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RIGOROUS THESIS

Impact of Securitization on House Price Dynamics in Spain

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature. The author also declares that the present thesis is her master thesis, defended at the Insitute of Economic Studies on June 25, 2014 and then published as a monography, with minor revisions have been made based on a referee process at the Insitute of Economic Studies prior to the publication. The author kindly asks this thesis to be accepted as a rigorous thesis.

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Prague, February 12, 2016

Signature

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Abstract

The rigorous thesis tries to explain different nature of the dynamics during the upward and downward part of the last house price cycle in Spain, characterized by important rigidities. 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. In a serious economic stress, lack of investment opportunities motivates investors to buy the 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. 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. Possible causality from issuance of covered bonds to house price dynamics was identified 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 was identified, stressing the need to model impact of the covered bonds on house prices in a situation when Basel III liquidity requirements motivate towards use of this instrument.

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

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Abstrakt

Rigorózní práce má za cíl vysvětlit rozdílnost v dynamice cen bydlení ve Španělsku ve fázi růstu a poklesu, a to během jejich posledního cyklu doprovázeného významnými rigiditami. Kryté dluhopisy jsou představeny jako jeden z možných determinantů nárůstu cen, ale i potenciální zdroj jejich narovnání. V situaci zhoršených ekonomických podmínek motivuje nedostatek kvalitních investičních příležitostí investory k nákupu tohoto druhu aktiv, který je charakteristický poskytováním zesílených garancí. To může posléze vést k rozmrznutí trhu s úvěry i bydlením. K vysvětlení rozdílu v režimu chování je dynamika cen nemovitostí modelována v rámci systému vzájemně se umocňujících cyklů, a to úvěrového, hospodářského a cyklu cen bydlení. K tomu je použit vektorový autoregresní model s plynulým přizpůsobením se dvěma režimům. Linearita tohoto systému je nejprve silně zamítnuta, což apeluje na nutnost uvažovat pro vysvětlování dynamiky cen nemovitostí nelineární modely. Dále je potvrzena vhodnost modelovat ceny nemovitostí v kontextu úvěrového a hospodářského cyklu. Výsledky testů v této nelineární struktuře dále ukazují na možnost kauzálního efektu vydávání krytých dluhopisů směrem k cenám nemovitostí. Závěrem je vyslovena obava z potenciálního ohrožení finanční stability z důvodů rostoucího podílu aktiv držených jako kolaterál, a to jak ve fázích růstu, tak i poklesu cen bydlení. Odhadování vlivu krytých dluhopisů na ceny bydlení je pak důležité v situaci, kdy likviditní požadavky v rámci Basel III k jejich držbě významně motivují.

Klasifikace JEL	E32, G21, G23, E44, E58, C32
Klíčová slova	Dynamika bydlení, úvěrový cyklus, rigidity na trhu s bydlením, kryté dluhopisy, sekuritizace, stavově podmíněné modely, vektorové autoregresní modely s plynulým přizpůsobením, asymetrické přizpůsobení

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Contents

List of Tables

List of Figures

Acronyms

CBs Covered bonds

ABSs Asset backed securities

MBSs Mortgage backed securities

ECBC The European Covered Bond Council

AHE Asociación Hipotecaria Española

LTV Loan-to-value

OTC Over-the-counter

GDP Gross domestic product

VAR Vector autoregression model

TVAR Treshold vector autoregressive model

STVAR Smooth transition vector autoregressive model

LSTVAR Logistic smooth transition vector autoregressive model

ESTVAR Exponential smooth transition vector autoregressive model

VECM Vector error correction model

STVECM Smooth transition vector error correction model

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 differences in 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 hypothetical explanations of the distinct dynamics of house price adjustment across countries might be the diverse use of covered bonds along the cycle. Their possible corrective effects during the downward part of the cycle have been recently discussed on theoretical grounds, but they have not been empirically examined yet. On the other hand, their possible enhancement effects on the upward part of the cycle have been completely neglected in light of the extensive use of the mortgage backed securities, which were typical of the U.S., but much less of some other countries like Spain, for example.

Although the usage of both of these instruments – the mortgage backed securities and the covered bonds – were associated with house price bubbles, in light of the development after the house price reversal, the nature of the underlying mechanism linking these instruments and house prices seems to be rather distinct, in fact. While in the past, then, covered bonds played an important role in several countries only, the new liquidity regulatory proposals under the Basel III framework, which favour usage of the covered bonds, may extend issuance of them among other economies. For this reason, empirical investigation of potential effects of the covered bonds on house prices should be definitely 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 prices in years preceding the financial crisis, with booming construction activity and household indebtedness rising sharp. Despite of a significant excess of dwellings, however, house prices long hesitated to fall when the bubble burst. At the same time, both sides of these cycles, the peak and the trough, were accompanied by increasing 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.

Regardless of the source of potential rigidities in the market with housing, modelling house prices remains largely in the linear framework. Existing attempts to put house prices into nonlinear regime switching models have been limited to univariate or at least 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 problems, Chapter 2 departs from Hejlová (2011), when it reviews house prices in Spain in the context of mutually reinforcing powers between business, credit and house price cycles and explains reason why such approach is important. It then presents possible sources of rigidities on the downward part of the house prices cycle and explains motivation for assuming covered bonds as a potential source of the corrective mechanism.

Chapter 3 then introduces covered bonds in detail, emphasizing differences between these and the mortgage backed securities. Discussion of possible threats to financial stability explains why it is important to assume covered bonds in the context of house price and business cycles, and explains differences from the mortgage backed securities again in this context. It contains important reasons for why covered bonds and house prices are modelled as to mutually effect each other in the following model and has implications for the final discussion of the possible impacts of cover bonds at the end of the work. The key hypothesis behind the role of covered bonds in house price dynamics in a situation of a housing bubble and increased indebtedness of households, as well as reasons why house prices may hardly be modelled in linear framework, are presented at the end of the chapter. Such hypothesis is then supported by data analysis for Spain as well as panel of selected countries to ensure that the model takes from the data indeed.

Chapter 4 first reviews theoretical background of the nonlinear, regime switching models. Given the scarce empirical implementation on house prices and economic time series in general, examples in which such models proved useful are included, with special attention to the range of possibilities which a researcher has for modelling. Procedure for smooth transition vector autoregression used in the empirical analysis is then described in detail. Finally, model for explaining house price dynamics in the framework of credit cycle, extended by the use of covered bonds, is presented. Improvements between various models in terms of fit are commented on.

Finally, it is concluded with the financial stability threats resulting from the usage of the covered bonds, which follow from the previous theoretical parts of the work and the empirical analysis.

The contribution of the present work is twofold. First of all, it attempts to testing the mechanism behind the usage of covered bonds and its impact on house prices in an empirical manner. which has not been dealt with so far. Secondly, it approaches to modelling house prices in an nonlinear framework extended to a vector of variables, where one of them is the covered bonds. For this purpose, a unique set of data on covered bonds obtained from the Asociación Hipotecaria Española, which is not publicly available, were used.

2. House price dynamics and financial crisis in Spain

2.1 House prices in the context of real economy and financial system

House prices have proved to be an important determinant of the overall economic performance, when the business cycle booms accompanied by a housing bubble have been identified as those that frequently lead to more costly busts (Borgy et al., 2009). In light of the recent financial crisis, the mutually enforcing powers between business, credit and house price cycle have been emphasized. Nevertheless, modelling house prices remains a crucial task: spillovers of house prices to the business cycle are important for a proper conduct of the monetary policy, while implications of possible financial imbalances between house prices and credit cycle are of particular concern for the financial stability issues. In Hejlová (2011), the transmission mechanism between real economy, housing market and financial sector has been analyzed in detail and so were discussed numerous determinants that might have been crucial in case of Spain. For purpose of this work, the relations will be briefly reviewed to give framework to the research topic and so will be mentioned the most important drivers of the house price dynamics. The context given thereby will be threfore based on results of Hejlová (2011), supplemented by results reported by other authors that have dealt with the topic so far.

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. There were several important factors that allowed for increased consumption as a whole. First, significant growth of gross domestic product was accompanied by an increase in real wages. Secondly, both incorporation of women into labour market and better conditions for employability of young workers accounted for an increase in disposable income of households, as the basic unit for decision making about house purchase. Since there has always been an extremely high propensity to primary home ownership in Spain and popularity of secondary housing, the favourable economic development, sometimes referred to as the Golden Age of Spanish economy, lead to increased number of purchases of housing of both types.

Positive price signals from the real estate market translated into economic activity through increased construction. Construction represented the most dynamic part of Spanish economy and gave rise to another significant increase of employment. Thus, the economy became construction industry based, what finally allowed for the mutually reinforcing relationships between real economy, credit and housing markets to interact.

Nominal interest rates determined by central bank combined with high average inflation in Spain and fiscal subsidies on mortgages, under which interest payments were tax deductible, made financing of house purchase by credit affordable. Moreover, "*credit is not only procyclical in Spain, but actually amplifies the cycle.*" (Herrero and de Lis, 2008) Dramatic upswing in real estate prices caused that value of the collateral, by which mortgages were backed, raised and allowed for further increase in mortgage lending. At the same time, overall conditions of borrowers were significantly improved, caused by economy being in its boom phase, 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.

This all meant that the borrower's financial conditions improved to some extent artificially, since the boom of the economy was partially triggered by the housing bubble being built up. So did not values of the collateral thoroughly reflect the correct intrinsic value of the real estate. In case of significant drop in housing prices, borrowers' conditions would deteriorate (partly because a lot of people were employed in the construction industry) and in case of non-repayment, the actual values of collateral would be found much lower than estimated. Thus, high indebtedness in connection with house price bubble posed serious financial stability problems.

With purpose of carrying out prudential regulation and with the aim to reduce procyclicality of lending as well as to eliminate feedback effect from the credit granting to the real economy, dynamic provisioning was introduced in 2000 by the Bank of Spain. The dynamic provisioning 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*" (Saurina, 2009). Such a tool should increase loan loss provisioning in the boom phase of the economy and reduce the feedback effect of lending, since otherwise in the boom phase "*some negative NPV projects financed to be later found impairment of the loan or default of the borrower, while in recessions, banks suddenly turn conservative and tighten credit standards well beyond positive net present values*" (Saurina and Jiménez, 2006). Probably the major advantage of the dynamic provisioning was the automatic accumulation and depletion of the provisioning fund, since the level of provisioning is determined by estimate of the risk in a cyclically neutral year. (based on Saurina, 2009)

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)

2.2 Determinants of house prices: Literature review

Up to now, research on house price determinants and house price dynamics in Spain has been twofold. One stream of investigators follow the asset market approach and thus base their research on microeconomic decision making model between purchasing housing as an asset and paying for it as a service. In this way, intertemporal equilibrium equation is searched based on information from both house prices and prices of rents. The second stream of investigators carry out more macroeconomic type of models, in which they let the housing market interact with the credit market. These in most cases included indicators of real economy and credit market conditions and lead to autoregression models or cointegration analysis with error correction representation.

From the perspective of this study, works by Gimeno and Martínez (2006) and Valverde and Fernández (2010) are the most relevant to study. Both of them concentrate on the cointegration between house prices and loans for house purchase and corrective powers between the two as represented by a VECM. The latter work is in fact extension of the former, when it brings additional information about structural breaks. Analysis by Esteban and Altuzarra (2008) then represents another macroeconomic type of models, in which the value added consists of employing additional demand and supply determinants, as well as assessing their relative importance to the last house price increase. The work will thus be presented first, to make an introduction to the house prices determinants in Spain. The rest of the research on Spain has concentrated on asset market approach and overview of existing studies of this type is included at the end, mainly for the review's completeness.

Esteban and Altuzarra (2008) offer an encompassing discussion of macroeconomic determinants of house prices in Spain, that were quite scarce before in terms of complexity. Authors emphasize that the increase in prices was demand driven and offer a comprehensive classification of demand for housing, useful for any kind of house price analysis. Apart from favourable financial conditions, authors determine the demographic trend and social changes in Spain as the main drivers of these dynamics. While the former was caused by increased natality and significant inflow of immigrants, the former accounted for atomisation of traditional families in Spain. Finally, the foreign investment into real estate was, according to the authors, another important driver, which was also reflected in the model presented in Hejlová (2011). Authors argue that this caused excessive supply of secondary housing in the coastal areas and not in the cities where the demand for primary housing was pressing on the local markets.

Regarding the assumptions about supply of housing, Esteban and Altuzarra (2008) use three-equational model where, most importantly, one of the equation models number of housing starts on real housing prices and number of households. Authors follow the macroeconomic approach to modelling but in comparison with the following studies, they employ a wider range of proxies for both demand and supply factors, mainly the supply factors of the housing market. Using cointegration analysis, they find that house prices are in long run positively and significantly dependent on real disposable income, debt service burden and real residential investment, while the effect of mortgage rate is negative and significant. Number of housing starts is positively explained by the number of households and house prices, from where comes their important conclusion about demand driven house prices in Spain.

Considering the analysis of Esteban and Altuzarra (2008) as a departure study for selection of drivers of the house price dynamics, the work by Hejlová (2011) addressed the issue of adequacy of supply to meet demand in a timely manner using so denominated upper estimate of effective demand[1]. The results

[1]Upper estimate of effective demand was calculated as a sum of yearly differences of both

support the analysis of Bank of Spain concerning the supply of new housing, which evidenced that the quantity of finished dwellings exceeded transactions with the same, and does not therefore suggest supply pressures on a house price increase. Having concluded that the aggregate supply of housing could not represent a limit for the demand for housing, which would in its consequence drive the house prices up, it was continued with analysis of whether spatial mismatch between supply and demand was not present. Cross-sectional analysis of house prices across regions (comunidades autónomas) was estimated including set of proxies for the households' disposable income, dummy variable taking value of 1 for coastal areas and indicators of demand pressures[2]. The relation between rising number of households and increase in stock of housing was not found to explain differences in house prices significantly. On the other hand, regional analysis suggests that the frequency of housing transactions with respect to existing stock of housing played significant role in explaining the house price differences. Given the importance of transactions during the house price boom and the fact that the absolute number of transactions far exceeded the demand, the analysis supports the hypothesis of the role of speculative demand on such behaviour of house prices in Spain and makes possible implications on evolution of house prices in the financial crisis aftermath.

