold

Table 7: Testing for transition function specification

	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
Model 0: dsl_hp, dsl_cred								
Endogenous*	Eq. 1: dsl_hp		Eq. 2: dsl_cred				System	
Transition var.	dsl_cred(-2)		None—					
H1	14.4770	0.0059						
Trans. fction	Logistic							
Model 0b: ch_i, dsl_cred								
Endogenous*	Eq. 1: ch_i		Eq. 2: dsl_cred				System	
Transition var.	dsl$_{c}red(-3)$		None					
H1	7.8077	0.0989						
Evaluation	Logistic							
Model 1: dls_hp, ch_i								
Exogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i				System	
Transition var.	dsl_cred(-5)		dsl_cred(-2)				dsl_cred(-3)	
H1	12.0707	0.0338	16.1097	0.0065			20.1159	0.0282
Trans. fction	Exponential		Exponential				Exponential	
Model 2: dls_hp, ch_i, dls_gdp								
Exogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_gdp		System	
Transition var.	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-2)		dsl_cred(-2)	
H1	24.6173	0.0009	24.6999	0.0009	9.1260	0.2437	56.5616	0.0000
Trans. fction	Exponential		Exponential		Logistic		Exponential	
Model 3: dls_hp, ch_i, dsl_cred								
Endogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred		System	
Transition var.							dsl_cred(-2)	
H1							66.7769	0.0000
Trans. fction							Logistic	

* Refers to specification of the test statistic for when transition variable is endogenous or exogenous to the system estimated

Table 8: Estimation: Model 0

Model 0: dsl_hp, dsl_cred			
	Eq. 1: dsl_hp		Eq. 2: dsl_cred
Regime	LOW	HIGH	One regime
c	-0.0733	0.0753	0.0039
	0.0312	*0.0329*	*0.0025*
dsl_hp(-1)	1.0779	0.1146	0.1146
	0.4232	*0.1487*	*0.1487*
dsl_hp(-2)	-0.2736	0.0408	0.0408
	0.4656	*0.1620*	*0.1620*
dsl_cred(-1)	-0.5674	1.3380	1.3380
	0.7541	*0.1454*	*0.1454*
dsl_cred(-2)	-0.0195	-0.4536	-0.4536
	0.7707	*0.1393*	*0.1393*
Transition variable	dsl_cred(-2)		–
Threshold value	-0.0535		
Smoothness parameter value	7		

* Standard errors in italics

Table 9: Estimation: Model 1

Model 1: dls_hp, ch_i				
Equation	Eq. 1: dsl_hp		Eq. 2: ch_i	
Regime	LOW	HIGH	LOW	HIGH .
c	-0.0144	0.0034	9.4280	8.5345
	0.0084	*0.0109*	*4.9298*	*-1.0761*
dsl_hp(-1)	0.8260	0.3378	-174.8040	243.5464
	0.2390	*0.3451*	*174.1166*	*262.9662*
dsl_hp(-2)	-0.3307	0.2267	174.6397	-243.2717
	0.1940	*0.3318*	*125.3783*	*248.9517*
ch_i(-1)	-0.0009	0.0007	0.2465	-0.1834
	0.0004	*0.0005*	*0.2707*	*0.4114*
ch_i(-2)	-0.0010	0.0011	-0.0030	0.3082
	0.0004	*0.0005*	*0.2888*	*0.4243*
Transition variable	dsl_cred(-5)		dsl_cred(-2)	
Threshold value	0.0721			
Smoothness parameter value	79.5			

* Standard errors in italics

Table 10: Estimation: Model 2

Model 2: dsl_hp, ch_i, dsl_gdp						
	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_gdp	
Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
c	-0.0107	-0.0051	10.6456	-13.3068	-0.0026	-0.0078
	0.0062	*0.0284*	*5.1643*	*16.5285*	*0.0029*	*0.0132*
dsl_hp(-1)	0.8072	0.2940	-183.9264	153.1451	0.1584	-0.2829
	0.2581	*0.4061*	*192.7290*	*300.8053*	*0.1204*	*0.1894*
dsl_hp(-2)	-0.2325	0.1954	171.4122	-137.8881	-0.1400	0.3439
	0.1983	*0.3978*	*148.1185*	*290.4885*	*0.0925*	*0.1856*
ch_i(-1)	-0.0009	0.0005	0.2249	-0.4210	-0.0001	0.0001
	0.0004	*0.0007*	*0.2839*	*0.4951*	*0.0002*	*0.0003*
ch_i(-2)	-0.0009	0.0009	-0.0383	0.1389	0.0002	0.0000
	0.0004	*0.0007*	*0.2986*	*0.5013*	*0.0002*	*0.0003*
dsl_gdp(-1)	0.0632	0.4154	72.8618	342.3774	1.4612	-1.1416
	0.2448	*0.6426*	*182.8540*	*429.9534*	*0.1142*	*0.2997*
dsl_gdp(-2)	-0.1486	-0.1044	25.6686	20.8786	-0.7241	1.3764
	0.2383	*0.6991*	*178.9154*	*480.0946*	*0.1112*	*0.3261*
Transition variable	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-2)	
Threshold value	0.0976					
Smoothness parameter value	32.5000					

* Standard errors in italics

Table 11: Estimation: Model 3

Model 3: dsl_hp, ch_i, dsl_cred						
	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred	
Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
c	-0.0357	0.0343	46.0095	-40.1450	0.0107	-0.0044
	0.0203	*0.0241*	*12.4850*	*14.2231*	*0.0374*	*0.0406*
dsl_hp(-1)	0.6018	0.9419	-242.7826	-16.2718	0.4678	-0.8718
	0.4937	*0.6128*	*289.4620*	*355.9340*	*0.7630*	*0.8985*
dsl_hp(-2)	-0.2102	-0.2967	32.4624	158.8709	-0.4584	0.9824
	0.4564	*0.5874*	*264.3706*	*335.6299*	*0.6671*	*0.8242*
ch_i(-1)	-0.0011	0.0015	0.1067	-0.8310	0.0002	-0.0008
	0.0006	*0.0009*	*0.3321*	*0.4724*	*0.0009*	*0.0011*
ch_i(-2)	-0.0012	0.0017	-0.2640	-0.1424	-0.0011	0.0011
	0.0006	*0.0009*	*0.3514*	*0.4914*	*0.0010*	*0.0012*
dsl_cred(-1)	-0.1677	0.2209	726.5346	-659.1191	0.6062	0.9580
	0.6353	*0.6895*	*362.4099*	*389.1195*	*0.9167*	*0.9591*
dsl_cred(-2)	0.0225	-0.1729	-272.5356	350.4255	0.4220	-1.0745
	0.5974	*0.6295*	*350.8910*	*363.6703*	*0.8888*	*0.9149*
Transition variable	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-5)	
Threshold value	-0.0186					
Smoothness parameter value	4					

* Standard errors in italics

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz

Institute of Economic Studies, Faculty of Social Sciences
Charles University in Prague

The Role of Covered Bonds in Explaining House Price Dynamics in Spain

Hana Hejlova

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Institute of Economic Studies,
Faculty of Social Sciences,
Charles University in Prague

[UK FSV – IES]

Opletalova 26
CZ-110 00, Prague
E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

Institut ekonomických studií
Fakulta sociálních věd
Univerzita Karlova v Praze

Opletalova 26
110 00 Praha 1

E-mail : ies@fsv.cuni.cz
http://ies.fsv.cuni.cz

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The Role of Covered Bonds in Explaining House Price Dynamics in Spain

Hana Hejlova[a]

[a]Institute of Economic Studies, Faculty of Social Sciences, Charles University in Prague, Smetanovo nábreží 6, 111 01 Prague 1, Czech Republic
Email (corresponding author): hejlova.hana@gmail.com

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Abstract:
This paper tries to explain different nature of the dynamics during the upward and downward part of the last house price cycle in Spain. Covered bonds are introduced as an instrument which may accelerate a house price boom, while it may also serve as a source of correction to overvalued house prices in downturn, where important rigidities may be present In a serious economic stress, lack of investment opportunities motivates investors to buy covered bonds due to the strong guarantees provided, which may in turn help to revitalize the credit and housing markets. To address such regime shift, house price dynamics is modelled within a framework of mutually related house price, credit and business cycles using smooth transition vector autoregressive model, in which volume of covered bonds issued is included. Linear behaviour of such system is rejected, indicating the need to model house prices in a nonlinear framework. Also, importance of modelling house prices in the context of credit and business cycles is confirmed and causality from issuance of covered bonds to house price dynamics is found in this nonlinear structure. Finally, potential threat to financial stability resulting from rising asset encumbrance both in the upward and downward part of the house price cycle is identified. It is suggested that the collateral valuation used for the dynamic adjustment of the cover pool is done using forward looking predictions of house prices and that the rate of asset encumbrance is monitored jointly with stress testing the house prices.

Keywords: House price dynamics, credit cycle, asymmetric behaviour, rigidities on housing market, covered bonds, smooth transition vector autoregressive models
JEL: E32, G21, G23, E44, E58, C32

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Introduction

In many domestic housing markets, behaviour of house prices around the last financial crisis revealed important rigidities on the downward part of the house price cycle, with different speed of adjustment across countries. While part of these differences may be explained by distinct indebtedness of households and subsequent deterioration on credit markets, adjustment mechanism in those countries where the indebtedness grew the most still remains largely unexplained.