Gimeno and Marínez (2006) present in fact the first attempt to implement credit market into a model of house prices in Spain, covering the period until 2004. Valverde and Fernández (2010) already cover a time span until 2008, and thus benefit from analysing the house prices during the whole period of boom. Authors of the first paper employ house prices, loans on house purchase, labour income and nominal interest rates in a model with two cointegrating relationships based on Eagle-Granger procedure. Valverde and Fernández (2010) use similar variables, but try to avoid problem of omitted variable bias by including proxy for a credit quality as represented by mortgage credit default rates. Apart from this, authors widen the set of variables used by Gimeno and Martínez (2006) by real interest rates and inflation to capture the effect of the membership in the European Monetary Union, and price-to-rent ratio (as an alternative to house prices) to measure degree of the house prices overvaluation, as used in the financial types of models. Although they use Johansen

primary and secondary home ownerships as well as primary home tenants. Such an estimate of effective demand is thus conservative, since usually some of the secondary homes may be provided by commercial sector.

[2]Number of existing dwellings per transaction and number of new families per stock of finished dwellings.

cointegration procedure, they arrive to detect equal number of cointegrating relationships as the former authors. In both models, variables are used in per households form to capture the wealth effect of the unit which is determinant for the decision making about a home purchase.

In the long run, Gimeno and Martínez (2006) find that house prices depend positively on income and level of credit financing. For identification of the long run relationships, authors impose restriction of zero coefficient to the nominal interest rates in the house price equations, so that changes in financing costs as well as in other credit market conditions are reflected in volume of mortgage loans. Level of indebtedness then positively depends on income and effect of nominal interest rates is found negative. House prices and credit aggregate are found to be positively dependent on each other in the long run. Valverde and Fernández (2010) present in fact similar results for the long-run relationships.

Regarding the adjustments after departure from the long-run equilibrium values, Gimeno and Martínez (2006) show that in the long run, house prices are corrected when the level of indebtedness exceeds its equilibrium value. Authors also point out at significant corrective power of nominal interest rates in re-establishing equilibrium on the credit market. Valverde and Fernández (2010), who do not impose any restriction on nominal interest rates in the house prices equation in case of house price disequilibrium, confirm results reached by the previous authors, but bring additional evidence about larger relative corrective power of nominal interest rates with respect to mortgage lending.

Both authors then proceed with more short-term analysis by vector error correction representation. In the short run, mortgage credit is positively influenced both by house prices and salary income, while interest rates have a negative impact on it. (Varverde and Fernández, 2010) House prices are then negatively influenced by interest rates. Both papers suggest the same results regarding the impact of lagged disequilibria on contemporaneous values. While correction for both house prices and mortgage credit long-term disequilibrium has effect on house prices in the short term, disequilibrium of house prices has no effect on mortgage credit in the short run.

Regarding the possibilities of including credit market conditions into the modelling, Valverde and Fernández (2010) note that in a situation of information asymmetries present in the market, interest rates or lagged values of house prices are important representatives of borrowers' expectations. On the other hand, as discussed in Gimeno and Martínez (2006), interest rates cannot completely capture effects of liberalization of financial markets in Spain, increased competition and changing business model of the banks. Borrowing capacity has thus been increased by factors such as lengthening of maturity of the mortgages. For this reason, inclusion of volume of mortgage credit granted may be also important. Valverde and Fernández (2010) then emphasize importance of testing for structural breaks in borrowing capacity. Importantly, they suggest presence of structural shock in lending before 2001, due to factors connected with approval of legislation on securitization and dramatic decrease in real interest rates. Regime shift was thus estimated using dummy variable multiplying the mortgage credit prior to 2001, coefficient of which was estimated as significant. Finally, model presented above was estimated for the two sub-samples separately, finding that house prices and interest rates have stronger effect on mortgage lending after the credit conditions were eased.

Hejlová (2011) departs from these works with the aim to capture the mutually reinforcing powers between real economy, housing and credit market and assess 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 (as discussed further based on Esteban and Altuzarra, 2008). The time series used cover the period between 1996 and 2010. On one hand, this brings problems with stationarity, since these variables were growing really significantly those years and the series were not found stationary without differencing them twice, as opposed to the respective series used by the previous authors that were I(1), as reported. On the other hand, the period analysed covers even the drop in house prices towards the end of the sample and thus offers additional information about the adjustment process. Regarding the nature of the data, cointegration analysis is first carried out. It is realized that when the sample is restricted only to the period covering the house price increase, more cointegrating relationships are found in the data. Finally, using the vector error correction representation, asymmetry of adjustment of house prices downwards was found, raising needs for further theoretical explanation. This confirms one of the previous findings, which suggested that mutually reinforcing powers between the real economy, credit and housing market function correctly in the upturn, whereas in the downturn, rigidities may be often present.

Turning briefly to the financial type of models, Pagés and Maza (2003) approach to modelling both long- and short-run interactions between house prices and other variables based on financial approach. They include determinants as used in the decision making models between housing purchase and renting, namely the income, user cost of housing ("*defined as nominal interest rate less the expected future rate of change of nominal house prices*," (Pagés and Maza, 2003) the stock of housing and the stock exchange return. In line with the previous discussion, limitation of such approach consists of ignoring other factors of credit availability than interest rates. Using uniequational model of house prices, they show that in the long run, house prices are only dependent on real income, while the nominal interest rates are not found significant. Imposing a unitary restriction on income elasticity, interest rates are found to have negative impact on house prices.

While in the previous model, the discount factor was proxied by the user cost of housing, Ayuso and Restoy (2006) use an intertemporal asset pricing model including both housing services and consumption which are allowed to interact, and so the discount factor is also determined. Their empirical analysis thus goes behind the asset pricing model when it introduces present value of the rental payments in sense of housing as a service, as opposed to the concept of housing as an asset, in which the discount factor is equal to the return on alternative investment. (based on Ayuso and Restoy, 2006) Using vector autoregression model for three countries (Spain, U.K and the U.S.), authors concentrate on estimating equilibrium value of house prices in each country and determining the implicit under- or overvaluation, and thus do not go into estimating short run dynamics. Interestingly, authors estimate the degree of house price overvaluation to be around 20% and attribute this "*to the sluggishness of supply in the presence of large demand shocks in this market and/or the slow adjustment of observed rents to the conditions prevailing in the housing market.*" (Ayuso and Restoy, 2006)

2.3 Why house prices in Spain did not drop more significantly?

The case of Ireland is often put into comparison with Spain as another example of a house price bubble that was built prior to the last financial crisis. In comparison to Spain, however the real house prices dropped more significantly and rapidly in the first years following the bubble bust. In Spain, the most frequent declaration concerning the house price bubble is that it is of speculative nature and there is clear evidence of vast quantity of dwellings that are empty for the majority of the year. How then comes that such an excess of supply has not driven house prices down?[3]

The role that the credit financing played in creating the house prices bubble suggests that holders of those dwellings, which were bought for speculative purposes, suddenly turned reluctant to sell their real estate, since offering it for a significantly lower price would leave them with negative equity. On the other hand, expectations of the potential buyers about house price burst lead to reluctance to buy for existing prices. Mortgages were often used to finance not only primary, but also secondary housing or purchases which were motivated by speculative reasons. This draws attention to rigidities on house price market in Spain and rises question about the role of rental market in returning these house prices back to the level determined by economic fundamentals.

Rigidities on housing market, which may in turn 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 constraints 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) On the other hand, equity constraint is described as a situation when owners of mortgage financed housing are reluctant to accept market price when housing prices are on decline, since this could cause problems with the asset repayment. (Engelhardt, 2003) Given that periods of house price overvaluation are typically accompanied by highly leveraged households on market-wide scale, the market may be found stuck very easily.

Aversion to loss as a more striking explanation argues with about general unwillingness of sellers to realize nominal losses by selling their housing bellow the initial purchase price (Genesove and Mayer, 2001). After all, "*nominal loss aversion, whereby households are averse to realizing nominal housing market*

[3]Remarks that the present author made are based on information gathered while studying the relevant subjects at the University of Granada, Spain, during academic year 2011/2012; these were particularly Economía Urbana given by Pedro E. Barillao and Sistema Financiero by José María Alcón.

losses and, hence, treat gains and losses asymmetrically, is a characteristic of preference." (Engelhardt, 2003) One may argue that the asking and bidding prices should always meet, so that the adjustment of both should naturally come. 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) As a result, households are less likely to transact, causing rigidities on the downward part of the house price cycle. (Balcilar et al., 2012) Genesove and Mayers (2001) point out that this is an especially puzzling feature, because "*the moves are local, so that the typical seller is also a buyer in the same market.*" This issue is also discussed in Hejlová (2011), where finding the equilibrium is supposed to lie in the rental market. The previous authors report that the volume sold may fall by 50% between the peak and through of the house price cycle. Genesove and Mayer (2001) also explore differences in behaviour of households and investors, finding that the owner-occupants tend to set higher reservation prices to avoid potential loss. On the other hand, low equity is reported to be more important for the investors, supposedly because they can calculate return on a wider portfolio of assets. This implies that the percentage of speculative demand by institutional investors also enters the price dynamics importantly. To capture these hypotheses, Muellbauer and Murphy (1997) suggest modelling nonlinearity in the predicted rate of return. Finally, it is argued that the area of inactivity increases around the equilibrium the bigger are the transaction costs, which are rather typical of housing market in general.

In Spain, however, rigidities on both demand and supply side of the housing market call attention. Problems of the housing market in Spain and overview of possible solutions to such situation, which have been recently discussed, are the following:

1. Vacant houses are not put on the market or do not find a buyer for the offered price.

2. On the demand side, accessibility of home ownership is limited in serious economic downturn; young households cannot afford buying a primary home, since the unemployment rate is extremely high; on the other hand, to avoid overcrowding of public universities as a result of high unemployment, the government has risen enrolment fees into courses significantly,

which makes the situation of starting up one's own living even more difficult.

3. On the other hand, the vacant houses are not rented either, since in Spain, protection of the subtenant is so strong that it creates motivation for the owners to keep it empty, rather that to face any problems connected to collecting the payments.

4. The general consensus on the way how to boost activity on housing market in Spain is therefore to reduce number of vacant dwellings; first, it should be done through introducing more flexibility on the rental market (so called "desahucio"[4]); secondly, since adjustment of house prices definitely requires the frequency of transactions with real estate to raise, increase in prices of rent would make decision making between renting and purchasing a primary home more prone to the second option.

At the end, however, there must be something that helps the system get back to the equilibrium, or at least explain different adjustment across the countries, in which house price bubbles were credit financed to similar extent.

2.4 Role of securitization in house price dynamics: Motivation

The real estate and financial crisis in Spain has also been widely compared to the crisis in the USA, in which a crucial role was played by the subprime mortgages. However, in the academic literature, it has not been pointed out enough on the differences between the two and not much attention has been devoted to the phenomenon of the securitization in Spain, which is in fact what probably stays behind the capacity of mortgage credit to grow in this country. Recently, there has been appearing broad evidence on specifics of securitization in Spain, which make the country a unique case to study. In this way, it is the covered bonds, which are in Spain referred to as cédulas hipotecarias, and not the mortgage backed securities, impact of which is particularly relevant to explore in case of Spain.

According to Valverde, Rosen and Rodríquez (2011), the upswing of securitization in Spain has been realised from insignificant scope in 1990s to be

[4]Set of legal arrangements, which should make moving the tenants out a dwelling in one's property easier.

largely spread in the loan portfolio right prior to the crisis. In its very peak between 2005 and 2007, Spain became the second largest issuer of securitized assets, following the U.K. At the same time, private sector exposure has been aligned with this phenomenon for the most part. (Álvarez, 2008)

As opposed to the relationship between real, credit and house price cycles, which is largely covered in the literature, the role of securitizations in this mutually enhancing system has not been very much addressed yet. Introducing securitisation into existing models might nevertheless add information to explaining causality from the housing prices to the credit, the so called feedback effect. Such a relationship has been largely reported in the research, however, the causality has not been clarified robustly, yet. The overall effect was finally underlined by the inherent procyclicality of the bank lending, that brought along loosening of lending conditions as a result of the overly favourable economic conditions.

In contributing to the empirical notions about the impact of usage of covered bonds, this work may help to solve such uncertainty by introducing covered bonds as a factor that might have, due to its capacity to provide cheap and liquid financing at all times including the downturn, accounted for part of dynamics of the house prices after the reversal. Key to this are the basic specific features of the covered bonds, as well as some less commonly known pitfalls connected to their use.

With this purpose, as well as due to the relatively new theoretical foundation about the instrument, covered bonds are presented in the next chapter. First, common characteristics are introduced and compared to those of uncovered bonds and mortgage (or generally asset) backed securities. Then, common features as well as country specific features are reviewed briefly to point at the heterogeneity and emphasize specifics of the Spanish market, which have prevailed. Secondly, evolution in the market with covered bonds is analysed with focus on the performance before, during and after the financial crisis and with the distinction of the episode of sovereign debt crisis in the European countries. Here again, differences between countries with respect to characteristics important for this work, are tracked. Third, to derive hypothesis about the role of securitization on house price dynamics and suggest on the underlying mechanism, financial stability implications connected to the use of covered bonds, and especially those related to the housing market via mortgages used for collateralisation, are analysed. This is then briefly supported in detail by using real data for Spain and countries with wide use of this instrument as of today.

3. Covered bonds and their link to house price dynamics

3.1 What is covered bonds

Definition

Covered bonds (CBs) are debt instruments secured by underlying asset pool and characterized by strengthened protection of investors. They are of fixed income and maturity and have notional amount, which is repaid at maturity[5]. There are several features which are common for CBs in general, but specific arrangements differ considerably across countries.

Characteristics

The ECBC (2014)[6] identifies four common essential features which it considers as the minimum standards for the CBs:

1. Preferential treatment of the covered bond holders against the cover pool over the holders of the unsecured debt.

   For case of insolvency of the issuer, the cover pool is either excluded from the insolvency estate, or the preferred claim for CB holders is ensured (bankruptcy remoteness).

[5]ECB defines CBs as: "*Covered bonds are bonds issued and owned by a bank or mortgage institution and are subject by law to special public supervision designed to protect bond holders. Proceeds deriving from the issue of these bonds must be invested in conformity with the law in assets which, during the whole period of the validity of the bonds, are capable of covering claims attached to the bonds and which, in the event of the failure of the issuer, would be used on a priority basis for the reimbursement of the principal and payment of the accrued interest.*" (BCBS, 2013)

[6]The European Covered Bond Council (ECBC) is an organization that serves as a platform for participants in the CB market, representing their interests of the cover bond issuers. To our limited knowledge, it serves as source of data for all cross country comparisons of the CBs.

2. Obligation 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.

   Assets in the cover pool are identified on an individual basis, which makes it possible to track the value of the cover pool as a whole. The minimum quality standards are required of these assets by law or contract governing the issuance, in which they are also defined. In this way, additional assets may be put in when the value of the existing ones falls down or replacement is done for assets that mature or default. To ensure sufficient value under stress, overcollateralization is required or is held voluntarily by the issuer.

3. Supervision of this process by appointed authorities.

   As pointed out by the ECBC (2014), such supervision is in fact different from other general monitoring operations aimed at the system as a whole, since it serves for enhancing attractiveness of the product for investors as one of the key features of the CBs (as will be seen later in this text, the transparency is a key condition upon which advantages of the use of CBs lie).

4. Double recourse provided to the covered bond holders, when they not only have a claim on the underlying cover pool, but also on the issuer.

   The last condition ensures that the investor's exposure is ultimately backed by the issuer's capital. (Ergungor, 2008) The credibility of such a guarantee is then strengthened by the fact that issuer is subject to public supervision and regulation.

In general, CBs are most typically used for financing mortgage loans, however, issuing CBs for funding public debt is also common, albeit used to much lower extent. The biggest mortgage covered bond markets have in last years developed in Spain, Germany, Denmark, France, Sweden, Norway and the UK. (Martín et al., 2013)

Supply and demand for covered bonds

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 in comparison to both secured and unsecured instruments. (Ergungor, 2008) Currently, the generally low interest rate environment makes it difficult to attract sufficient volume of deposits, what makes the importance of the 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 then, 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) On the other hand, CBs might not have been so favourite compared to ABSs in the past due to the seemingly low risk-return characteristics, notion of which has been somewhat corrected as a result of the last financial crisis. 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).

Legal foundation and classification

Protection of CBs is mostly founded on the basis of high standardization of the instrument, which is, however, despite substantial attempts for unification still country specific to a large extent. Based on the type of the legal basis, legislative and structured covered bonds are distinguished.

The legislative (or benchmark) covered bonds are CBs issued under a special legal framework based on law and/or binding regulations of a public supervisory authority. In differences between these laws then consist the idiosyncratic features of national CBs. Issuance of structured covered bonds is, opposite to this, conducted through private contractual agreements based on general law framework, which consist of law and regulations not intended to regulate CBs specifically. Such arrangements allow to carry out issues in countries where the specific legislative frameworks are nonexistent, or simply to take advantage of higher flexibility offered by such contracts in setting features of the issue. Special model of covered bonds called Jumbo then concentrates on determining the size, format, issuance and buyback practices in particular. It was first created in Germany in 1995, but spread to other jurisdictions.[7]

The nature of the legal framework also seems to determine the investor base in terms of geographical scope. Based on the existing literature, home bias mostly concerns countries where these securities have traditionally been issued, i.e. countries where specific law frameworks developed (Martín et al., 2013). Ultimately, there has been increased activity in a standard setting regulation on the EU level, triggered by the need to attract investors in times of increased uncertainty.

Markets with covered bonds

CBs are issued in the primary market for the first time, be it either directly or indirectly through a market maker. On-tap issues are additional amounts issued under the framework of the original issuance as a response to increased demand for the issue. (Sandstrom et al., 2013) While the terms remain unchanged, the price is set according to the rate currently prevailing in the market at the given moment in time. Several months before the contract matures, the issuer often approaches to the holder of the covered bond, offering him to replace the old contract with a new one under the currently prevailing yield. This is intended to reduce the risk of rolling the contract over in time, which is one of the most important risks born by the issuers.

Market makers then keep the custody of the secondary market where the CBs are traded. These are usually the benchmark CBs, whereas the structured bonds, which are usually rather specific, are traded extraordinarily. In this way, the secondary market serves as an alternative investment for those searching in the primary market, meaning that the two markets are interlinked through the rule of arbitrage. As a result, "*the possibility of issuing on the primary market is negatively affected during periods of heavy selling pressure on the secondary market, because yields then rise.*" (Sandstrom et al., 2013)

To keep the secondary market deep is therefore important to ensure that it serves as a reference for investors, and so that the covered bonds maintain their high liquidity (even the primary market with CBs therefore gains from the information efficiency in the secondary market). In this way, the Jumbo covered bonds are in fact benchmark covered bonds models, since their basic

[7]Under the national legislation, CBs may further bear different specific names, which are usually in language of the domicile. Apart from the previously mentioned Cédulas Hipotecairas (Spain), there are also Pfandbrief (Germany) or Obligacion Fonciere and Financement de l'Habitat (France).

feature is the commitment of the market makers for a limited amount of cash orders, which guarantees a minimum amount traded, and also certain liquidity in the market as a consequence. In case of access demand or supply compared to what is actually in the secondary market, market makers may approach to the repo market or, if unavailable, they access to the issuer directly.

Regarding where the trading takes place, CBs may be traded either in an organised market place, most typically stock exchange, or over the counter (OTC). While the first option is regulated to be open to all traders with information about prices disclosed publicly, OTC may serve to closed bi- or multilateral trading.

In terms of geographical scope, the covered bond market has been evolving from domestic oriented to much more globalized debt market recently, due to the introduction of euro and growing standardization of the instrument through legal frameworks since the first Jumbo Pfandbrief in 1995 in Germany. (Martín et al., 2013)

Differences between CB, non-secured debt and MBS

The main differences between CBs, ordinary secured debt and asset or mortgage backed securities consist of two aspects, which 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)

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[8]. This leaves the CBs the only instrument for which collateral pool may be adjusted subject to its value.

In case of bankruptcy then, 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

[8]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.

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.

Additionally, 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. As will be seen later in this chapter, however, considering such risk is not straightforward when the underlying mortgages are of variable interest rate.

In their work, 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 need to raise liquidity at the first place, 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. As an evidence, there is a higher proportion of banks issuing covered bonds with low returns and high LTD ratio. Riportella et al. (2010) then address the motivation behind the excessive use of securitization directly, confirming that liquidity has been the driver of CB issues.

According to the present author, the particular usefulness of CBs for increasing liquidity is primarily caused by three reasons:

1. Existence of a liquid secondary market for covered bonds, which is almost missing for the ABS, strengthened by

2. Maintenance of this market by the market makers, even when the demand and supply are not met in the market at the given moment.

3. Acceptability of the covered bonds as collateral in the repo market then makes the instrument even more liquid than if only the secondary market might be used.

As will be seen later in the data analysis, CBs and ABSs alternated each other to a significant extent in Spain, with varying use depending on to the overall conditions of the market. Nevertheless, prevailing use of CBs in Spain as opposed to MBSs in the U.S. is what constitutes the main source of distinction between the origins of the financial crisis in these two countries.

3.2 Cédulas Hipotecarias and mortgage financing in Spain

In Spain, CBs have historically played an outstanding role when compared to other countries in which they are common today. The instrument was first regulated there in 1981 already, as opposed to year 1995 for Germany or 1999 for France, as other of the CB pioneers. For quite a long time, additionally, there was practically no alternative to them. (both from Herrero, de Lis, 2008) Interestingly, the current design of the instrument still differs in some of the important features, which are prevailingly uniform in most other countries where CBs are widespread today.

First, all credit institutions active in the mortgage market have been allowed to issue CBs since the early introduction of the instrument in Spain. In most other countries, the issuance is still conditioned by a special licence (e.g. Germany or Sweden), or it is still only permitted to institutions specialized in mortgage financing (e.g. France or Norway). (Martín et al., 2013)

Secondly, in Spain, CBs that are backed by mortgage loans are secured by the entire mortgage loan book. As a result, the tool of imposing LTV limits on mortgages which are allowed to back the CBs reduces to setting loan-to-value (LTV) limits on issuance because all the mortgages issued then comprise the cover pool, in fact. This is in Spain set by law on 80% for residential and 60% for commercial mortgages. In other countries, on the contrary, only some of the mortgage loans issued may be placed into the cover pool, which is ring-fenced from the rest of them in this way. These mortgage loans are required to comply with special LTV limits, which may be more prudent than the existing LTV limits on issuance. In most countries then, these limits are tighter for the commercial mortgages (about 60%), as opposed to residential ones (about

75%). In some jurisdictions, the share of commercial mortgages in the cover pool is also limited (e.g. Germany). (Martín et al., 2013)

On the other hand, Spain has the tightest overcollateralization limit implied by the LTV limit on issuance, which is 125% for CBs backed by mortgage loans; this should mitigate the risk that may potentially arise from higher LTV mortgages in the pool. In the rest of the countries, the minimum coverage ratio ranges between 100 and 110%. In Spain, tighter limit is also imposed on securitization assets or loans securing mortgage bonds which may count to the cover pool. This limit is set on 5% of the pool. (Martín et al., 2013)

Finally, Spain and Denmark are the only two countries in which monitoring and reporting about the cover pool is done by the issuer itself. In other countries, this is always done by an independent trustee.

In their review, Catarineu and Pérez (2008) describe the model of securitization in Spain as traditional overall. Authors note that although the securitized assets are usually transferred to the SPV, such transfer does not result in removing asset from the issuing bank's balance sheet. For this reason, securitization in Spain like in most other countries served almost exclusively for financing credit (allowing in this way for increased activity of the bank) and not for risk transferring. At the same time, such model as opposed to the originate-to-distribute allowed for maintaining strong relationship between the bank and its client, in line with character of the entity as "banca minorista". At the same time, this reduced the information asymmetry and had favourable effects on confidence in the sector.

The different nature of the securitization in Spain and the U.S. brings along several more implications. Whereas in Spain, the process was held within traditional structures, in the U.S., it was accompanied by large financial disintermediation (Álvarez, 2008). While issuing covered bonds does not remove the risk from the issuing entity's balance sheet, there may still be a latent increase in risk resulting from over optimism of banks while granting credits, which is related to the increased liquidity in the system. However, as further reported by Álvarez (2008), there has not really been any risk transfer in Spain connected with securitization, yet the particular features of the process in Spain were:

1. Ability to evaluate correctly the risks, since the structures underlying the CBs were well known as opposed to complexity of the MBSs in the U.S.

2. Actually high quality of securitised assets, with average LTV ratios of 70%

and degree of overcollateralization of 25% (the case of cédulas hipotecarias as discussed in Catarineu and Pérez (2008). According to Catarineu and Pérez (2008), the morosity of mortgages to households is even lower than for the non-securitized portfolio. Next, the same authors confirm that there was no subprime market in Spain as far as quality of the portfolio is concerned.

Such differences are then of regulatory nature mainly, since in the U.S., banks did not have to hold reserves against securitised loans, unless they had an ownership position in the SPV which the loan was placed in. As opposed to this, in Spain, such assets had to be consolidated on balance sheets of banks, and thus constituted capital requirements. (based on Valverde, Rosen and Rodríguez, 2011)

3.3 Behaviour of the covered bond markets under stress

Like for any other instruments, the best way to assess nature of the CBs is to analyze its behaviour under market stress. Furthermore, distinct reactions under various sources of such inconvenience as well as differences across countries may help to explain the mechanism through which CBs may have effects on real economy. 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. While in the first episode, the effect might have been limited to the concerns about overvalued housing prices in the respective markets, during the second period, the consciousness of risks broadened and there was a prevalent fear of nexus between sovereigns and banks.

During the initial period of the financial crisis, the amount of securitization of the ABS type even rose on global level, while on the other hand, the volume of unsecured bonds fell notably except for the government bonds. Compared to these dynamics, the 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. In particular, 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 the activity on the secondary market, the ECB launched the first wave of the Covered Bond Purchase Program in 2009.

When the sovereign crisis deepened the problems arising from the financial crisis itself, the reaction of the national markets with CBs sharply diversified. The issuance in the Eurozone as a whole dropped, while the activity shifted to other countries, like the north-European ones, Canada or Australia. Importantly, within the Eurozone, the 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) This polarization was also evident from the data of the maturity profile of the issues, with decreasing length in countries from the periphery, in which the increased uncertainty is reflected. This then lead to the second CBPP by the ECB in 2011[9]. To increase transparency of the instrument and boost the market with CBs, period of legislative activities followed in the most affected countries, including Spain in 2007 and 2009.