One of the explanations of the different dynamics of house price adjustment across countries may be the different to which covered bonds were used along the cycle. Their possible enhancement effects on the upward part of the house price cycle have been neglected in light of extensive use of mortgage backed securities, which were typical of the U.S., but less of some European countries like Spain, for example. Their possible corrective effects on the downward part of the house price cycle have been recently discussed on theoretical grounds, but they have not been empirically examined yet.

Although the use of both securitization instruments – the mortgage backed securities and the covered bonds – were in many countries associated with house price bubbles, nature of the underlying mechanism between use of these instruments and house prices seems to be different in light of development after the house price reversal. While in the past, covered bonds played an important role in several countries only, the new liquidity regulatory regulation based on the Basel III framework may extend issuance of them to other economies. For this reason, empirical investigation of potential effects of the covered bonds on house prices should be getting more attention.

There are several features that make Spain a convenient country to address such question. The housing market in Spain experienced an unprecedented upswing in house prices in years preceding to the financial crisis, with household indebtedness rising sharp. Despite a significant excess of dwellings, however, house prices long hesitated to fall after the bubble burst. At the same time, both sides of these cycles, the peak and the trough, were accompanied by significant issuance of covered bonds. Should therefore the covered bonds had some impact on the house price dynamics, its importance for credit financing in Spain makes this country a unique case to study this effect.

Regardless of the source of potential rigidities in the market with housing, different dynamics on the upward and downward part of the house price cycle showed that modelling house prices using linear models may not always give valid results. Despite this, existing attempts to put house prices into nonlinear models have been limited to univariate or uniequational framework, most of all. In the theoretical literature, some authors nevertheless argue that given the interrelations between house prices and business cycle, nonlinearities in house prices might well explain nonlinerities in macroeconomic variables like the output, which have been largely modelled apart. (Balcilar et al., 2012)

To address these issues, Part 2 reviews house prices in Spain in the context of mutually reinforcing powers between business, credit and house price cycles and presents possible sources of rigidities on the downward part of the house price cycle. Part 3 introduces covered bonds, describes their importance for house price price dynamics and explains motivation for assuming them as a potential source of the corrective mechanism on the downward part of the house price cycle. Part 4 reviews procedure for estimating STVAR models and presents model for explaining house price dynamics in the framework of business and credit cycles, extended by the use of covered bonds.

The contribution of the present work is twofold. First, it tests the mechanism behind the use of covered bonds and development of house prices in an empirical way, which has not been done so far. Secondly, it models house prices in a nonlinear framework extended to a vector of variables, where one of them is the covered bonds.

2. House prices and the last financial crisis in Spain

House prices, real economy and financial system

The last boom phase of the Spanish economy was not only of higher amplitude, but also of a longer duration than the booms previously experienced. Significant growth of gross domestic product was accompanied by an increase in real wages. Growing incorporation of women into labour market and better conditions for employability of young workers accounted for an increase in disposable income of households, the basic unit for decision making about housing purchase. Since there has always been a high propensity to primary home ownership in Spain and popularity of secondary housing, the favourable economic development lead to increased number of purchases of housing of both types.[2] Positive price signals from the real estate market then translated into economic

[2] For an overwhelming discussion of housing demand and supply determinants in Spain, see Esteban and Altuzarra (2008).

activity through increased activity in the construction sector, which turned to be the most dynamic part of Spanish economy and helped to boost the real economy even more.

In a situation of rising house prices, decreasing nominal interest rates combined with high average inflation in Spain and tax deductibility of mortgage interest payments made financning house purchases more affordable. Moreover, "*credit is not only procyclical in Spain, but actually amplifies the cycle.*" (Herrero and de Lis, 2008) Upswing in real estate prices caused that value of the mortgage collateral raised and allowed for further increase in mortgage lending. Similarly, income conditions of borrowers were significantly improved due to the booming phase of the economy, what lead to general over-optimism of banks at the time of mortgage granting. Banks were strongly motivated to lend by increasing profitability, since there were both lower loan loss provisions and loan losses incurred. The surge in credit was also significantly allowed for by recourse to foreign funding, which also made it less anticipated by the national authorities. (Jimeno and Santos, 2014)

With purpose of increasing bank resilience, reducing procyclicality of lending and eliminating feedback effect from the credit granting to the real economy, dynamic provisioning was introduced in 2000 by the Bank of Spain. It was designed on the premise that lending mistakes (such that materialize in the downturn) are prevalent in the upturn. In this way, it complemented the already existing general and specific provisioning by a statistical component, counting with losses that "*have not yet been identified in specific loans*".[3] (Saurina, 2009)

Modelling house prices in Spain: Literature review

Existing research on house price dynamics in Spain has been twofold. One stream of investigators follow asset market approach and base their approach on microeconomic decision making between purchasing housing as an asset and paying for it as a service.

Ayuso and Restoy (2006) use inter-temporal asset pricing model where housing services and consumption are allowed to interact. Equilibrium house prices are then estimated on a dataset until the first half of 2003 using VAR model

[3] To gain approval of the IFRS, statistical provisions became a part of the general provisions fund in 2005. However, until the proposal of the Basel III, which introduced countercyclical tools, Spain was the only example in the world of application of such anticyclical regulatory tool. (Hilbers et al., 2005)

for three countries including Spain. They find that the degree of house price overvaluation was about 20% and attribute this to the sluggishness of supply to demand shocks and slow adjustment of rents.

The second stream of research, which also this work belongs to, cover more macroeconomic type of models, which often include indicators of house prices, real economy and credit market and usually lead to autoregressive models.

Gimeno and Martínez (2006) and (2010) model house prices using loans on house purchase and nominal interest rates in a VECM model covering period until 2004 and 2009, respectively. They find that in the long run, house prices depend positively on income and level of credit financing. By imposing restriction of zero coefficient to the nominal interest rates in the house price equation, so that changes in financing costs are only reflected in volume of mortgage loans, they find that level of indebtedness depends positively on income and negatively on nominal interest rates. House prices then tend to adjust when the level of indebtedness exceeds its equilibrium value, with significant corrective power of nominal interest rates.

Esteban and Altuzarra (2008) provide broad discussion of macroeconomic determinants and analyse house price dynamics until the first half of 2006 using cointegration analysis. Compared to other works, they also include determinants of housing supply. They find that number of housing starts is positively explained by the number of households, house prices and real residential investment, while the effect of mortgage rate is negative. They conclude that house price increase in Spain was mainly demand driven, but, they did not attribute these dynamics to a speculative bubble.

Valverde and Fernández (2010) broaden the set of variables used in Gimeno and Martínez (2006) by adding real interest rates and inflation to capture effect of membership in the EMU and price-to-rent ratio. They also try to avoid problem of omitted variable bias by including proxy for credit quality using mortgage credit default rates. By employing VECM on period until 2010, they confirm results reached by Gimeno and Martínez (2006) but they suggest presence of structural shock in lending before 2001, when legislation on securitization was adopted and real interest rates dropped significantly. By estimating the model on two subsamples, they also find that house prices and interest rates had stronger effect on mortgage lending after credit conditions were eased.

Hejlová (2011) then aims at capturing mutually reinforcing powers between real economy, housing and credit market as described earlier and assessing the role of anticyclical prudential tools within this framework. It proposes simple model where the three markets are represented by gross domestic product, volume of credit on housing and house prices (in both real and nominal terms). Limited by short time span of publicly available data, it employs less variables than the previous models, but takes advantage of including volume of dynamic provisioning and foreign investment in real estate as endogenous and exogenous variable, respectively. The time series used cover the period between 1996 and 2010, and thus offer additional information about the adjustment process. In such setting, cointegration analysis was first carried out. It was found that when the sample is restricted to the period covering the house price increase, more cointegrating relationships are found in the data. This suggests that mutually reinforcing powers between the real economy, credit and housing market function correctly in the upturn, whereas in the downturn, rigidities may be present.

Rigidities on the downward part of the house price cycles

Rigidities on housing market, which may cause asymmetric behaviour of house prices on the downward side of the cycle, have been recently widely addressed on theoretical grounds. The main motivation for research is the so called house price puzzle, when there has been found "*a strong positive correlation between house prices and sales volume.*" (Genesove and Mayer, 2001) There have been two main theoretical contributions explaining such rigidity: the equity constraint and aversion to loss. On one hand, households tend to buy their own housing when they expect prices to rise and so avoid paying more in the future. (Balcilar et al. (2012) from Abelson et al. (2005)) On the other hand, general unwillingness of sellers to realize nominal losses by selling their housing bellow the initial purchase price has been noticed during the downward part of the house price cycle, called aversion to loss. (Genesove and Mayer, 2001) One may argue that the asking and bidding prices should always meet, so that the adjustment of both should happen. In reality, only a small correction of the original asking prices is documented by the final transaction prices. Instead, "*homes tend to sit on the market for long periods of time with asking prices, and many sellers eventually withdraw their property without sale.*" (Genesove and Mayer, 2001) Special case of aversion to loss called equity constrain has then been identified for mortgage financed housing, where accepting lower price might leave debtor with negagive equity. (Engelhardt, 2003)

In the particular case of Spain, mortgages were often used to finance not only primary, but also secondary housing or purchases which were motivated by speculative reasons.