While it used to be unimaginable 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 thus started to trade within the government bonds.

Finally, while CBs have generally recognized more significant changes in spreads compared to those of government bonds, there have been lags identified in their reaction as a result of hold-to maturity strategies. Therefore, while the size of change in spreads was generally bigger for the CBs, delays in their reactions might eventually translate into lower spread volatility.

3.4 Dynamics of covered bonds and implications for financial stability

The past episodes of stress revealed high interconnectedness of covered bonds to both house prices and economic performance of the countries. Although some authors point out that "*the covered bond market has the potential to add*

[9]For this reason, when analysing both the issuance of CBs and the volume traded on the secondary market, special attention has to be paid to the impact of extraordinary liquidity programs launched either by the ECB or the national central banks.

significant stability to the banking system," (Biswas et al., 2010) it may be shown that this may not necessarily hold. In fact, CBs may, under certain circumstances, bring imbalances to the mutually related system of business, credit and house prices cycles.

In their attempts to favour the CBs, regulatory authorities usually argue with rising credit quality, which the usage of the CBs should generally lead to. Assets underlying the CBs remain on the balance sheet of the issuer, who bears the risk of change in value, may it occur along the duration of the portfolio. This in turn reduces the adverse incentives to maximize borrowing, which are in place when assets are removed from the balance sheet as soon as funding is obtained for them (which was typically the case of the MBSs). This should finally translate to more sound credit granting policies.

On the other hand, favourable costs of funding, which further translate into more attractive terms of mortgages, may easily give rise an upward house price spiral. Given the interrelations between housing and business cycle, when borrower's conditions tend to improve with the house price upswing in large, a house price boom may be easily initiated even in a presence of these sound credit granting policies.

When conditions in housing or financial market deteriorate, banks may be encountered with substantial funding risk in turn. Mortgages, which serve for backing the CBs most typically, are usually of much longer maturities than the CBs themselves, from where arise maturity mismatch and duration gap. This is then source of interest rate risk, when cost of financing a mortgage until maturity is not known when it is being issued. Under stress, banks may then find it difficult to roll-over the mortgage under comparable term or to fund it ever.

This is in fact a highly procyclical feature of the CBs, since average maturity of mortgages usually increases with the house price upswing, when the probability of the downturn also gets higher. When it comes, the increased uncertainty leads to lowering maturity of the CBs which the investors are willing to buy in order to decrease the risks. As a result, the maturity gap gets bigger in times when there is the biggest volume of mortgages outstanding on the bank's balance sheets. Getting to relatively cheap financing may therefore become increasingly difficult. Interestingly, such interest rate risk may be lower for variable rate mortgages, which may effectively serve as a hedge. In such a situation, the rate under which the CBs are issued corresponds to the cash flow generated by the mortgage covered by the bond, and evolves similarly until when the bank rolls the maturing CBs over. Variable rate mortgages are, by the way, a prevalent type of mortgages in Spain.

In case when the CBs are sold off heavily under stress, the role of banks as market makers, obliged to accept certain amount of CBs in the primary market, might also lead to accumulation of CBs on their balance sheets. This may in turn create shortage of funding and press banks to recourse to other sources of financing, including the short-term market funds. (Sandstrom et al., 2013) In such a way, deterioration on market with covered bonds would spread to other markets, which would make the ability of banks to get to financing even lower.

With declining house prices, also the ratio of the original loan issued to the current value of the unit of housing increases. This presses banks to add more assets to the collateral pool in order to increase its value, or even substitute some of them if the cap on LTV ratio on assets eligible to the pool is imposed by regulation. (Sandstrom et al., 2013)

Finally, CBs may also be severely affected by deterioration of the sovereign risk, when the sovereign rating represents in fact the upper limit to the rating of the CBs. According to this, the sovereign spreads should trade inside the corridor set by the CBs spreads. (ECBC, 2013) In the last financial crisis in Spain, however, cases when the CBs traded tighter than the government bonds appeared after the outbreak of the sovereign debt crisis. This is rather characteristic of the CBs, but might never happen to the MBSs. These are, on the other hand, characteristics which may make them slightly more procyclical overall.

To sum this discussion up, at the beginning of the turnaround, extensive stock of CBs previously used for financing may in fact cause the credit market even more stuck. On the other hand, when the overall conditions deteriorate, the seeming protection provided by the CBs make 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 possibly 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 a popular investment. Mortgages, which are most often used as collateral for the CBs, might have then been favoured, in a consequence, and CBs thus became one of the sources of adjustment. This would also explain why the house price correction was somewhat limited at the beginning of the downturn compared to Ireland for example, where CB market was not that buoyant, but then it gradually rose.

With respect to this, adding CBs to the framework of house price, credit and business cycles used in Hejlová (2011) might be particularly relevant.

3.5 Relationship between covered bonds and housing market

On one hand, therefore, favourable terms provided by the investor on 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, in 2011, the Banking Supervision Committee of the ECB reported about CBs as an alternative for typical instruments of securitization, which might be particularly useful in the downturn. (ECB, 2011) In line with the need for correcting housing bubbles and thus to ensure access to financial resources, there has been hope that CBs might represent new sources of mortgage financing. (Rosen, 2008) According to the present author, inherent prerequisite to such an assumption is that the security provided by CBs to investors has capacity to reduce uncertainty which would persist with use of any other instrument in times when general conditions significantly deteriorate. In other words, guarantees provided with CBs are able to maintain confidence among investors even when the market turns over, including likely deterioration in the value of the collateral.

Putting these two things together, definition of the CBs implies that while they may help to drive the prices up, they may eventually also help to return them back to equilibrium. There are two main reasons why CBs may help to revitalize the credit market, which is needed to restore equilibrium on market with housing. First, their issuance simply makes financing mortgages 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.

Although neither of the mechanisms described has been widely investigated so far, one thing rests clearly puzzling. In the linear framework, it would be intuitive to get estimate of a positive relationship between volume of credit on housing and house prices. That is, rising house prices are usually accompanied with rising amount of credit. Such positive relationship, however, also implies that when house prices fall down, the volume of credit shrinks as well. While this may be generally true, it is not completely in accordance with what is known about correcting a house price bubble. In such situation, transaction activity, which requires activity on credit market in turn, is assumed to be crucial to drive house prices back to equilibrium. (Hejlová, 2011) For this reason, keeping the credit market unfrozen is a key to the house price correction. Therefore, strictly positive relationship between house prices and credit should no longer necessarily hold in the downside part of the house price cycle. Alternatively, the CBs might help to explain dynamics in both upward and downward part of the house price cycle.

While the previous paragraph does not want to say that credit may never be decreasing when house prices are on their way down, which is in fact a common property of the respective time series, it is rather suggested that CBs might be thought of as a force behind the reversal in the mutually related markets of housing, credit and business cycle in which, as has been documented, they represent an important source of interrelatedness. In this way, CBs might in certain way approximate the additional increase in credit that would not have been granted otherwise, which is generally a difficult task in economics to estimate.

3.6 Data analysis: Spain

There are two reasons why Spain is a unique case to study as far as the effects of CBs on housing cycle are concerned. First, there was a house price bubble built on the housing market, accompanied by significant indebtedness of households that rose sharply whole this time along. Secondly, regarding the significant share of CBs on housing credit before the financial crisis already, which may be considered as a measure of importance of the CB financing, it makes sense to at least consider potential effects that the CBs may have had on both upward and downward part of the house price cycle in Spain. In other of the countries in which CBs are common today, the importance of financing through CBs, measured again as a ratio of their stock over credit to housing, either increased to comparable levels after 2007 when mortgage loans were already descending in general, or it was already comparable before 2007 when the mortgage loans were rising in general, but it was not combined with such elevated indebtedness of households like the one experienced in Spain. In this respect, the need for unfreezing the market with housing credit may not have been so pressing and the potential effect of the CBs on unfreezing the market may not have been activated, so to say.

In what follows, relationship between securitization related variables and credit and housing market related variables are analyzed. The aim is to explore the role of securitization in the mutually related cycles of credit and house prices, and make the empirical analysis which follows in the next section data driven. As already indicated, patters in data are looked for along three dimensions:

1. Impact of securitization is analyzed vis-a-vis house price cycle (proxied by house prices) and credit cycle (proxied by mortgage credit).

2. For both house prices and mortgage credit, impact of securitization is searched in both yearly rate of change (computed as logarithmic differences of the data series) and speed of such change (calculated as the second logarithmic differences of the data series).

3. While the empirical analysis is aimed at capturing effects of the CBs on house prices, comparison to the MBSs is being used heavily along the present work, with the aim to make finding the true mechanism behind these instrument easier this way; therefore, CBs and MBSs are considered as securitization related variables individually and the four above combinations are replicated for both of these types of instruments separately.

Finally, by disclosing information about the observation dates, the time dimension is introduced into the analysis. This proved to be a particularly useful tool, since it may help to assess whether information contained in an observation belongs to some pattern in the data (this is while the observation fits between other observations in the proximate period), or might rather belong to some noise in it.

Along these three dimensions, patterns in the data are analyzed using scatter plots. A need for a thorough data analysis stems mainly from two concerns.

The first one is the absence of clear theoretical notions about the impact of the CBs, which the model might be securely based on. The second one is the complexity of the econometric method for modelling such relation, used in the next section, which might eventually lead to misleading results due to an easy over-specification of the model. In this respect, the sample of the data is not long enough to permit checking model's performance out of sample either. Detailed analysis is therefore crucial to make sure that the model proposed takes from the underlying data, indeed. For this analysis of the CBs and MBSs, monthly data obtained from Asociación Hipotecaria Española, which are not publicly available rather than in yearly frequency, were used. Data on mortgages and house prices are provided by Bank of Spain. The data set covers the period between year 2003 and 2013.

The visual inspection of the data then aims at answering the following questions:

1. Is there some relationship between securitization- and credit/house price related variables?
2. When approximated linearly, is there only one such relationship, or are there more of them depending on values of the variables included? (Implicitly, is there some threshold in one of the variables from the pair that governs the relationship between the two series?)
3. If yes, then is there some smooth adjustment between these regimes, or is the change abrupt?

To analyse a wider range of properties of the CBs and MBSs vis-a-vis credit and house price cycle, several expressions or transformations of securitization related variables - the same for CBs and MBSs where it made sense - were used. First, it is assumed both the net change in stock of CBs and the volume of CBs issued. On one hand, valuing the net change in stock takes into account that CBs are heavily traded among banks in the secondary market, through which need for financing may also be satisfied. On the other side, such variable is necessarily influenced by the maturity profile of the past issues; in this way, information about the incremental volume of CBs and its timing, which is more in line with thinking about CBs as a proxy of additional credit granted at a certain moment, may be somewhat distorted. Secondly, the ratio of the instrument - both its stock and new issues - to the volume of mortgages outstanding is considered. The aim of such exercise is to assess whether with more extreme values of house prices and credit related variables, achieving a marginal change to these variables[10] is associated with increasing effort in terms of use of the securitization instruments. Alternatively, elasticity of credit or house prices related to issuance of the securitization instruments, measured as ratio of respective changes, is assumed. Finally, amount of the CBs traded on the secondary market over the total volume outstanding is used to assess impact of the overall liquidity, which may possibly account for spillovers to other markets with funding, and have some accelerating effects in this way.

The last concern relates to the selection of the credit cycle related variable. With the purpose of getting to know the mechanism behind the use of CBs, only mortgages, which are eligible as collateral, were first related to the CBs at this stage, assuming that the direct impact of the use of CBs may be viewed more clearly in this way. It also allows a more precise analysis, since both data on CBs and mortgages are, different from other credit on housing, of monthly frequency. Nevertheless, mortgages financed by the CBs may also have important secondary effects on other credit on housing. For this reason, the total amount of credit on housing, including both mortgages and other credit on housing, is used in the empirical model in the next section. This is, on the other hand, more in line with the purpose of assessing effects of the CBs in broader framework of mutually related system of house price, credit and business cycle.

Finally, it is important to emphasize that the following comments concern possible relationship between pairs of variables, and not the potential causality between the two. Then, the main conclusions from such analysis are:

1. With respect to the rate of change of mortgages/credit on housing outstanding and house prices (Figure 2 in Appendix A):

    a. Dependence is found between both rate of change of credit and house prices on one side and the change in CBs, measured by change in volume outstanding as well as volume of new issues, on the other side; although the relationship is evident from both these measures of change in CBs, it may be more clearly seen from the data on new issues and sum of mortgages and general credit on housing.

[10] This may stand for a situation of increasingly higher, or lower rate or speed of growth in either mortgages or house prices.

b. The pattern seems 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 or mortgages. In other words, their issuance increases with more extreme values of both.

c. Under the assumption that in the downturn, house price correction is favoured by new issues of mortgages, which help to revitalize housing market in turn, it is increasingly hard to achieve higher values of house price decrease by the means of funding mortgages with CBs. This follows from the observation that towards higher values of the house price decrease, the share of CBs on mortgages outstanding increases more than linearly. Such a conclusion is then more compelling when properties of the "base effect" of such measure, which is calculated as a ratio, are considered. Reason for this may be higher interest rates demanded by investors compared to more normal times, which require bigger share of such funding in order to attain more attractive terms for mortgages. Compared to this, the same relationship is linear on the whole interval of house price change in the case the of MBSs.

   As will be discussed in the concluding part, such property may have important financial stability implications for case when house prices drop; in such a situation, the more significant fall in collateral concerns increasing share of encumbered assets over the mortgage portfolio.

d. CBs and MBSs then alternate each other in terms of their relative use. Relationships with opposite signs to those described for the CBs were found for MBSs on both intervals of values of house prices and mortgage growth. In this way, the amount of securitization with MBSs attained its highest relative values at the house price turnover, which is in line with what has been reported for countries in general (Section 3.3). However, even in times when issuance of CBs was on its minimum over the sample, CBs still played a dominant role in the Spanish market with securitization.

   In this respect, issuance of CBs accounted for roughly 50% of the sum of CBs and MBSs issued when the house prices were turning around. In their best times then, CBs accounted for over 60% (during period before year 2007) or almost 100% (prior to year 2011)[11] of the respective amount. When measured by the volume outstanding, CBs played significantly more important role in terms of volume outstanding during the whole period considered, when its share on total volume of securitization instruments outstanding, both CBs and MBSs, accounted for from 59% at the beginning of the sample to 77% at the end.

2. For the speed of change of credit on housing and house prices (Figure 3 in Appendix A):

   a. Just one relation is visually found for the whole interval of values for both house prices and credit;

   b. However, if approximated by linear function, such relationship has opposite direction for house prices compared to the credit. That is, with bigger changes in the volume of the CBs outstanding, the speed of change of credit is increasing, while the opposite applies for the speed of change of house prices, which is decreasing at the same time. Rather than a special property of the CBs, this may be, however, attributed to the general property of dynamics on the housing and credit market, when the speed of credit growth usually peaks when house prices attain their maximum value.

   c. For both CBs and MBSs, direction of the relationship vis-a-vis respective speed of growth of house prices and mortgages is of the same sign.

To the author's limited knowledge, this is the first time when such dataset of the AHE, which is available on monthly basis but was transformed to quarterly frequency where necessary, was used to an empirical analysis other than of ECBC. In other empirical comparisons so far, annual data, which are available on the internet, were used.

[11] Source: AHE and author's calculations.

3.7 Data analysis: Selected countries

To verify these patterns, housing and credit cycles are briefly analysed for a panel of countries which are the most important issuers of CBs as of today. This panel includes Spain, Denmark, Germany, Ireland, Sweden and the UK, what offers a lot of heterogeneity to analyze. First, evolution of house prices and household indebtedness are compared across countries, completing the analysis of CBs reviewed in Section 3.3. For countries that show features which are similar to Spain, scatter plots are used to verify the above charted patterns in the same way as it was done for Spain. To make sure that assuming potential effects of the CBs makes sense on both sides of the house price cycle, its ratio to stock of credit on housing is again controlled for in both the pre- and post-crisis time. The data used come from a unique set gathered by the ECBC, which is available on the internet, albeit of annual frequency only.

Countries that belong to the most important issuers of CBs today have recognized diverse evolution on their domestic housing markets. On one hand, Spain, Ireland, the UK and to certain extent also Denmark experienced significant rise in house prices which were then gradually corrected in the following years, albeit with significant differences in timing and pace (Figure 5 in Appendix A). While Ireland recognized an abrupt fall in house prices immediately after the turnaround, the house price correction in Spain was less pronounced in the first quarters of the downturn.

On the other hand, house prices in Spain attained its maximum value of house price decrease only recently, when they fell by 12.8% towards the end of year 2012. Additionally, they have kept falling significantly until the last observation available in the fourth quarter of 2013 (-5.8%), when Ireland already marked a significant renewed rise (6.2%; all changes are in real terms and refer to the same quarter of the previous year). While part of this rise in Ireland may then be regarded as a consequence of possibly overshot fall of house prices by no less than 56% in real terms, such correction still remains the biggest with significant lead to Spain, where house prices have declined by slightly less than 40% so far. Denmark and the UK followed with a fall by 27.6% and 25.9% so far, respectively. On the other hand, for Germany, the highest value of house prices available is from the beginning of the sample in year 2001, with house prices stagnating or moderately decreasing since then. Contrary to this, the peak in house prices in Sweden marked in the first quarter of 2013, which is the last period for which data is available, after a relatively mild development characterized by presence of a cyclical pattern. (Table 1)

Table 1: House prices: Panel of countries

House prices, index (2005=100), real terms							
	min before max	max	min after max	time of max	% change precr.	% change postcr.	sample
Denmark	93.47	101.18	73.29	2007:Q3	- *)	-27.56%	2006:Q1
Germany		109.14	90.83	2001:Q1	- **)	-16.78%	2000:Q1
Ireland	96.70	118.30	55.75	2007:Q1	- *)	-52.87%	2005:Q1
Spain	61.00	110.16	70.18	2007:Q1	80.59%	-36.29%	1997:Q1
Sweden	77.88	128.23		2013:Q4	64.66%	- **)	1997:Q1
UK	57.68	112.57	83.40	2007:Q3	95.17%	-25.91%	1997:Q1

Source: BIS, Nationwide UK and author's computations.

Note: In the UK only structured CBs were initially being issued; therefore, when the legislation for CBs was introduced in the UK in 2008, the increase with respect to the initial levels was significant.
*) Calculations of rate of growth over the precrisis period is for some countries by data availability at the beginning of the sample. For this reason, information about the initial change is missing for Denmark and Ireland, for which the sample starts in 2005 and 2006, respectively.
**) For Germany and Sweden, where one of the were recognized at the beginning or end of the sample, one of respective percentage changes is missing.

The house price upturn was then to the biggest extent debt financed in Ireland, where indebtedness of households due to possession of loans for housing grew by 50.6 p.p. approximately. In comparison, indebtedness in Spain grew from the same pre-crisis level (32.5% compared to the same value of 32.6% in Ireland), although by nearly 20 p.p. less (by 29.5 p.p.). While Denmark, Sweden and the UK marked comparable absolute value of the rise (by 23.5, 21.6 and 26.6 p.p. respectively), it was realized from higher initial levels in absolute terms (71.0, 48.4 and 57.3%, respectively), and thus it accounted for somewhat lower relative increase. (Table 2)

Table 2: Household indebtedness: Panel of countries

Household indebtedness for housing, ratio of credit on housing of households to GDP, %						
	2001	2012	p.p. change	min 2001-2012	max 2001-2012	p.p. change
Denmark	71.00	94.50	23.50	71.00	103.40	32.40
Germany	53.40	46.30	-7.10	44.80	53.80	9.00
Ireland	32.60	83.20	50.60	32.60	91.70	59.10
Spain	32.50	62.00	29.50	32.50	64.90	32.40
Sweden	48.40	70.00	21.60	48.40	80.70	32.30
UK	57.30	83.90	26.60	57.30	87.20	29.90

Source: ECBC and author's computations.

In the same fashion, big differences persist among these countries in terms of importance of financing with CBs, when the share of CBs over the credit on housing ranges from very low to high values. Some countries in which this share of CBs on credit on housing outstanding is very high today have recognized a remarked growth in the last years particularly. The importance of financing with CBs was comparatively high before and after the past financial crisis in Denmark, where the ratio of CBs to credit on housing exceeds 100%, and much lower but still significant in both periods in Spain, Germany and Sweden (with this ratio from about 20% to more than 60% of credit on housing in Spain and Sweden). While Germany is the only country where importance of CB in mortgage financing has been decreasing, their importance in Ireland grew from negligible values in years preceding the crisis to represent almost 20% share of credit on housing in 2009 and 23% over the same in 2011. (Table 3)

Table 3: Importance of CBs: Panel of countries

	Ratio of CBs over credit on housing, %						
	value start of sample	2012	p.p. change	min start-2012	max start-2012	p.p. change	sample
Denmark	138.60	145.92	7.31	114.73	145.92	23.50	2003
Germany	22.14	18.23	-3.91	17.87	22.14	-7.10	2003
Ireland	2.58	19.80	17.23	2.58	22.98	50.60	2004
Spain	18.25	63.40	45.15	18.25	63.40	29.50	2003
Sweden	26.93	65.80	38.87	26.93	67.71	21.60	2006
UK	0.45	11.94	11.49	0.45	15.83	26.60	2003

Source: ECBC and author's computations.

Note: In the UK only structured CBs were initially being issued; therefore, when the legislation for CBs was introduced in the UK in 2008, the increase with respect to the initial levels was significant.

From the perspective of explaining impact of the CBs on house price dynamics on both sides of the cycle, Denmark and Ireland are thus natural candidates to focuse on. In Germany, both house prices and issuance of CBs have been decreasing, however, no housing bubble was previously recognized in the country. In Sweden, house prices have been currently growing together with the issuance of CBs. In the UK, the analysis is biased by missing legislation for CBs for the period before year 2008.

On scatter plots in Figure 6 (Appendix A), clearly negative relationship is visible between the CBs and change in house prices for values of the change approximately lower than zero, when the issuance of CBs also rises with more abrupt decline in house prices. Therefore, the preliminary suggestions from analysis for Spain are confirmed for the downward side of the house price cycle. Although the importance of financing with CBs is still much lower in Ireland, CBs already represented about 20% of the credit on housing during the period of house price decline, which are values comparable to Spain from the beginning of the sample. It is then fair to assume that CBs might account for a part of these dynamics in Ireland as well. At the same time, lower importance of financing with CBs might explain why house prices in Ireland corrected more significantly in the first period after the bubble burst, despite the fact that higher previous increase in indebtedness of households was realized in Ireland compared to Spain. With respect to this, deterioration on the market with CBs, connected to the expected change in value of the real estate, did not hit the credit market that much at the beginning of the period, when even increased deterioration might have marked in Spain due to this reason.

For the upward side of the house prices dynamics, information is limited by the data availability of house prices from the beginning of the sample. It is, however, known that house prices in both countries realized a significant upswing in years preceding the crisis in both Ireland and Denmark. At the same time, we know from the data on CBs that there were higher issues in the two years before the sample on house prices starts. It is therefore safe to assume that two more observations would be placed in the upper right corner of both scatter plots, and the positive relationship between issues of CBs and house price dynamics would be apparent for the upward part of the house price cycle as well.

Before continuing with the econometric modelling, the hypothesis of CBs, which may help to drive the house prices up, but may also help to return them back to equilibrium, has thus hopefully found good support in data.

4. Empirical analysis

4.1 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)

Baxa (2012)[12] then gives examples of several other time series, for which such characteristics have been described in literature: "*GDP time series usually exhibit sharper falls into recessions than the speed of increase in times of recoveries and wages are downward rigid and upward flexible. These are perhaps the most quoted examples of non-linear adjustment.*" ARIMA approach based on linear differenced equations is then no longer applicable in this context.

To address this problem, first, CBs have been introduced as a potential source of change in the underlying mechanism between house prices and credit. Secondly, differences in mechanism behind the dynamics between both sides of the cycle are tested and modelled using a smooth transition vector autoregression model. Such a 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, which is modelled using logarithmic function.

[12] Lectures of Business Cycle Theory at the IES, Charles University in Prague, given by Baxa in academic year 2011/2012.

4.2 Introduction to nonlinear modelling

There has been a long time evidence that various time series in economics tend to be of nonlinear nature. The idea of the presence of nonlinearity has, however, emerged from a negation of linearity, whose symmetric property was perceived as too restrictive, unable to capture different reactions to shocks in different phases of business cycle fluctuations, as an example.

While the economic theory is now already quite sure about presence of nonlinearities in the economic time series and relations between them, there is no class of models that can be universally applied to modelling of the time series dynamics in nonlinear manner, as opposed to the linear models with Box-Jenkins methodology and the vector autoregressive models. (Granger et al., 1993)

Several streams of modelling have then emerged since 1970s. Currently, there has been three main types of nonlinear models, namely the Markov switching, threshold autoregression (TAR) and the smooth transition autoregression (STAR), which has developed as a natural follow-up of the previously mentioned models.

First, a univariate self-exciting threshold autoregressive models was proposed by Tong (1990). In general, however, these univariate models showed higher persistence of shocks during expansions compared to the recessions. (Koop et al., 1996) Next, a multivariate TAR model followed in work by Granger and Terasvirta (1993). Although it was still maintaining the uniequational form, this work already assumed smooth transition modelled by a logistic function. Terasvirta (1994) then departed from these notions and proposed exponential function as additional form of nonlinearities modelling. Finally, vector extensions of both variants were proposed by Camacho (2004). In this respect, Koop et al. (1996) argue that including information from not only multiple time series, but also from different sectors of the economy considerably helps to model different response to shocks across regimes. After introducing these few models, missing statistical apparatus has been emerging rapidly since then. The main problem in its development follows from the fact that statistical properties of the nonlinear models are not known a priori. This means that the nonlinear models are generally estimated after rejecting linearity of the underlying relations. Completely new to these models with a smooth nonlinear transition are then the generalized impulse responses, which were developed to loosen the linear properties of the traditional impulse responses.

As for the practical usage of the nonlinear autoregressive modelling, the initial models were applied on noneconomic data. First empirical results from economics have been ambiguous, failing to reject linearity of the time series in many cases. With emergence of the theoretical framework, it has improved towards rejecting linearity in increasing number of cases. However, the empirical evidence following the theoretical proposals is still scarce, albeit it has been growing rapidly. One of the reasons may also be its complicated implementation in practice, when it has not yet been fully built into the existing statistical packages.

The present work is, to the author's limited knowledge, the first attempt to model house prices in a framework of mutually related system of house prices, credit and business cycle using the vector smooth transition autoregressive model. The previous works that followed smooth transition autoregressive approach were mostly applied on output or its components, albeit still using univariate or single-equational models. The vector extensions, which were applied afterwards, concentrated on issues like effects of monetary policy or exchange rate pass-through. Given the complexity of the estimation technique that has been evolving dynamically in the recent years, the smooth transition models, either univariate or their multivariate extensions, are reviewed in the following section.