As a result of these rigidities, households are less likely to transact, causing stickiness on the downward part of the house price cycle. Therefore, modelling house price dynamics must be done in a nonlinear framework, using different regimes along the house price cycle. To this end, researches should better know mechanism which underlies the house price reversal. In what follows, covered bonds are introduced as a potential source of such correction.

3. Covered bonds and house price dynamics

Selected features of the covered bonds

Covered bonds (CBs) are debt instruments secured by underlying pool of assets (cover pool) and characterized by strengthened protection of investors. Although specific arrangements differ considerably across countries, there are several features which are common for CBs in general.[4] First, the CB holders have preferential claim on the cover pool over unsecured investors in case of the issuer´s bancruptcy. Secondly, the issuer has to maintain required value of the cover pool all the time, i.e. to adjust assets in the pool dynamically according to changes in value. Minimum quality standards may also be required of these assets by law or contract governing the issuance. To ensure sufficient value under stress, overcollateralization is often mandatory or is held voluntarily by the issuer. Third, the double recourse guarantees that when the value of the cover pool is not sufficient to cover the incured loss, CB holders may also proceed to the issuer´s insolvency estate. CBs are most typically used for financing mortgage loans, but issuing CBs for funding public debt is also common.

The main differences between CBs, ordinary secured debt and asset or mortgage backed securities are the balance sheet treatment of the underlying assets and the investor's recourse in case of issuer's default. Being "*a form of secured debt that also shares some characteristics of securitized products, in some sense covered bonds could be interpreted as a mixed instrument between both classes of debt securities.*" (Martín et al., 2013)

[4]See for example ECBC (2014) (ECBC is an organization that serves as a platform for participants in the CB market, representing interests of the cover bond issuers. To our limited knowledge, it serves as source of data for all cross country comparisons of the CBs.)

Both CBs and other secured bonds are subject to a balance sheet treatment. However, while assets underlying the CBs are fenced into the pool on an individual basis, the pool for secured bonds may be any assets on the balance sheet of given minimum value. Contrary to this, the cover pool is sold together with the asset backed securities as a part of the special purpose vehicle (SPV) created for this purpose, which means that it gets off the balance sheet. To remove the assets, special purpose vehicle is usually created[5]. This leaves the CBs the only instrument for which collateral pool may be adjusted subject to its value. Guarantee of sufficient value of the CBs collateral pool is further strehghtened when overcollateralization is in place.[6]

In case of bankruptcy, investors in CBs not only have a claim on the issuer like in case of ordinary secured bonds, but this is not either limited solely to the collateral pool like in case of ABSs. In the latter case, the recourse of the investor is constrained by the cash flows from the securitized portfolio of assets, performance of which is not further guaranteed by the issuer. (ECBC, 2014) When the default rate of the pool underlying securitization exceeds the expected rate, the resulting loss is borne by the investor. In case of CBs, such an access to the issuer's proceeds is ensured even in cases when securities are issued by a special purpose entity, which further claims the proceeds upon the originating credit institution.

Following from the different treatment with regards to the balance sheet, both the principal and interests are paid out from the pool of assets in case of ABSs. On the contrary, the cover pool behind the CBs only serves as collateral, when it stays on the issuer's balance sheet, with instalments paid out from the cash flows of the bank. This applies for both CBs and other secured bonds. Moreover, while these payments usually have fixed interest rates for CBs, they are often floating for the ABSs (Packer et al., 2007), which may further be a source of interest rate risk (however, considering such risk is not straightforward when the underlying mortgages are of variable interest rate).

The covered bonds have historically been typical of the European markets, while asset backed products have been associated with the US. The first covered bond type of products can be dated back to the 18th century. The first "modern

[5]Although a purposefully created SPV may serve for putting the cover pool by in case of covered bond contracts, too, which is typical of the U.K. (Rosen, 2008), it still belongs to the issuing entity.

[6]Spain has the tightest overcollateralization limit implied by the LTV limit on issuance, which is 25% for CBs backed by mortgage loans; this should mitigate the risk that may potentially arise from higher LTV mortgages in the pool. (Martín et al., 2013)

type" CB legislations are those of Switzerland (1931), Denmark (1951) Spain (1981) and Germany (1990). The widespread use of CB is associated with the introduction of euro, when the first CBs in benchmark format (Jumbo) called Pfandbrief were issued in 1995. The biggest CB markets have created in Germany, Denmark, France and Spain, while the most dynamic markets are nowadays is that of Sweden. As of 2013, almost 90% of CB volume was issude in the EU. Around 20% of the European issuance was made in Germany, while in Denmark and Spain it was 16 and 14% respectively. Mortgage backed CBs represented 100% of mortgage volume in Denmark and around 60% in Spain and Sweden. (based on ECBC (2014))

For an issuer, CBs represent a way of obtaining relatively cheap long-term financing, since guarantees provided by the double recourse make the interest payments demanded by investors effectively lower compared to both secured and unsecured instruments. (Ergungor, 2008) Currently, the generally low interest rate environment have made it difficult to attract sufficient volume of deposits, what makes the importance of CBs increasing. With the differential treatment introduced by the liquidity regulation under the Basel III (BCBS, 2013), CBs have also become an important tool for an efficient asset-liability management. (IMF, 2006) For reasons of the strengthened guarantees provided, CBs are on the other hand attractive among conservative and long-term oriented investors (Martín et al., 2013), interested in the highest quality instruments (Packer et al., 2007) with hold-to-maturity strategies. From the investor's point of view, such security bears higher yield than other safety investments like the government bonds. This in turn creates another advantage for the issuer, since such an investor base is different to the one attracted by ABSs for example, what further helps to diversify their portfolios. (Ergungor, 2008) Finally, CBs may represent an easy way of recourse to substantial amount of repo liquidity, since they are eligible as collateral in some of the central banks (e.g. the ECB). In these cases, regulatory standards of CBs like requirement for overcollateralization may play an important role (see for example EC (2014) for coditions of CBs eligibility for the ECB).

Valverde, Rosen and Rodríguez (2011) examine whether the systematic use of MBSs and covered bonds vary across banks depending on their characteristics related to their performance and risk profile in six countries including Spain, U.K. and the U.S. Authors find that banks issue covered bonds in times when they mostly need to raise liquidity, which is not the case of the MBSs. They also confirm that issuing covered bonds is a successful strategy in meeting such goal across banks. Cardone et al. (2010) address motivation behind the excessive use of securitization directly, confirming that liquidity has been the driver of CB issues.

Due to the enforced protection of investors embedded in the regulation, CBs were often regarded as close substitute to government bonds. Prokopczuk, Siewerty and Vonhoff (2013) point out that "*yield spread with respect to government securities has often been interpreted as pure liquidity premium.*" However, they show on data from Germany that credit risk was also embedded in the CB pricing, when diference between the risk premia of CBs backed by mortgage loans and government bonds varied during different phases of the last financial crises. Prokopczuk and Vonhoff (2012) also show that risk premia of mortgage backed CBs differes across countries depending on the conditions of real estate markets. These differences tend to be minor during normal times and tend to grow up to significant levels during periods of financial stress.

Covered bonds and house prices

On one hand, favourable terms provided by the investor to CBs translate to lower interest rates on housing credit offered to the households, which may tend to borrow more than they would otherwise do. For this reason, CBs may serve as an important fuelling factor during the initial part of the house price upswing, while home proprietorship is becoming accessible and the boom starts to build up. On the other hand, the Banking Supervision Committee of the ECB in 2011 reported about CBs as an alternative for typical instruments of securitization, which might be particularly useful in the downturn. (ECB, 2011) In line with need to ensure access to financial resources, which is needed to restore equilibrium on market with housing, there has been hope that CBs might represent new sources of mortgage financing. (Rosen, 2008) To address such question, I analyzed behaviour on the covered bond markets under market stress.

Recently, there have been two such episodes of stress – the financial and the subsequent sovereign crisis in the EU and the rest of the world. During the initial period of the financial crisis, the volume of unsecured bonds fell notably except for the government bonds, while the amount of securitization of the ABS type even rose on global level. Compared to these dynamics, market with CBs showed high stability when measured by the change in spreads. Prevailing sources of uncertainty were predominantly linked to valuation of assets that serve as collateral. The most significant increase in spreads was realized in countries where house prices were believed to be overvalued the most, with expectations of their correction (Spain and the UK). (Martín et al., 2013)

CBs then did not get into more severe troubles until the deterioration of the financial crisis after September 2008, when the hardship mainly concerned issuance on the primary markets. These fell to the pre-crisis levels, accompanied by rising spreads. To boost activity on the secondary market, the ECB launched the first wave of the Covered Bond Purchase Program in 2009.