4.2 Options for ST(V)AR models and its empirical practice

To first come up with an important procedure for testing threshold nonlinearity, Tsay (1989) follows the self exciting threshold autoregressive model as suggested by Tong (1990). He also gives guidance on how to find the threshold variable and estimate the threshold values. The model allows for at least two different regimes, each of them modelled using linear regression technique. Later, Tsay (1998) also provides a multivariate extension to this model.

Granger et al. (1993) extend the previous univariate model by Tsay by adding multiple explanatory variables. In this model, however, there is still only one dependent variable, which is modelled using multiple explanatory variables and lagged values of the explained variable itself. Importantly, such model already contains a smooth transition component, with the transition modelled using logistic function. Terasvirta (1994) then departs from this model, considering two families of nonlinear autoregressive models. Apart from one-threshold model with logistic function, he also considers two-threshold model, where the function used to model this transition is exponential. The author also proposes a four-step procedure for model specification, estimation and evaluation, which some authors compare to the procedure proposed by Box and Jenkins for the linear autoregressive models. (e.g. Potter, 1999) Escribano and Mira (2002) then deal with both nonlinearity and nonstationarity of the data in the first early empirical application of the model, extending these nonlinear models by an error correction component. Granger and Swanson (1996) then argue that the ideas upon which the cointegration is based could still be valid under the nonlinear framework, although variables are not necessarily standard I(1) and I(0).

Finally, Camacho (2004) proposes a vector autoregressive extension of the STAR models developed by Granger et al. (1993) and Terasvirta (1994), for both logistic and exponential function as a form of modelling the smooth transition part of the process. This model of Camacho (2004) is currently the most comprehensive STVAR model, with multivariate extension to all important tests which are frequently used in the modelling procedure.

The multivariate autoregressive smooth transition model as presented in Camacho (2004) then takes the 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.)

Such a representation has important implications for interpretation of results. When the value of the transtion function F approaches zero, the system reduces to VAR with coefficients β_{yi}. When its value approaches one, the system reduces to another VAR with coefficients $\beta_{yi} + \tilde{\beta_{yi}}$.

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 Bhattacharya (2009) model dynamics of home prices, which depend on the sign and size of its own lagged values. Authors use nominal house prices as suggested by Genesove and Mayer (2001) and Engelhardt (2003) and annual growth rates for higher smoothness. Authors find that the nonlinear model performs better when measured by higher R^2, improved standard errors, log likelihood value of the regression and better significance of the estimated coefficients, when coefficients in the nonlinear part are significantly improved. Smoothness of adjustment is different for each of the four regions, as well as the threshold value of the exponential transition function. From the complex roots of the estimated model, it is evident that the house prices are dominated by cyclical movement in both expansion and contraction. Secondly, explosive roots in most of the middle regimes indicate that the house prices pass through the middle regime very quickly, as opposed to the stability found in the outer regime. Importantly, 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.

Apart from this work, most of the existing models of house price dynamics are still conducted in linear framework or remain limited in number of variables used. In this way, they do not capture important interaction of house prices with other macroeconomic variables and remain inattentive to important macroeconomic and financial variables.

4.3 Suggested approach to modelling using STVAR models

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.

Approach to the individual steps in estimations is reviewed as follows.

Choosing AR order

As emphasized by Terasvirta (1994), both "*linearity testing and model specification build on the assumption of knowing the autoregressive structure*", for which reason determining the maximum lag order is important. Existing literature agrees that it should be done using the linear technique, applying the same procedure like when the linear VAR is estimated. However, using such procedure for a nonlinear model may entail several pitfalls. Tsay (1989) suggests using the partial autocorrelation function as a supplement to the information criteria, since information provided by these criteria may be misleading in case the true model is nonlinear. Terasvirta (1994) points out that if it is decided based on SBIC, tests for serial correlation of the residuals should be used once the model is estimated, since the SBIC may lead to too parsimonious models. Remaining autocorrelation may then lead to rejection of the zero hypothesis of linearity and using a wrong model in this way. On the other hand, AIC tends to prefer overparametrized model, which may then overfit in sample.

Choosing threshold variable

Terasvirta (1994) admits a whole range of possible threshold variables. It may be a lagged endogenous variables, an exogenous variable, or a function of various variables that are again endogenous to the model. Special case concerns including the linear trend as a transition variable, which then leads to a model with smoothly changing parameters.

Linearity testing

The basic problem of testing for nonlinearity is that the nonlinear model is not known a priori, so that the classical distribution theory may not work in this framework. Instead of using the standard LM test, which has low power against the alternative, Luukkonen et al. (1988) proposed a way how to test for linearity without the need to estimate the nonlinear alternative. Authors propose substituting the nonlinear function by a Taylor series expansion and accepting nonlinearity as a rejection of linearity.

Camacho (2004) introduces its vector extension, which may be used to test for nonlinearity of a system as a whole. Such test takes the 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 as of the system, LR statistic is used in a form of $LR = T\,(|\sum_R| - |\sum_U|)$, where $|\sum_R|$ and $|\sum_U|$ are determinant 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 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 is equal to $\varepsilon_{i1} = \varepsilon_{i2} = 0$, $\xi_{i1} = \xi_{i2} = 0$.

The natural inconvenience of such test is the dimension of the null hypothesis, when Terasvirta (1994) suggests applying higher level of significance on relatively large samples.

Although the alternative nonlinear model remains unknown and the transition function is being only approximated, equations used in linearity testing include switching expression for which a set of alternative transition variables as well as the number of lags have to be proposed in advance. In such setting, researchers often face a situation in which linearity is rejected for more than one variables and its lags. Terasvirta (1994) suggests using the model which has the smallest p-value in the linearity tests. Camacho (2004) points out that such procedure may lead to misleading results, when appropriate model is omitted just because it rejects the linearity weakly. Moreover, based on the estimation experience from the present paper and the experience evidenced in Kavkler et al. (2007), it may happen that in the multivariate models, some of the transition variables report very small p-values in some of the equations of the system, while not in the others. Solution to overcome this problem is proposed in Kavkler et al. (2007), where it is approached to the nonlinear modelling using specific threshold variable for every equation.

Choosing transition function

After determining the autoregressive lag structure and the transition variable as well as rejecting linearity, it is necessary to decide on the exact form which the transition function will take. Among the infinite possibilities that the nonlinear form of modelling offers, 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 $D_{t,i} = (z_{t,i} - g_i)^2$.

Type of the transition function then 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). In both cases, different dynamics are associated with value of the transition function equal to 0 and 1, which makes the two regimes strictly different (for these values, the transition function takes the form of indicator function determining the regime). With large values of gamma, the logistic function then approaches the indicator function on whole interval of values of the threshold variable, converging to the more simple TAR models.

For this reason, use of one of these functions for modelling the transition may be often relatively straightforward. On one hand, the logistic STAR models are able to capture "*a situation where contraction and expansion phases of an economy may have rather different dynamics.*" On the other hand, exponential STAR models can represent "*an economy which returns from high growth towards more normal growth in the same fashion as it accelerates from low or negative growth towards the middle ground.*" (both Terasvirta and Anderson, 1992)

To decide between these two model specifications in more rigorous way, Terasvirta (1994) proposes a 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.

Estimating threshold value

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. Such method of parameter finding then generates nxj number of models, where n and j are the number of values of the threshold variable and smootheness parameter.

The respective parameter values are then found in 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. However, several problems may be encountered when estimating the models. Dijk et al. (2002) points out that "*if the transition function remains almost constant in the whole sample, the moment matrix is ill-conditioned and the estimation fails.*" Next, with large values of gamma and the threshold values close to 0, results may not be obtained even when the convergence is achieved.

Finally, accurateness of the transition parameter estimates is conditioned by sufficient number of observations of the transition variable close to the threshold value. This follows from the fact that impact of the change the transition parameter on the shape of transition function is very limited and the convergence of estimates of this parameter is very slow. With large values of the parameter then, the transition function becomes very steep and the model approaches the simple TAR model with sharp switch between regimes. However, Dijk et al. (2002) state that estimating the transition parameter very accurately is not crucial for finding a well performing model. This is obvious from the practical experience of estimating model for the present paper, when after rearranging values of the measure of fit from its minimum to maximum values, models with the same threshold value but different transition parameter were typically coming in sequence.

Estimating the model

As pointed in Weise (1999), 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. Where necessary, nonlinear least squares are automatically applied by Eviews.

Nonlinear Granger causality

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 the 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.

4.4 Empirical model of house price dynamics and covered bonds

Approach

The following empirical model follows from the discussion of both theoretical properties of CBs in Sections 3.3 - 3.5, as well as empirical characteristics of the data as analyzed in Section 3.6. The primary aim of the model is to test on the role of CBs in house price dynamics in Spain. Such evidence would serve for assessing possible impact of the CBs on house prices and financial stability in other countries, provided that CBs keep extending over the financial markets.

Secondly, this empirical analysis is also an attempt to model house prices in a nonlinear way in a framework of credit and business cycles, in which important nonlinearities have been suggested, but they have been modelled in isolation so far. Given the limited number of observations, which makes forecasting impossible in practice, diverse options for researchers are investigated, to provide basis for future analysis in this fields. Overall, the following model should be regarded as the first attempt to model impact of the CBs empirically and to extend existing transition autoregressive model of house prices into multivariate and multiequational framework.

With regards to the specification, ambition of the model is to stay within the framework of mutually enhancing powers between house prices, credit and business cycle, described in the first part of the present thesis and investigated already 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. Such variables may be 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, makes the estimation on small samples technically possible and allows to model these cycles so as they affect each other. Apart from that, including these basic proxies for credit and business cycle, some of the latent information like the general over optimism during the boom phase of the economy, which are at the same time important fuelling factors within the system of these three cycles, enter into the model.

With the aim to test whether there are nonlinearities present in the house price cycle, and whether it is relevant to explain house price dynamics in the system of credit and business cycle, it is approached to testing for nonlinearity and estimating LSTVAR models for a sequence of different sets of variables. 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. This is done by comparing respective models and submodels with the use of the likelihood ratio test. 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.

Data

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

House prices Collected by the Spanish Ministry of Housing and reported by Bank of Spain, it measures price in euro per squared metre of general dwelling, both new and existing; of quarterly frequency.

Credit on housing Calculated as a sum of both mortgage and general credit on housing for households and non-profit organizations. Collected and reported by Bank of Spain, measured in thousand euros of the stock outstanding; of monthly (mortgages) and quarterly frequency (credit). By including both 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, as well as secondary effects of increased banks' liquidity on general credit market, are assumed.

Covered bonds Data on new issues of CBs, measured in thousand euros, were obtained from AHE, which compiles this dataset from information on individual issues of CBs by institutions from Comisión Nacional del Mercado de Valores. The data provided are of monthly frequency, while the publicly available data, from which other data analyses take, are yearly. New issues of CBs 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.

Gross domestic product Measured in thousand euros, collected and reported by Instituto Nacional de Estadística (the Spanish National Statistical Office); in quarterly frequency.

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 7) 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, were found stationary and were put into the model in levels (in billion of euros).

Given the fact that most data are of quarterly frequency, data on CBs were also converted. On one hand, this significantly reduces the number of observations; on the other hand, intrapolating the rest of the time series is not appropriate in this case, when within the autoregressive framework, time series would be regressed on its own lags, values of which were calculated based on an a priori assumption. Finally, monthly data on issues are rather volatile, since it is not an exception that there are no issues in some of the months even in times of increased activity in the primary markets with CBs. For this reason, the dataset is of quarterly frequency and covers period between 2003 and 2013. While this is not much, it is still the largest data set on CBs available. (Individual time series used in the models are described in Figure 1, with abbreviations and models summarized in 4).

Table 4: Models and variable abbreviations

Model	Variables included, in notations
Model 0a	dsl_hp, dsl_cred
Model 0b	ch_i, dsl_cred
Model 1	dsl_hp, ch_i
Model 2	dsl_hp, ch_i, dsl_gdp
Model 3	dsl_hp, ch_i, dsl_cred
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

Source: Author.

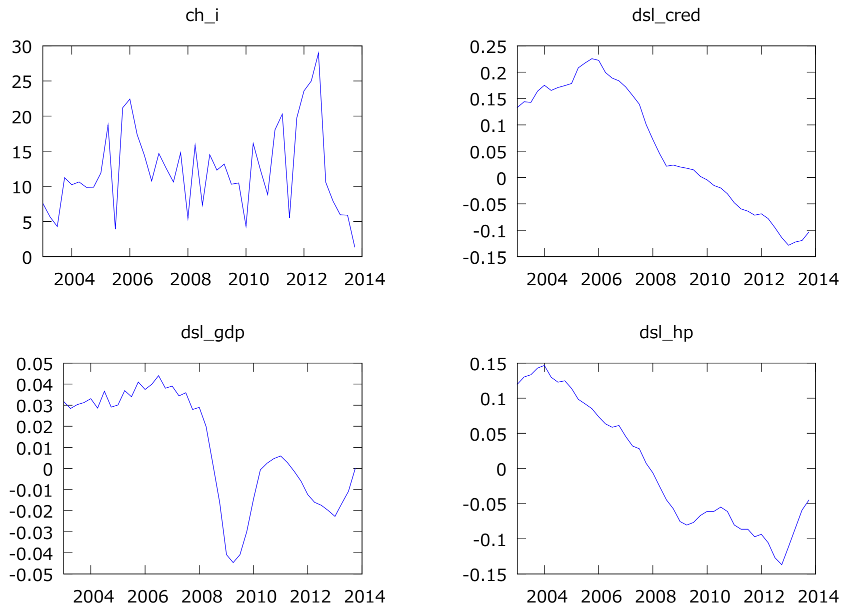
Note: All variables are in real terms. For further description of the variables, please, refer to the main text.