When the sovereign crisis aggravated problems arising from the financial crisis itself, reaction of the national markets with CBs sharply diversified. Issuance in the Eurozone as a whole dropped, while the activity shifted to other countries, like the north-European ones, Canada or Australia. Within the Eurozone, countries split along the peripheral and non-peripheral countries, when "*the market almost closed for Irish and Portuguese investors and issuance weakened in Italy and Spain.*" (Martín et al., 2013) That polarization was also evident from the data on maturity profile of the issues, with decreasing length in countries from the periphery as a result of increased uncertainty. This lead to the second CBPP by the ECB in 2011. While it had not been seen before that rating of the CBs would accede that of the sovereign bonds, dramatic deterioration in some of the economies connected with worsening of the sovereign crisis made this relation reverse. Accidentally, Spanish CBs started to trade within the government bonds.

Possible explanation may be that at the beginning of the turnaround, extensive stock of CBs previously used for financing may in fact cause the credit market even more stuck. When the overall conditions deteriorate, the seeming protection provided by the CBs makes them a relatively favourable instrument for investors, what then implicitly helps the credit market get back to equilibrium. For this reason, the house price decrease in Spain may have been found limited due to the initial deterioration on the credit market resulting from high share of CBs in banks' portfolios. As the crisis proceeded and the sovereign conditions deteriorated, CBs might have become an increasingly popular investment and became one of the sources of adjustment.

CBs can then help to revitalize the credit market for two reasons. First, their issuance simply makes the mortgage financing possible. Secondly, relatively favourable terms under which CBs are issued even in more turbulent times make mortgages more attractive to households in a situation when house prices are expected to fall, which would otherwise press them to postpone the house purchase to a later moment in time. Investors into CBs, on the other hand, take advantage of getting higher interest compared to its levels in more normal times, while they still believe that the guarantees provided safeguard them from any potential loss connected to the fall in house prices. Inherent prerequisite for such an assumption is that the security provided by CBs to investors reduces uncertainty which would persist with use of any other instrument in times when general conditions significantly deteriorate. Guarantees provided with CBs may be able to maintain confidence among investors even when the market turns over, including likely deterioration in the collateral value.

Under such hypothesis, relationship between covered bonds and house prices is both positive and negative depending on the phase of the house price cycle. This would suggest that modelling house prices in linear framework does not work and confirm the need to model dynamics on the upward and downward part of the house price cycle differently. To address such concern, I approach to modelling house prices using smooth transition vector autoregressive model.

4. Empirical analysis

Motivation

Abrupt rise in house prices prior to 2008 and their sluggish adjustment thereafter raises questions about ways of modelling such asymmetric behaviour. As was found in Hejlová (2011) after splitting the sample around the turning point, there are relations between housing prices, credit and business cycle which tend to function smoothly during the boom periods, but cease to exist during recessions. Valverde and Fernández (2010) then find evidence of structural break in credit financing of housing before 2011, pointing at the fact that this occurred at the time when "*mortgage credit securitization substantially grew.*" (Valverde and Fernández, 2010)

To address this problem, first, CBs have been introduced as a potential source of change in the underlying mechanism between house prices and credit. In the following part, differences in mechanism behind the dynamics between both sides of the cycle are tested and modelled using a smooth transition vector autoregression model. Such model assumes existence of two linear regimes, governed by values of the so called transition variable vis-a-vis some threshold value, with smooth transition between these regimes. Such transition then depends on the size of departure of this threshold variable from the threshold value.

Using ST(V)AR models

Currently, the most comprehensive STVAR model is that of Camacho (2004), which is a vector extension of previous STAR models as developed by Granger et al. (1993) and Terasvirta (1994). The model takes form of:

$$y_t^1 = \beta_{y1}^t A_t + \left(\tilde{\beta_{y1}^t} A_t\right) F_{y1}\left(D_{t,y1}\right) + \alpha_{y1} e_{t-1} + u_{y1,t}$$

$$\vdots$$

$$y_t^n = \beta_{yn}^t A_t + \left(\tilde{\beta_{yn}^t} A_t\right) F_{yn}\left(D_{t,yn}\right) + \alpha_{yn} e_{t-1} + u_{yn,t},$$

where y_i are n endogenous variables ($y = 1, ..., n$, n$\in N$),A=$\left(1, X_t'\right)'$ is the vector of constant and lagged variables until the lag p ($p \in N$),β_{yi} and $\tilde{\beta_{yi}}$ are vectors of coefficients and F is a transition function, where $D_{t,i} = z_{t,i} - g_i$, i.e. departure of of the transition variable z_i from the threshold g_i. e_t is the equation error included in case of cointegrated variables and t denotes time ($t = 1...T$). The series of errors, u_i, are assumed to be serially uncorrelated. (Rewritten from Camacho (2004) for case of n variables.)

When the value of the transtion function F (governed by departure of of the transition variable z_i from the threshold g_i) approaches zero, the system reduces to VAR with coefficients β_{yi}. When its value approaches one, the system reduces to another VAR with coefficients $\beta_{yi} + \tilde{\beta_{yi}}$.

The standardized procedure to estimate STAR models proposed by Terasvirta (1994) consists of the following steps:

1. Specifying linear VAR with maximum lag length determined using linear estimation techniques.

2. Suggesting whether nonlinearity is present in the time series by the means of testing for linearity of the system of equations.

3. Estimating parameters of the model; estimating parameters of the transition function is done a priori using two-dimensional grid search.

4. Evaluating the model and retrieving impulse responses.

5. Evaluating predictive power of the model by the means of comparing forecasts of alternative models.

For testing nonlinearity, Camacho (2004) introduces vector extension to test for nonlinearity as developed by Luukkonen et al. (1988). Such test may be used to test for nonlinearity of a system as a whole or each equation separately. It takes form of:

$$y_1 = \varepsilon_{y1,0} + \sum_{h=0}^{3} \xi'_{y1,h} X_t w^h + u_{y1,t}$$

$$y_2 = \varepsilon_{y2,0} + \sum_{h=0}^{3} \xi'_{y2,h} X_t w^h + u_{y2,t},$$

where y_i $(i = 1, 2)$ are endogenous variables, X is the vector of lagged variables until lag p $(p \in N)$, $\varepsilon_{yi,0}$ and $\xi_{yi,h}$ are vectors of coefficients, u_i are series of errors and t denotes time $(t = 1...T)$. The null hypothesis of linearity is equal to $H0 = \xi_{i1} = \xi_{i2} = \xi_{i3} = 0$. For testing linearity of the system, LR statistic is used in a form of $LR = T\,(|\sum_R| - |\sum_U|)$, where $|\sum_R|$ and $|\sum_U|$ are determinants of the estimated variance-covariance matrix of the restricted and unrestricted model, respectively, and T is the number of observations in each equation. Distribution of the statistic is with χ^2 with degrees of freedom equal to number of the restrictions. For testing individual equations, LM statistic is used, in a form of $LM = (SSR_0 - SSR)/\hat{\sigma}^2$ with asymptotic $\chi^2(3p)$ degrees of freedom, where SSR_0 and SSR is the sum of squared residuals of the restricted and unrestricted model, respectively.

Additionally, Camacho (2004) also assumes situation when threshold variable is exogenous to the autoregressive system. In such case, the Taylor approximation reduces to:

$$y_1 = \sum_{h=0}^{2} (\varepsilon_{y1,h} w^h + \xi'_{y1,h} X_t w^h) + u_{y1,t}$$

$$y_2 = \sum_{h=0}^{2} (\varepsilon_{y2,h} w^h + \xi'_{y2,h} X_t w^h) + u_{y2,t},$$

with the same notation. The null hypothesis of linearity here is equal to $\varepsilon_{i1} = \varepsilon_{i2} = 0$, $\xi_{i1} = \xi_{i2} = 0$.

For modelling of the smooth transition between the regimes, two concrete functions have been widely assumed:

Logistic function $F_i(D_{ti}) = \frac{1}{1+e^{-\gamma_i D_{ti}}}$, where again $D_{t,i} = z_{t,i} - g_i$ and

exponential function $F_i(D_{ti}) = 1 - e^{-\gamma_i D_{ti}}$, where $D_{t,i} = (z_{t,i} - g_i)^2$.

The type of the transition function has a key role in the interpretation of the model. The logistic function is suitable for modelling economic relations in which different regimes – higher and lower – are associated with values of the transition variable below and above certain threshold, respectively. The exponential function is, on the other hand, only governed by the size of deviation from such threshold, offering one outer regime for deviations from the threshold which are more significant, and one inner regime for deviations which are smaller. (Terasvirta and Anderson, 1992). For this reason, use of one of these functions for modelling the transition may be often relatively straightforward.

However, to decide between these two model specifications in more rigorous way, Terasvirta (1994) proposes series of nested hypothesis testing using simple F-tests, which result from the Taylor series approximation of the functions as in the linearity tests alternative. In the multivariate extension, Camacho (2004) again proposes using the two modifications for case when transition variable does and does not to the vector of explanatory variables, respectively.

To limit the number of possible values of the threshold and smoothness parameters, two ways of dealing with the grid search may be particularly helpful. First, dividing the exponent by standard deviation of the transition variable makes the threshold roughly scale free, so that an arbitrary number of values of the transition parameter ranging from 0 to 100 may be used in searching for the most appropriate value. Secondly, the set of the threshold values may be narrowed by taking sample percentiles of the transition variable and searching through these (from Dijk et al, 2002 and Tsay, 1989). To ensure enough observations in both regimes, which are split by the value of the threshold value that is being looked for, such value may not be close to the 0th and 100th percentiles. The respective parameter values are then found using a grid search, by choosing the model with the best fit measured, i.e. for which the sum of squared residuals, or logarithm of their determinant, is minimized. With large values of the parameter, the transition function becomes very steep and the model approaches the simple TAR model with sharp switch between regimes.

When threshold and transition parameters are searched for value by value as in the grid search, the model is linear for each of this particular combination of parameter values and ordinary least squares may be used for estimating. (Weiss, 1999)

Finally, Skalin and Terasvirta (1999) developed a way of testing for pairwise non-granger causality in a nonlinear framework, when they again use the suitable Taylor series expansion of the variable which is tested for having causal effects. With use of the previous notation, such test takes form of:

$$y_1 = \left(\phi_0 + \sum_{i=1}^{p} \phi_i y_{1,t-i}\right) + \left(\rho_0 + \sum_{i=1}^{q} \rho_i y_{1,t-1}\right) F_{y1}\left(D_{t,y1}\right)$$

$$+ \sum_{i=1}^{q} \delta_i y_{2,t-i} + \sum_{i=1}^{q} \sum_{j=1}^{q} \gamma_{ij} y_{2,t-i} y_{2,t-j} + \sum_{i=1}^{q} \psi y_{t-i}^3 + \varepsilon_t$$

where ϕ_0, ϕ_i, ρ_0, ρ_i, δ_i, γ_{ij}, ψ_i are coefficients. The null hypothesis of variable y_2 non-granger causing variable y_1 is equal to $\delta_i = \gamma_{ij} = \psi_i = 0$, which is tested using F-statistic.

Turning to the scarce empirical implementations of these models, from the univariate models, Terasvirta and Anderson (1992) apply STAR to quarterly logarithmic production indices for 13 countries and Europe. Camacho (2004) applies the multivariate extension to assess predictive power of the Composite Leading Indicators (calculated as weighted average of 10 macroeconomic leading variables) to forecast both output growth and business cycle phases. Koop et al. (1996) demonstrate the use of generalized impulse response functions using bivariate model of U.S. output and unemployment rate. Weiss (1999) uses generalized impulse responses to assess symmetry of monetary policy in a model that includes output, money supply and prices. From the models that also contain an error correction term, Escribano and Mira (2002) apply VECM on money demand in the UK. Mendoza (2003) use smooth transition VECM (STVECM) to assess relationship of real interest rates and credit supply on private investment in Venezuela, while Kavkler et al. (2007) use STVECM to model components of the real exchange rate between Slovenia and Slovakia. As an improvement to previous works, they also allow for different transition variables and transition functions in different equations of the system.

As for the examples of nonlinear models applied to market with housing, the existing application of STAR models was on regional housing prices in the U.S. Kim and Bhatacharya (2009) model dynamics of home prices, which depend on the sign and size of its own lagged values. They also explore the causal relationship between the growth in house prices and the mortgage rate in this nonlinear framework. The results strongly reject the null hypothesis of no Granger causality in the nonlinear framework, whereas the same hypothesis was not rejected in the linear model.

Model of house price dynamics with covered bonds

Ambition of the model is to stay within the framework of mutually enhancing powers between house prices, credit and business cycle, described in part 2 and investigated in Hejlová (2011). Practical advantage of such an approach is that variables which are used to proxy these three cycles (house prices, credit on housing and GDP) tend to contain information about most of the variables which are frequently used in models of house price determinants, like real wages, unemployment or even interest rates. Compared to a situation when all these relevant variables individually were included in a model, choosing the three cycle proxies saves a lot of degrees of freedom and makes the estimation on small samples technically possible. It also allows to model these cycles so as they affect each other, so that it well captures the overheating nature of the economy.

In the following empirical analysis, it is approached to testing for nonlinearity and estimating logistic STVAR models for a sequence of different sets of variables. Besides deciding whether nonlinear framework is needed to estimate these models, such an approach allows to test whether additional variables, i.e. proxies of credit and business cycle and the CBs, should be included in the model explaining the house price dynamics. Finally, it is approached to testing about the non-granger causality between house prices, credit on housing and the covered bonds in a nonlinear structure.

The basic variables which are assumed as proxies of house price, credit and business cycles are:

House prices

Prices of general dwellings, both new and existing. In euro per squared metre and of quarterly frequency. Collected by the Spanish Ministry of Housing and reported by Bank of Spain.

Credit on housing

Sum of both mortgage and general credit on housing for households and non-profit organizations. By including mortgages, which are allowed to back the CBs, as well as general credit on housing, both direct effects of relatively favourable terms of financing via CBs and secondary effects of increased banks' liquidity on general credit market are assumed. Measured in thousand euros of stock outstanding, of monthly (mortgages) and quarterly (credit) frequency. Collected and reported by Bank of Spain.

Covered bonds

Volume of new issues of covered bonds. New issues are included to capture the possible incremental effects on credit and house prices. Since such data abstract from the effect of the maturity profile of the last issues, they provide more accurate information about conditions under which mortgages are granted at each point in time, and thus also the easiness of repaying the debt. In thousand euros, of monthly frequency. Obtained from AHE, which compiles this dataset from information on individual issues of CBs by institutions from Comisión Nacional del Mercado de Valores.

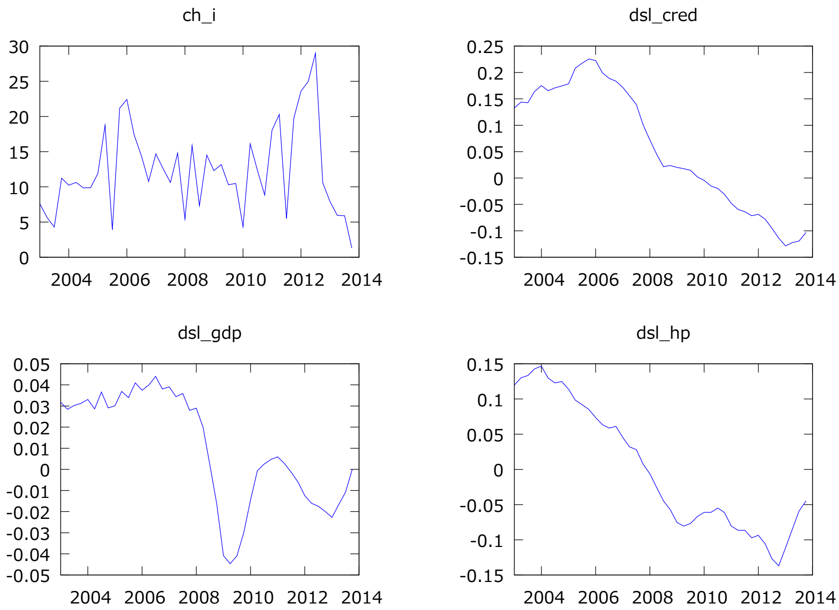
Gross domestic product

In thousand euros, of quarterly frequency. Collected by Instituto Nacional de Estadística.

All data series were transformed from nominal to real terms using Harmonized Index of Consumer Prices, as compiled and reported by Eurostat. House prices, credit on housing and GDP, which were found stationary in the first differences (Table 4), enter the models in rate of change to capture the dynamics of the system. For higher smoothness, yearly rate of changes calculated as seasonal logarithmic differences of the original time series were used. Issues of CBs, as already an incremental variable, are put into the model in levels (in billion of euros).

The dataset is of quarterly frequency and covers period between 2003 and 2013. While this is not a long timespan, it is still the largest data set on CBs available. Individual time series used in the models are described in Figure 1, with variable abbreviations and models summarized in Table 1.

Figure 1: Time series modelled



Source: Banco de Espana, Asociación Hipotecaria Espanola, Instituto Nacional de Estadística.

Table 1: Models and variable abbreviations used

Variable	Notation
dsl_hp	seasonal logarithmic differences of house prices
ch_i	issues of covered bonds (cédulas hypotecarias), in euro billion
dsl_cred	seasonal logarithmic differences of credit on housing
dsl_gdp	seasonal logarithmic differences of gross domestic product
Model	**Variables included, in notations**
Model 0	dsl_hp, dsl_cred
Model 1	dsl_hp, ch_i
Model 2	dsl_hp, ch_i, dsl_gdp
Model 3	dsl_hp, ch_i, dsl_cred

Source: Author.

To assess mutual relations between housing and credit market including the CBs, four simple STVAR models were proposed – two two-variable and two three-variable ones. These are:

- Models that explain dynamics of house prices and credit on housing (model 0) and dynamics of house prices and issues of CBs (model 1).
- Models that explain dynamics of house prices, credit on housing and issues of CBs (model 2) and dynamics of house prices, GDP and issues of CBs (model 3).