Models

Five simple models were proposed to test them for nonlinearity, while four of them are estimated. These are:

To assess mutual relations between housing and credit market, three two-variable models are first assumed. These are model of the rate of change in house prices and credit on housing (benchmark model 0a), rate of change in

Figure 1: Time series modelled



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

house prices and issues of CBs (model 1), and finally issues of CBs and rate of change in credit on housing (benchmark model 0b)[13].

Next, three-variable model with rate of change in house prices and both issues of CBs and rate of change in credit on housing is assumed (model 2), to allow for testing whether adding issues of CBs is important for explaining the house price dynamics (by comparing model 2 and benchmark model 0a). Alternatively, proxy of the business cycle is added to the pair of house prices and issues of CBs (model 3), to assess relevance of the overall economic conditions in explaining the house price movements (by comparing model 3 and model 1). Summary of the models as well as variable abbreviations is included in Table 4. For all tests and estimates, Eviews was used.

The most difficult task has, however, been the choice of 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,

[13]The last model was added to assess dynamics within the credit market, i.e. to assess whether CBs and credit on housing behave in the same way along the whole data span. That way, conclusions are aimed to respond to the visual observations of the data in Section 3.6.

while others are 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 the theoretical discussion in part 3.5, which is also the approach preferred by Camacho (2004). In this way, change in credit on housing was picked up. The main reason is that the credit market is assumed to stay in between the market with housing on one side and market with CBs on the other side. That way, credit market is supposed to be an important environment for the transmission of shocks between housing and CB markets. Secondly, it again follows from the visual inspection of the data in Section 3.6, when two regimes under which CBs are issued were identified depending on values of both rate of change in house prices and volume of credit on housing. With this respect, increased issuance of CBs is assumed to be governed more probably by situation on the credit market, when better alternatives for investment are missing during the downturn, rather than by falling house prices, which also means decreasing collateral value. Anyway, frozenness of credit market was identified as one of the main reasons for assumed rigidities in the housing market, i.e. different behaviour of house prices on upward and downward part of the cycle, which is the third reason why rate of change in credit on housing should be assumed to govern the state of the system. For sake of completeness, however, more candidate variables were tested for being transition variables in models to which credit on housing is endogenous, where single test statistics may be used to test all these variables. Therefore, change in credit on housing is assumed as the transition variables in all models assumed. However, it is still statistically tested for the lag of the transition variable on equation by equation basis.

In the first step, linear VAR was estimated for the five model specifications. The information criteria are often consistent in choosing two lags of the endogenous variables (Table 9); if not, the lag length selection is made based on Hannan-Quinn information criterion, leading equally to two lags in all models assumed. With respect to the length of the data sample and maximum number of variables included in the models, this length seems to be a reasonable number. At the same time, no cointegration relationship was found between variables in levels for either of the five model specifications (Table 8).

In the second step, it is tested for nonlinearity, which is accepted as a rejection of the null hypothesis of linearity. For each model, the test is conducted for two to five lags of the transition variable. Also, it is tested for both linearity of the system of equations and of individual equations in all five models (Table 10). Tests for linearity of the system of equations reject the null hypothesis of linearity with high level of significance for all five 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 benchmark models 0a and 0b. 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 benchmark model 0a, 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, having rejected the null hypothesis of linearity in most of the equations, it is tested for specification of the regimes. As described in 4.3, two transition functions are assumed, exponential and logarithmic, which lead to a model with inner and outer regime or high and low regime, respectively. Precisely the same as for linearity testing, auxiliary regressions are estimated in two modifications corresponding to the situation when the transition variable is endogenous or exogenous to the system. Based on the sequence of F-tests on estimates of such auxiliary regressions, logarithmic function is suggested to approximate the regime switch for all models in which rate of change of credit is included as endogenous variable (models 0a, 0b and 1). In the rest of the cases, exponential function is suggested by the same sequence of tests (Table 11). On one hand, it might be said that without including the CBs into the system of equations, there are rigidities present in the market, for which reason the house prices and credit on housing behave asymmetrically during booms and recessions (interpretation of model 0a with logistic function). Similarly, 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 would be misleading, since we do not a priori know which of the models is correctly specified, in fact. 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 (leads to logistic transition function) or exogenous to the system (leads to exponential transition function). 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 first estimated on the full sample, as well as two subsamples corresponding to positive and negative growth rates of credit on housing, which were identified as potential source of a regime shift in Section 3.6. 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 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 this is supported by theory.

Finally, since the transition variables in each equation only differ in how much they are lagged, one common threshold value and transition parameter are estimated for all equations in the individual models. This is motivated by the assumption that the state, which is implicitly determined by the threshold value of the switching variable, should be common to the system, under the assumption of the house price, credit and business cycles being interconnected. However, they 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 12 - 15 of Appendix B.

In the final step, four of five initially assumed models (model 0a, 1, 2 and 3), are estimated in 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 this grid search over the four models reflect their specification in terms of variables included. For model 0a with rate of change in house prices and credit, the negative threshold value corresponds to the rate of change in credit on housing in the second half of the sample, possibly confirming that credit on housing may not really explain potential regime shift in house price dynamics right around the turnover. On the other hand, when rate of change in house prices and issues of CBs are being explained together (model 1 and 2), the value of the threshold is estimated such that the system switches to the second regime around the moment when house prices start to fall. Finally, when rate of change in house prices, credit and issues of CBs are all included in one system, the transition into the second regime is characterized by switch of the credit dynamics into negative values. Also, estimates of the transition parameter, which are very much close to zero for three models (model 0a, 2 and 3), 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, it may be approached to testing for variable inclusion in the system of equations. This is possible, since there were estimated two three variables models, and also two two-variable models, which are each submodels of the previous three-variable models. That is, they may be both obtained from the three-variable models by imposing restrictions on some of their parameters. By comparing suitable pair of two- and three-variable model, it may be tested using the likelihood ratio test, whether the third additional model should be kept in the more complicated models. This way, by comparing model 0a and 3, it may be effectively tested whether issues of CBs should be added to the rate of change in credit on housing to explain the house price dynamics.

Table 5: Testing for inclusion of variables

	Model 3 vs. model 0a:	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.

Vice versa, by contrasting model 1 and 3, it may be suggested whether rate of change in credit on housing should be kept in such system. Finally, by comparing model 1 and 2, it may also be seen whether adding proxy of the business cycle - the rate of change in GDP - is desired. The null hypothesis of the submodel being better than the full model, is rejected on high level of significance for all three cases. This finally confirms the assumption that house prices, credit and business cycle are mutually interlinked and that CBs play an important role in these relations (Table 5).

Last, pairwise Granger causality tests in a LSTVAR setting are 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, is again adjusted for these pairwise submodels to which the transition variable is exogenous.

Importantly, the null hypothesis of non-Granger causality is rejected for the relation from volume of CBs issued to the house prices, suggesting on possible leading effects of the covered bonds. The null hypothesis in the opposite causal relation was not rejected, however, corresponding to the fact the falling house prices may hardly lead to increased issuance of the CBs, to which housing serve as collateral. While the null hypothesis of non-Granger causality was rejected on level of significance 0.9 for the relation from house prices to credit, the null hypothesis of the opposite causality failed to be rejected. This is fact confirms results of many previous empirical studies, which suggested existence of the financial accelerator, which they did not confirm in practice. This, in fact, further points at the importance of CBs in Spain in leading the house price dynamics over the last cycle (Table 6).

Table 6: 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.

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 high 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, like it happened during the most recent episode. In such a situation, lack of other investment opportunities with favourable risk-return characteristics turn investors to buy covered bonds, even when they may expect value of the collateral to decrease. Crucial condition to this are the strong guarantees provided to investors by laws or special contracts governing the covered bonds. In this way, covered bonds are backed by collateral pool which remains on the issuer's balance sheet, so that it may be dynamically adjusted according to the house price movements. The cover pools is also bankruptcy remote and investor has recourse to full issuer´s resources in case the collateral value is not sufficient to cover the resulting loss.

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 have 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 autoregressive model. In a sequence of models representing various systems of equations explaining yearly rate of change in house prices, credit on housing and GDP, as well as issuance of covered bonds, linearity was rejected for system as a whole in case of all models and also for most of the individual equations. This, at the first place, confirms the need of modelling the house price dynamics in nonlinear framework. Estimates of the parameters governing the change in regimes further support the 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. This shift is then not abrupt. Further, 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. At the same time, presence of no causality was rejected in the relation from issuance of covered bonds towards house price dynamics, when tested in this regime switching setting. On the other hand, however, causality is not suggested in the relation from credit on housing to house prices, giving importance to the covered bonds in leading the house price cycles.

With this respect, contrary to the case of mortgage backed securities, when there were adverse incentives of issuers to loose credit lending standards, different type of danger is connected to the issuance of covered bonds. Based on the data for Spain, in a situation of a significant house price overvaluation, issuance activity of the covered bonds tends to rise with both increasing rate of house price growth, as well as accelerating house price decline. That is, when the house price overvaluation is credit financed, the asset encumbrance increases along the whole duration of house price and credit cycle.

At the same time, the current liquidity requirements under the Basel III framework may lead to further significant preference for holding the covered bonds, when it ranks them among the high quality liquid assets of Level 1, with the highest rate for the liqudity coverage requirement. While the usage of the covered bonds on a wider scale has been limited to several countries so far, such rule is then expected to increase importance of this instrument significantly and across countries.

This may, however, potentially pose problems to the financial system. In a situation when house price decrease is connected with deterioration on other credit markets, sense of security related to guarantees provided to covered bonds, which motivate buyers to invest into them, would be increasingly illusionary with growing rate assets encumbrance. To explain this, with some rate of asset encumbrance, potential significant decline in house prices may lead to losses which cannot be covered for whole volume of assets that have claims against the pool, not even with initially prudential degree of overcollateralization. Moreover, increasing issues of the covered bonds may drive the prices down further, reducing safeguard of the overcollateralization even more.

In this way, the danger connected to the covered bonds may lie 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. Should the issuance of covered bonds rise in the future, there may be two potential actions to limit these risks. As the first step, it might be beneficial to include forward looking predictions of house prices into the method of the collateral valuation used for the dynamic adjustment of the cover pool. 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.

To sum up, although the data series on covered bonds are still short, with the liquidity regulatory proposals under Basel III, the need for assuming their effects on house price dynamics and financial stability as a whole has become pressing. Empirical analysis in this thesis may be regarded as the very starting step in so doing.

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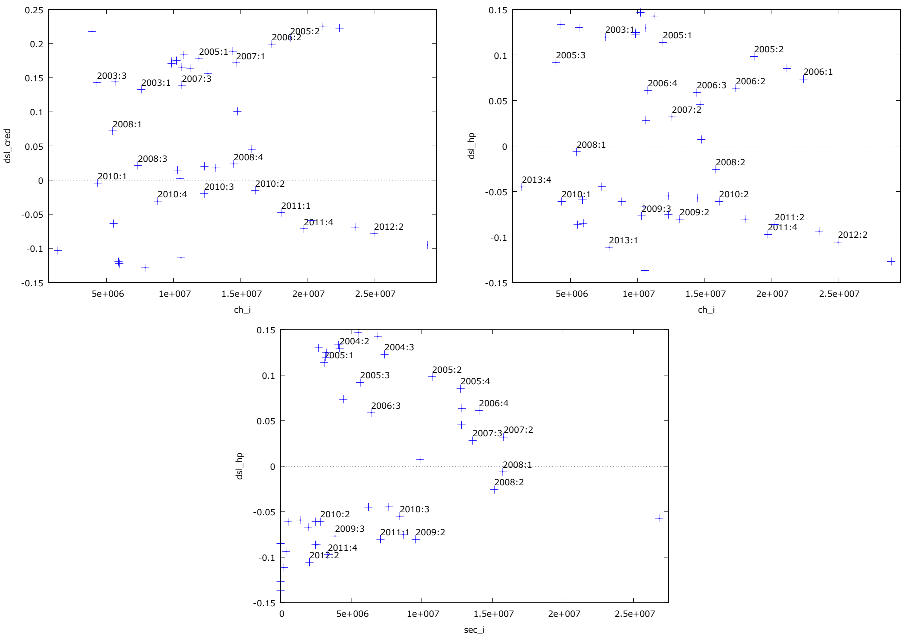
Appendix A: Data and visual analysis

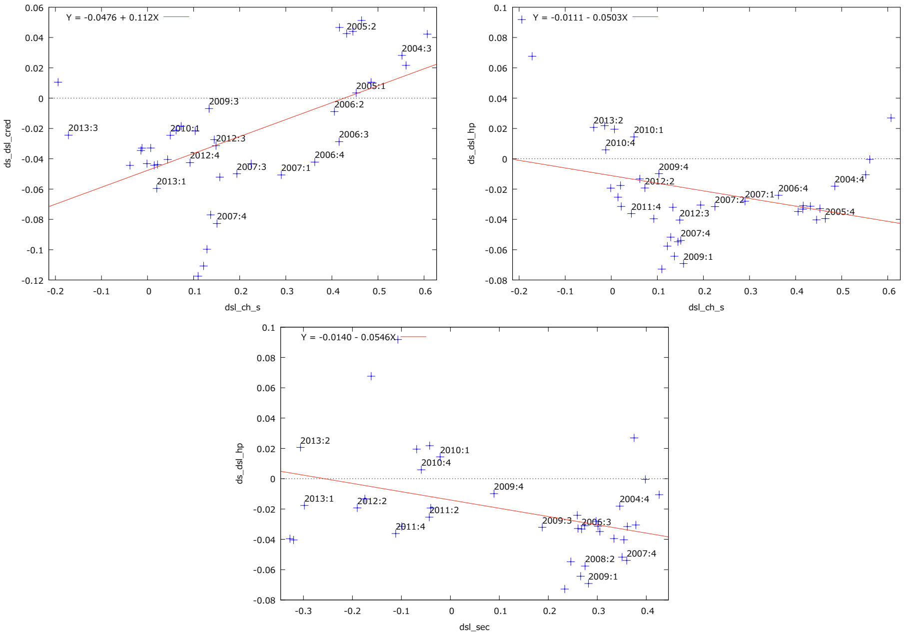
Figure 2: Dynamics of house prices, credit and securitization I



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

Notation dsl_cred stands and dsl_hp for seasonal logarithmic differences of credit on housing and house prices, respectively, ch_i and sec_i for volume of covered bonds and other securitization instruments issued.