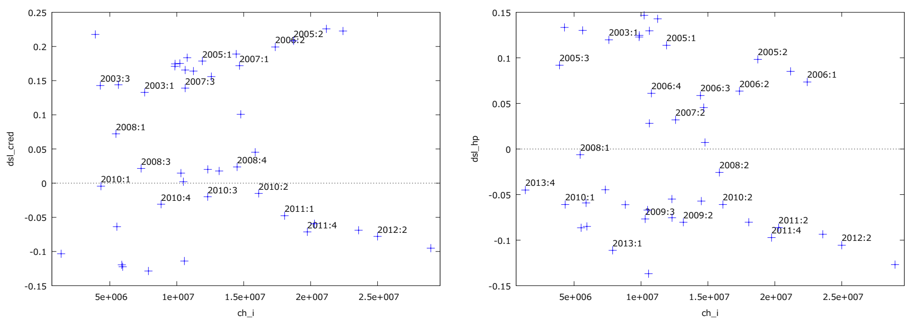
By comparing suitable pair of two- and three-variable model, it may be tested for variable inclusion in the sytem of equations. This is done using likelihood ratio test, since the two-variable models are submodels of the three-variable models, i.e. they may be both obtained from the three-variable models by imposing restrictions on some of their parameters.

By comparing model 3 with model 0, it may be tested whether adding issues of CBs is important for explaining the house price dynamics. Vice-versa, by contrasting model 3 with model 1, it may be tested whether assuming credit dynamics is important for explaining the house price dynamics. Finally, by comparing model 3 with model 1, it may be assessed whether the overall macroeconomic conditions are relevant for explaining the house price dynamics.

The most difficult task here was to choice the threshold variable. Suggested procedure of testing for choice of the transition variables within the test for linearity is complicated by the fact that there exist two alternatives of the corresponding test statistics, depending on whether the candidate variable is endogenous or exogenous to the model. In a situation of small sample and restricted models when some of the candidate variables are endogenous and others exogenous, choosing the threshold variables based on the lowest p-value is not possible, since p-values obtained from different alternatives to the test cannot be compared.

Therefore, it was approached to choosing the threshold variable based on theoretical discussion in part 3, which is also the approach preferred by Camacho (2004). As a result, change in credit on housing was chosen to govern the state of the system of equations. The main reason is that credit market is supposed to be an important environment for transmission of shocks between housing and CB markets, when frozenness of credit market was identified as one of the main reasons for assuming rigidities in the housing market, i.e. the different behaviour of house prices on upward and downward part of the cycle. To verify this choice on data, pairs of variables were plotted (Figure 2). From visual inspection of these plots, dependence is found between dynamics of credit and house prices (the first plot) and dynamics of house prices and issues of CBs (the second plot). The patterns seem to consist of two approximately linear relationships with opposite sign. These relationships are connected with higher and lower rates of growth in credit and house prices respectively. This means that the issuance of CBs increases with higher rate of both growth and fall in either house prices and mortgages. In other words, their issuance increases with more extreme values of both. With this choice, it is then statistically tested for the lag of the transition variable on equation by equation basis.

Figure 2: Dynamics of house prices, credit on housing and CBs



Source: Banco de Espana, AHE and author's computations.

Note: x-axis: yearly change in volume of credit on housing outstanding and house prices respectively, y-axis: volume of CBs issued, labels: year and quarter of observation.

In the first step, linear VAR was estimated for each model specification. Based on Hannan-Quinn information criterion, 2 lags of endogenous variables were included in each model. At the same time, no cointegration relationship was found between variables in levels in either of the four model specifications.

In the second step, it was tested for nonlinearity, which is accepted as a rejection of the null hypothesis of linearity. For each model, the test was conducted for two to five lags of the transition variable. Also, it was tested for both linearity of the system of equations and of individual equations. Tests for linearity of the system of equations reject the null hypothesis of linearity with high level of significance for all four models and all four lags of the transition variable considered. However, tests for linearity of the individual equations fail to reject the null hypothesis of linearity for some of the lags, and they even reject the null for all lags in equation describing the credit dynamics in model

0. That observed, it seems that the test of the nonlinearity of the system tends to be "spoiled" by evidence of nonlinearity in at least one of the equations. Actually, the null hypothesis is often rejected with high level of significance even when it is not rejected for some other equations and lags. Therefore, in model 0, only equation describing the house price dynamics is estimated for two regimes, while just one regime is assumed to describe the dynamics of credit on housing. Similarly, it is approached to choosing the lag of the threshold variable based on equation specific approach. This corresponds to the situation when it takes more time to certain variable to react.

Third, it was tested for specification of the regimes. Two transition functions were assumed, exponential and logarithmic, which lead to a model with inner and outer regime or high and low regime, respectively. Auxiliary regressions for nested hypothesis testing are estimated in two modifications corresponding to the situation when the transition variable is endogenous or exogenous to the system. Based on a sequence of F-tests on estimates of such auxiliary regressions, logarithmic function was suggested to approximate the regime switch for all models in which rate of change of credit is included as endogenous variable (models 0 and 1). In the rest of the cases, exponential function was suggested by the same sequence of tests. On one hand, it might be said that without including the CBs into the system of equations, rigidities are present in the market and for this reason house prices and credit on housing behave asymmetrically during booms and recessions (interpretation of model 0 with logistic function). On the other hand, it might be argued that when issues of CBs are included into the system together with house price dynamics, they may potentially help to correct these rigidities by increasing activity in the market in the downturn, so that inner and outer regimes, which are symmetric around the turnover, are found (interpretation of model 1 with exponential function). However, such conclusions might be misleading, since we do not a priori know which of the models is correctly specified. Instead, it seems that results of the tests are governed by the degree of the Taylor series approximation in the auxiliary regressions, determined by whether the transition variable is endogenous or exogenous to the system. To help to decide on the nature of the regime switch, linear VAR including rate of change of house prices and issues of CBs was estimated on full sample, as well as two subsamples corresponding to positive and negative growth rates of credit on housing. Then, impulse responses were analysed. While for the estimate on the full sample, response of house prices to shock in issues of the CBs evolves close to zero, for the positive and negative regimes of credit growth, the response of house prices in the first quarters is positive and negative, respectively. For this reason, logistic function is assumed to better approximate the change between two regimes in the relation of house price dynamics and issues of the CBs. The same is assumed for dynamics of credit on housing and GDP vis-a-vis both rate of changes in house prices and issuance of CBs, where such an assumption draws out of theory.

Since the transition variables in each equation only differ in how much they are lagged, one common threshold value and transition parameter were estimated for all equations in the individual models. This is motivated by the assumption that if the house price, credit and business cycles are interconnected, the state which is implicitly determined by the threshold value of the switching variable should be common to the system. However, dynamics of each variable may still differ in how lagged their reaction is, which is controlled for by equation specific lag of the transition variables. Results of these tests as well as model specifications and estimates are reported in Tables 5 – 10 of the Appendix.

In the final step, models were estimated using a multivariate LSTVAR model. The grid search was conducted on 50% of the sample, excluding 25% of the observations with the lowest and highest values. It was allowed for 50 partitions of values of the potential threshold values over this interval and 200 values of the smoothness parameter. Having standardized the transition variable by its standard error, the smoothness parameter is scale free and it may run from 0 to 100.

Results of grid search reflect different specification of the models. When house prices dynamics are explained by dynamics of credit only (model 0), estimated transition into the second regime happens when credit on housing already falls by 5% anually. This possibly confirms the hypothesis that regime shift in house price dynamics right around the turnover may not be explained by credit dynamics only. When house prices dynamics are explained using issues of CBs (model 1 and 2), estimated threshold value (7% and 10% change in credit, respectively) suggests the system switches to the second regime around the moment when house prices start to fall. Finally, when house prices dynamics and explained using both credit dynamics and issues of CBs, the transition into the second regime happens when the credit dynamics turn into negative values (-2% change in credit).

Also, estimates of the transition parameter, which are very much close to zero for three models (7, 32.5 and 4 for models 0, 2 and 3 respectively), confirm appropriateness or using TVAR model with smooth transition between regimes. That is, values of the transition parameters are sufficiently far from the value of 100, for which transition function of LSTVAR would approach indicator function of the TVAR model with instantaneous switch between regimes, and thus simpler TVAR would be the preferred option.

Results

Based on these interim results about model specifications, it was approached to the hypothesis testing.

First, inclusion of variables into the system explaining house price dynamics was tested using likelihood ratio test. The null hypothesis of the submodel being better than the full model was rejected on high level of significance for all three cases assumed. This confirms the assumption that house prices, credit and business cycle are mutually interlinked and that CBs play an important role in these relations. (Table 2)

Table 2: Testing for inclusion of variables

	Model 3 vs. model 0:	Model 1 vs. model 2:	Model 1 vs. model 3:
H0:	ch_i shall be excluded	dsl_gdp shall be excluded	dsl_cred shall be excluded
LR test stat.	79.9387	489.3062	439.7871
DF	27	22	22
P-value	3.8580E-07	1.2368E-89	2.4206E-79
Selection	Model 3 with ch_i	Model 2 with dsl_gdp	Model 3 with dsl_cred

Source: Author's computations.

Secondly, pairwise Granger causality tests in a LSTVAR setting were conducted based on approach suggested by Granger and Swanson (1996). For this, the Taylor series expansion approximating the nonlinear behaviour of the variable, which is tested as a potential source of causality, was adjusted for these pairwise submodels to which the transition variable is exogenous.

The null hypothesis of non-Granger causality was rejected for the relation from volume of CBs issued to the house price dynamics, suggesting possible leading effects of the covered bonds. On the contrary, null hypothesis of no causality in the opposite relation was not rejected, corresponding to the fact that falling house prices may hardly lead to increased issuance of CBs.

The null hypothesis of non-Granger causality was then rejected for the relation from house prices to credit on housing. On the contrary, the null hypothesis of the opposite causal relationship failed to be rejected. This confirms results of many previous empirical studies, in which existence of the financial accelerator from credit to house prices is suggested, but not it fails to be empirically confirmed. Finally, this results points at the importance of CBs in Spain in leading the house price dynamics over the last cycle. (Table 3)

Table 3: Results of tests for non-Granger causality

	Model 1: dsl_hp, ch_i		Model 0a: dsl_hp, dsl_cred	
Pair of variables	ch_i – dsl_hp	dsl_hp – ch_i	dsl_hp – dsl_cred	dsl_cred – dsl_hp
H0	ch_i $\nrightarrow$ dsl_hp	dsl_hp $\nrightarrow$ ch_i	dsl_cred $\nrightarrow$ dsl_hp	dsl_hp $\nrightarrow$ dsl_cred
Test stat.	2.8447	1.4634	1.2359	1.9429
P-value	0.0316	0.2300	0.3158	0.0961
DF	5, 31	7, 29	7, 32	7, 32

Source: Author's computations.

Conclusion

The aim of the thesis was to explain different dynamics of house prices on the upward and downward parts of the last house price cycle in Spain, in a situation of overheated economy, indebtedness of households and unprecedented use of covered bonds for mortgage funding. It was suggested that covered bonds first helped to drive house prices up, but they might have also helped to drive them back to equilibrium when the credit market froze and transaction activity became limited.

Due to the interconnectedness of housing, credit and business cycle, significant house price correction may be accompanied by serious economic downturn with occurrence of financial or even sovereign crisis. In a situation of economic stress, lack of other investment opportunities with favourable risk-return characteristics turn investors to buy covered bonds, even when they may expect collateral value to decrease. Crucial condition to this are the strong guarantees provided to investors by law or special contracts governing the covered bonds.

To capture these potential effects, house price dynamics is modelled within the mutually related system of house prices, credit and business cycles, in which the covered bonds are assumed to play an important role. Presence of nonlinear regime switching behaviour between situations of credit boom and squeeze is tested within the framework of vector extension to the smooth transition VAR. In a sequence of models which represent various systems of equations explaining yearly rate of change in house prices, credit on housing, GDP and volume of covered bonds issued, linearity was rejected for these systems as a whole and also for most of the individual equations. This first confirms the need of modelling the house price dynamics in nonlinear framework. Estimate of the threshold parameter supports hypothesis that change in behaviour of the house prices and credit dynamics, as well as the issuance of covered bonds, happens around the credit and house price cycle reversal. Such shift, however, does not happen abruptly. That confirms appropriateness of modelling such relationships using smooth transition VAR. For explaining the house price dynamics, behaviour on market with credit and covered bonds, as well as dynamics of the real economy, are found important. Hypothesis of no causality was rejected in the relation from issuance of covered bonds towards house price dynamics when tested in the nonlinear way. On the other hand, hypothesis of no causality was not rejected in the relation from credit on housing to house prices. This finally gives importance to the covered bonds in leading the house price cycle in Spain.

Data for Spain show that issuance of covered bonds tends to rise with both increasing rate of house price growth, as well as accelerating house price decline. This means that the asset encumbrance increases along the whole duration of house price and credit cycle, which may become source of risks to financial stability. With increasing asset encumbrance, sense of security related to covered bonds, which motivates buyers to invest into them, is increasingly illusionary. With some rate of asset encumbrance, decline in house prices may lead to losses which cannot be covered by the pool of assets, neither with prudent degree of overcollateralization. Moreover, increasing issues of the covered bonds may drive the prices down more rapidly, reducing further the safeguard of the overcollateralization. In this way, the danger connected to the covered bonds lies in the blind faith connected to the guarantees provided, leading to accepting latent risks, while at the same time contributing to the procyclicality of the house price and credit cycle.

Currently, the preferential treatment of the CBs under Basel III framework may lead to further significant preference for holding this instrument. Should the issuance of covered bonds rise in the future, there may be two potential actions to limit these risks. First, including forward looking predictions of house prices into the metod of the collateral valuation used for the dynamic adjustment of the cover pool might be helpful. Secondly, the rate of asset encumbrance should be monitored jointly with stress testing the house prices, since the excessive asset encumbrance may cause the danger of an abrupt fall in house prices more appealling.

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Appendix: Results of the empirical analysis

Table 4: ADF unit root test

Variable	Statistic	P-value
ch_i	-4.2783	0.0079
l_cred	-1.8238	0.6765
l_gdp	-1.5920	0.7805
l_hp	-2.8871	0.1762

* Results for test specification with intercept and trend. H0: The time series contains unit root.

Table 5: Lag lenght criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
Model 0: dsl_hp, dsl_cred						
0	113.8905	-	0.0000	-5.0859	-5.0048	-5.0559
1	277.8836	305.6235	0.0000	-12.3584	-12.1151	-12.2681
2	289.8299	21.1775*	0.0000*	-12.7195*	-12.3140*	-12.5692*
3	290.5953	1.2872	0.0000	-12.5725	-12.0048	-12.3620
4	293.7665	5.0451	0.0000	-12.5348	-11.8049	-12.2642
Model 1: dls_hp, ch_i						
0	-86.4508	-	0.2856	4.4225	4.5070	4.4531
1	0.4778	160.8179	0.0045	0.2761	0.5294*	0.3677
2	7.3442*	12.0163*	0.0039*	0.1328*	0.5550	0.2855*
3	9.1089	2.9118	0.0044	0.2446	0.8357	0.4583
4	15.2141	9.4630	0.0040	0.1393	0.8993	0.4141
Model 2: dls_hp, ch_i, dsl_gdp						
0	27.7198	-	0.0001	-1.2360	-1.1093	-1.1902
1	145.3982	211.8211	0.0000	-6.6699	-6.1632*	-6.4867
2	161.4477	26.4817	0.0000	-7.0224	-6.1357	-6.7018*
3	171.3561	14.8626	0.0000	-7.0678	-5.8011	-6.6098
4	184.0919	17.1934*	0.0000*	-7.254595*	-5.6079	-6.6592
Model 3: dls_hp, ch_i, dsl_cred						
0	-16.8044	-	0.0005	0.9902	1.1169	1.0360
1	130.6176	265.3597	0.0000	-5.9309	-5.4242*	-5.7477
2	144.9214	23.6012	0.0000	-6.1961	-5.3094	-5.8755*
3	149.6531	7.0976	0.0000	-5.9827	-4.7160	-5.5247
4	165.2254	21.0226*	0.0000*	-6.3113*	-4.6646	-5.7159

* Indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 6: Linearity testing

Test stat.**/ Transition var.*	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
				Model 0: dsl_hp, dsl_cred				
Endogenous	Eq. 1: dsl_hp		Eq. 2: dsl_cred				System	
dsl_cred(-2)	1.9111	**0.0741**	0.8288	0.6213			43.1770	**0.0095**
dsl_cred(-3)	1.0913	0.4016	1.0482	0.4341			31.4743	0.1406
dsl_cred(-4)	1.2881	0.2757	1.0196	0.4565			34.1760	0.0816
dsl_cred(-5)	0.9106	0.5479	1.6537	0.1291			38.3953	0.0316
dsl_hp(-2)	1.3511	0.2430	1.1341	0.3711			39.0137	0.0272
dsl_hp(-3)	1.2089	0.3219	1.5620	0.1569			39.7580	0.0227
dsl_hp(-4)	1.3445	0.2462	1.4481	0.1992			42.1431	0.0124
dsl_hp(-5)	1.1465	0.3626	1.5718	0.1537			48.1198	0.0024
				Model 1: dls_hp, ch_i				
Exogenous	Eq. 1: dsl_hp		Eq. 2: ch$_i$				System	
dsl_cred(-2)	3.0885	0.0081	3.9038	**0.0018**			67.4460	0.0000
dsl_cred(-3)	3.0467	0.0088	3.5828	0.0032			73.2303	**0.0000**
dsl_cred(-4)	3.1025	0.0079	1.6860	0.1305			56.9202	0.0000
dsl_cred(-5)	3.8586	**0.0020**	1.2481	0.3024			60.1419	0.0000
				Model 2: dls_hp, ch_i, dls_gdp				
Exogenous	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl$_{g}dp$		System	
dsl_cred(-2)	4.0687	**0.0010**	2.9731	0.0079	4.7583	**0.0003**	163.7855	**0.0000**
dsl_cred(-3)	2.6857	0.0142	3.0930	**0.0062**	3.6854	0.0020	150.5214	0.0000
dsl_cred(-4)	2.8379	0.0104	2.2473	0.0359	3.1949	0.0051	135.0466	0.0000
dsl_cred(-5)	3.3819	0.0035	2.1044	0.0489	2.8892	0.0094	133.5797	0.0000
				Model 3: dls_hp, ch_i, dsl_cred				
Endogenous	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred		System	
dsl_cred(-2)	5.9952	**0.0001**	2.9224	0.0113	2.0498	0.0614	193.7746	**0.0000**
dsl_cred(-3)	2.5108	0.0245	3.1107	**0.0080**	2.1873	0.0465	184.7436	0.0000
dsl_cred(-4)	3.2793	0.0060	1.9333	0.0779	1.8446	0.0934	173.3336	0.0000
dsl_cred(-5)	4.3366	0.0011	1.9950	0.0686	2.9277	**0.0112**	209.8875	0.0000
dsl_hp(-2)	4.2967	0.0011	1.4261	0.2204	1.9927	0.0689	174.8981	0.0000
dsl_hp(-3)	2.4071	0.0301	2.7475	0.0156	2.5698	0.0219	180.2284	0.0000
dsl_hp(-4)	2.7648	0.0151	3.6051	**0.0034**	2.0447	0.0620	177.3910	0.0000
dsl_hp(-5)	2.5583	0.0224	2.0817	0.0575	1.9951	0.0686	172.6773	0.0000
ch_i(-2)	2.0426	0.0623	3.3675	0.0051	0.3404	0.9873	131.3640	0.0000
ch_i(-3)	2.7389	0.0159	3.7629	0.0026	1.9831	0.0703	168.5088	0.0000
ch_i(-4)	3.6248	0.0033	4.3229	**0.0011**	1.1404	0.3857	184.1717	0.0000
ch_i(-5)	2.3301	0.0350	1.6445	0.1410	0.8354	0.6470	131.8820	0.0000

* Number of lags in parenthesis
** Refers to specification of the test statistic for when transition variable is endogenous or exogenous to the system estimated
*** Transition variables the lowest p-values are in bold

Table 7: Testing for transition function specification

	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
Model 0: dsl_hp, dsl_cred								
Endogenous*	Eq. 1: dsl_hp		Eq. 2: dsl_cred				System	
Transition var.	dsl_cred(-2)		None—					
H1	14.4770	0.0059						
Trans. fction	Logistic							
Model 0b: ch_i, dsl_cred								
Endogenous*	Eq. 1: ch_i		Eq. 2: dsl_cred				System	
Transition var.	dsl$_{c}red(-3)$		None					
H1	7.8077	0.0989						
Evaluation	Logistic							
Model 1: dls_hp, ch_i								
Exogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i				System	
Transition var.	dsl_cred(-5)		dsl_cred(-2)				dsl_cred(-3)	
H1	12.0707	0.0338	16.1097	0.0065			20.1159	0.0282
Trans. fction	Exponential		Exponential				Exponential	
Model 2: dls_hp, ch_i, dls_gdp								
Exogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_gdp		System	
Transition var.	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-2)		dsl_cred(-2)	
H1	24.6173	0.0009	24.6999	0.0009	9.1260	0.2437	56.5616	0.0000
Trans. fction	Exponential		Exponential		Logistic		Exponential	
Model 3: dls_hp, ch_i, dsl_cred								
Endogenous*	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred		System	
Transition var.							dsl_cred(-2)	
H1							66.7769	0.0000
Trans. fction							Logistic	

* Refers to specification of the test statistic for when transition variable is endogenous or exogenous to the system estimated

Table 8: Estimation: Model 0

Model 0: dsl_hp, dsl_cred			
	Eq. 1: dsl_hp		Eq. 2: dsl_cred
Regime	LOW	HIGH	One regime
c	-0.0733	0.0753	0.0039
	0.0312	*0.0329*	*0.0025*
dsl_hp(-1)	1.0779	0.1146	0.1146
	0.4232	*0.1487*	*0.1487*
dsl_hp(-2)	-0.2736	0.0408	0.0408
	0.4656	*0.1620*	*0.1620*
dsl_cred(-1)	-0.5674	1.3380	1.3380
	0.7541	*0.1454*	*0.1454*
dsl_cred(-2)	-0.0195	-0.4536	-0.4536
	0.7707	*0.1393*	*0.1393*
Transition variable	dsl_cred(-2)		–
Threshold value	-0.0535		
Smoothness parameter value	7		

* Standard errors in italics

Table 9: Estimation: Model 1

Model 1: dls_hp, ch_i				
Equation	Eq. 1: dsl_hp		Eq. 2: ch_i	
Regime	LOW	HIGH	LOW	HIGH .
c	-0.0144	0.0034	9.4280	8.5345
	0.0084	*0.0109*	*4.9298*	*-1.0761*
dsl_hp(-1)	0.8260	0.3378	-174.8040	243.5464
	0.2390	*0.3451*	*174.1166*	*262.9662*
dsl_hp(-2)	-0.3307	0.2267	174.6397	-243.2717
	0.1940	*0.3318*	*125.3783*	*248.9517*
ch_i(-1)	-0.0009	0.0007	0.2465	-0.1834
	0.0004	*0.0005*	*0.2707*	*0.4114*
ch_i(-2)	-0.0010	0.0011	-0.0030	0.3082
	0.0004	*0.0005*	*0.2888*	*0.4243*
Transition variable	dsl_cred(-5)		dsl_cred(-2)	
Threshold value	0.0721			
Smoothness parameter value	79.5			

* Standard errors in italics

Table 10: Estimation: Model 2

Model 2: dsl_hp, ch_i, dsl_gdp						
	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_gdp	
Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
c	-0.0107	-0.0051	10.6456	-13.3068	-0.0026	-0.0078
	0.0062	*0.0284*	*5.1643*	*16.5285*	*0.0029*	*0.0132*
dsl_hp(-1)	0.8072	0.2940	-183.9264	153.1451	0.1584	-0.2829
	0.2581	*0.4061*	*192.7290*	*300.8053*	*0.1204*	*0.1894*
dsl_hp(-2)	-0.2325	0.1954	171.4122	-137.8881	-0.1400	0.3439
	0.1983	*0.3978*	*148.1185*	*290.4885*	*0.0925*	*0.1856*
ch_i(-1)	-0.0009	0.0005	0.2249	-0.4210	-0.0001	0.0001
	0.0004	*0.0007*	*0.2839*	*0.4951*	*0.0002*	*0.0003*
ch_i(-2)	-0.0009	0.0009	-0.0383	0.1389	0.0002	0.0000
	0.0004	*0.0007*	*0.2986*	*0.5013*	*0.0002*	*0.0003*
dsl_gdp(-1)	0.0632	0.4154	72.8618	342.3774	1.4612	-1.1416
	0.2448	*0.6426*	*182.8540*	*429.9534*	*0.1142*	*0.2997*
dsl_gdp(-2)	-0.1486	-0.1044	25.6686	20.8786	-0.7241	1.3764
	0.2383	*0.6991*	*178.9154*	*480.0946*	*0.1112*	*0.3261*
Transition variable	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-2)	
Threshold value	0.0976					
Smoothness parameter value	32.5000					

* Standard errors in italics

Table 11: Estimation: Model 3

Model 3: dsl_hp, ch_i, dsl_cred						
	Eq. 1: dsl_hp		Eq. 2: ch_i		Eq. 3: dsl_cred	
Regime	LOW	HIGH	LOW	HIGH	LOW	HIGH
c	-0.0357	0.0343	46.0095	-40.1450	0.0107	-0.0044
	0.0203	*0.0241*	*12.4850*	*14.2231*	*0.0374*	*0.0406*
dsl_hp(-1)	0.6018	0.9419	-242.7826	-16.2718	0.4678	-0.8718
	0.4937	*0.6128*	*289.4620*	*355.9340*	*0.7630*	*0.8985*
dsl_hp(-2)	-0.2102	-0.2967	32.4624	158.8709	-0.4584	0.9824
	0.4564	*0.5874*	*264.3706*	*335.6299*	*0.6671*	*0.8242*
ch_i(-1)	-0.0011	0.0015	0.1067	-0.8310	0.0002	-0.0008
	0.0006	*0.0009*	*0.3321*	*0.4724*	*0.0009*	*0.0011*
ch_i(-2)	-0.0012	0.0017	-0.2640	-0.1424	-0.0011	0.0011
	0.0006	*0.0009*	*0.3514*	*0.4914*	*0.0010*	*0.0012*
dsl_cred(-1)	-0.1677	0.2209	726.5346	-659.1191	0.6062	0.9580
	0.6353	*0.6895*	*362.4099*	*389.1195*	*0.9167*	*0.9591*
dsl_cred(-2)	0.0225	-0.1729	-272.5356	350.4255	0.4220	-1.0745
	0.5974	*0.6295*	*350.8910*	*363.6703*	*0.8888*	*0.9149*
Transition variable	dsl_cred(-2)		dsl_cred(-3)		dsl_cred(-5)	
Threshold value	-0.0186					
Smoothness parameter value	4					

* Standard errors in italics

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Univerzita Karlova v Praze, Fakulta sociálních věd
Institut ekonomických studií [UK FSV – IES] Praha 1, Opletalova 26
E-mail : ies@fsv.cuni.cz http://ies.fsv.cuni.cz