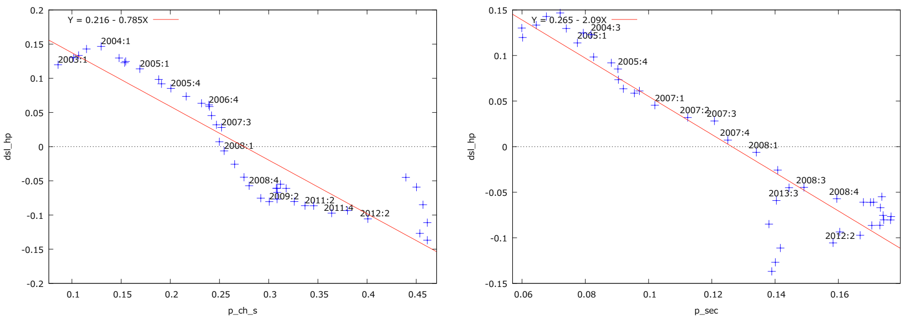
Figure 3: Dynamics of house prices, credit and securitization II



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

Notation: ds_dsl_cred and ds_dsl_hp stands for second seasonal logarithmic differences of credit on housing and house prices, respectively, dsl_ch_s and dsl_sec_s stand for logarithic differences of the outstanding volume of covered bonds and other securitization instruments.

Figure 4: Dynamics of house prices, credit and securitization III

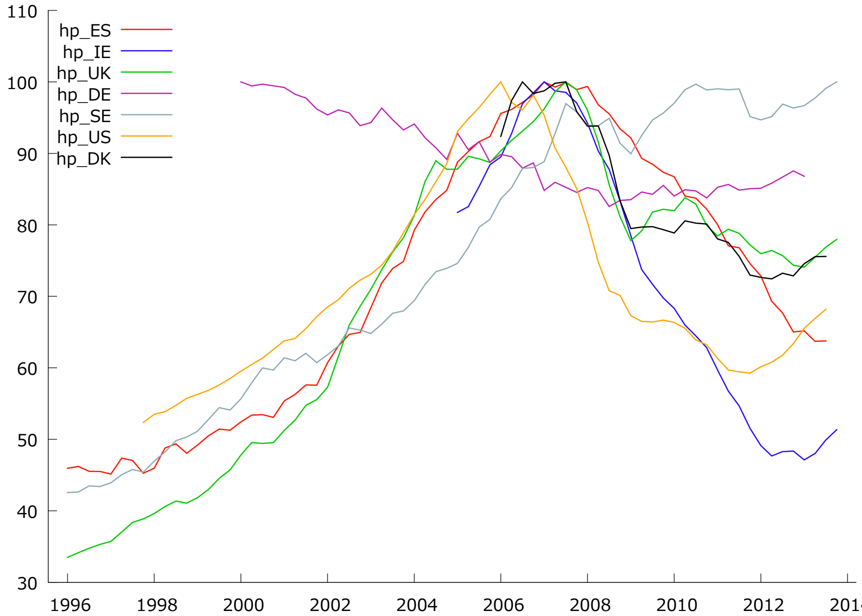


Source: Banco de Espana, AHE and author's computations.

Notation: dsl_hp for seasonal logarithmic differences of house prices, p_ch_s and p_sec_s for ratio of the outstanding volume of cédulas hipotecarias and other securitization instruments over credit on housing

Figure 5: House prices: Panel of countries

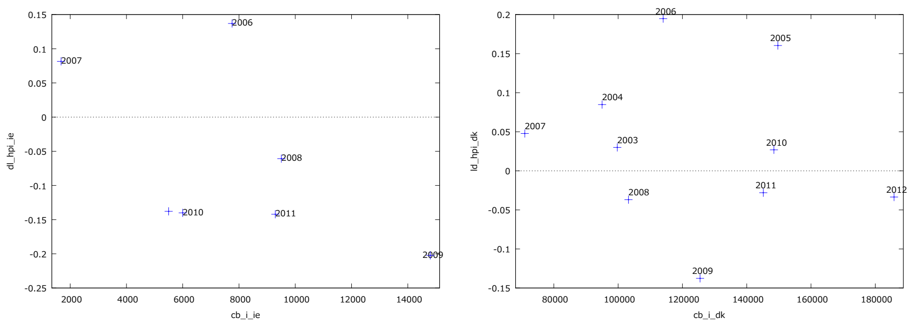
House price index, max over period = 100



Source: BIS, Nationwide UK and National Statistical Offices and author's computations.

Notation hp stands for house price index of the respective country.

Figure 6: Dynamics of house prices and securitization: Ireland and Denmark



Source: ECBC Author's computations.

Notation dl_hpi_ie and dl_hpi_dk stands for logarithmic differences of house price index of Ireland and Denmark, respectively, cb_i_ie and cb_i_dk for volume of covered bonds issued in these two countries.

Appendix B: Empirical analysis

Table 7: 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 8: Johansen cointegration test

Cointeq. relationships	Trace stat.	5% critical value	Max-Eigen stat.	5% critical value
Model 0a: dsl_hp, dsl_cred				
None	30.0499	25.32	20.9545	18.96
At most 1	9.0954	12.25	9.0954	12.25
Model 0b: ch_i, dsl_cred				
None	15.5761	25.32	9.5834	18.96
At most 1	5.9927	12.25	5.9927	12.25
Model 1: dls_hp, ch_i				
None	13.2149	25.32	10.1067	18.96
At most 1	3.1082	12.25	3.1082	12.25
Model 2: dls_hp, ch_i, dsl_gdp				
None	38.3717	42.44	24.1187	30.34
At most 1	14.2530	25.32	7.9087	23.65
At most 2	6.3444	12.25	6.3444	16.26
Model 3: dls_hp, ch_i, dsl_cred				
None	68.8552	42.44	47.0479	30.34
At most 1	21.8073	25.32	12.3259	23.65
At most 2	9.4814	12.25	9.4814	16.26

*Results for test specification with intercept, trend and four lags.

Table 9: Lag lenght criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
Model 0a: 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 0b: ch_i, dsl_cred						
0	-100.5581	-	0.5782	5.1279	5.2124	5.1584
1	-9.4625	168.5269	0.0074	0.7731	1.0265	0.8647
2	2.5440*	21.0114*	0.0050*	0.3728*	0.7950*	0.5255*
3	4.1975	2.7283	0.0056	0.4901	1.0812	0.7038
4	4.7929	0.9228	0.0067	0.6604	1.4204	0.9351
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 10: Linearity testing

Test stat.**/ Transition var.*	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
				Model 0a: 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 0b: ch_i, dsl_cred				
Endogenous	Eq. 1: ch_i		Eq. 2: dsl_cred				System	
dsl_cred(-2)	2.8838	0.0092	0.8768	0.5780			50.1465	0.0014
dsl_cred(-3)	3.6256	**0.0021**	0.9960	0.4755			58.6613	**0.0001**
dsl_cred(-4)	1.8804	0.0792	0.9776	0.4907			42.7439	0.0106
dsl_cred(-5)	2.3518	0.0285	0.6787	0.7578			42.4218	0.0116
				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 11: Testing for transition function specification

	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value	Test stat.	P-value
Model 0a: 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 12: Estimation: Model 0a

Model 0a: 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)		No nonlinear component assumed
Threshold value	-0.0535		
Smoothness parameter value	7		

* Standard errors in italics

Table 13: Estimation: Model 1

Model 1: dls_hp, ch_i				
Equation	Eq. 1: dsl_hp	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 14: Estimation: Model 2

Model 2: dsl_hp, ch_i, dsl_gdp						
Regime	Eq. 1: dsl_hp LOW	Eq. 1: dsl_hp HIGH	Eq. 2: ch_i LOW	Eq. 2: ch_i HIGH	Eq. 3: dsl_gdp LOW	Eq. 3: dsl_gdp 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 15: Estimation: Model 3

Model 3: dsl_hp, ch_i, dsl_cred						
Regime	Eq. 1: dsl_hp LOW	Eq. 1: dsl_hp HIGH	Eq. 2: ch_i LOW	Eq. 2: ch_i HIGH	Eq. 3: dsl_cred LOW	Eq. 3: dsl_cred 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

TEZE RIGORÓZNÍ PRÁCE

(tvoří přílohu přihlášky ke státní rigorózní zkoušce)

VYPLŇUJE UCHAZEČ:

Předpokládaný název rigorózní práce v češtině:

Vliv sekuritizace na dynamiku cen bydlení ve Španělsku

Předpokládaný název rigorózní práce v angličtině:

Impact of Securitization on House Price Dynamics in Spain

Předpokládaný termín předložení práce:	únor 2016

Charakteristika tématu a jeho dosavadní zpracování žadatelem (rozsah do 1000 znaků)**:**

Following a house price boom, adjustment of house prices to their equilibrium values may be rather sluggish due to possible rigidities on the housing and credit market. One of the possible sources of correction may be the use of covered bonds for mortgage financing. Their possible corrective power has been discussed on theoretical grounds, but it has not been empirically examined yet. To address such question, Spain is a very convenient country to study due to i) the size of the last house price boom and ii) the role which covered bonds play in financing mortgage loans in this country.

In her bachelor thesis, the present author found asymmetric adjustment of house prices during the downward part of the cycle using a vector error correction model. Frozenness of the housing market in a situation of elevated households' indebtedness was introduced as a source of these rigidities. In the master and proposed rigorous thesis, such asymmetry is modelled using a tailored nonlinear model, in which covered bonds are used to explain the mechanism between return of house prices back to their equilibrium.

Předpokládaný cíl rigorózní práce, původní přínos autora ke zpracování tématu, případně formulace problému, výzkumné otázky nebo hypotézy (rozsah do 1200 znaků)**:**

The thesis 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 in a downturn. In a serious economic stress, lack of investment opportunities motivates investors to buy the covered bonds due to the strong guarantees provided, helping to revitalize credit and housing markets in turn.

House price dynamics is modelled within a framework of mutually related house price, credit and business cycles using STVAR model. It tests the hypothesis of nonlinear behaviour of house prices, importance of modelling house prices in the context of credit and business cycles and causality from issuance of covered bonds to house price dynamics.

The contribution of the thesis compared to the passed research is twofold. First, it attempts to test the link between covered bonds and house price dynamics in an empirical manner. Secondly, it approaches to modelling house prices in a nonlinear framework extended to a vector of variables. For this purpose, a unique set of data on covered bonds obtained from the Asociacion Hipotecaria Espanola, which is not publicly available, was used.

Předpokládaná struktura práce (rozdělení do jednotlivých kapitol a podkapitol se stručnou charakteristikou jejich obsahu):

1. Introduction

House price dynamics around the 2007/2008 financial crisis in core markets, importance of securitization for credit market, motivation for studying the role of covered bonds for the house price dynamics on the case of Spain.

2. House price dynamics and financial crisis in Spain

Economic and house price dynamics around the 2007/2008 financial crisis in Spain, literature review on house price determinants in Spain, motivation for the hypothesis about the house price dynamics in the downturn and the possible role of covered bonds.

3. Covered bonds and their link to house price dynamics

General features of covered bonds, specifics of covered bonds issued in Spain, hypothesis about the house price dynamics in the downturn and the possible role of covered bonds, corresponding data analysis.

4. Empirical analysis

Motivation for explaining house price dynamics in Spain using nonlinear autoregressive model, overview of nonlinear autoregressive models and suggested approach to their use, empirical model of house price dynamics and covered bonds in Spain, discussion of the results.

5. Conclusion

Summary of the main points and results, implications for financial stability, suggested approach to eliminate possible risks stemming from the link between covered bonds and house prices.

Vymezení podkladového materiálu (např. analyzované tituly a období, za které budou analyzovány) **a metody (techniky) jeho zpracování:**

Different dynamics of house prices on both parts of the house price cycle are modelled using a smooth transition vector autoregressive model. It is a specific type of nonlinear autoregressive model which assumes existence of various regimes governed by the value of the transition variable and a smooth transition between these regimes. The hypotheses are tested using specific tests developed for such nonlinear vector model in the existing literature as described in the following section. The software used is Eviews 4.

Regarding the data, time series on house prices, credit on housing, gross domestic product and issues of covered bonds in Spain are used. These are obtained from Spanish Ministry of Housing, Banco de Espana, National Statistical Office and Asociación Hipotecaria Espanola, respectively. The data is of quarterly frequency and covers the period between 2003 and 2013. While this is not a long timespan, it is the longest time series on covered bonds issued in Spain.

Základní literatura (nejméně 10 nejdůležitějších titulů k tématu a metodě jeho zpracování; u všech titulů je nutné uvést stručnou anotaci na 2-5 řádků)**:**

1. Gimeno, R., & Martínez-Carrascal, C. (2006). The interaction between house prices and loans for house purchase. The Spanish case. Banco de Espana Working Papers, (0605)

Gimeno and Martínez (2006) present in fact the first attempt to implement credit market into a model of house prices in Spain, studying the cointegration between house prices and loans for house purchase and the corrective powers between the two using a VECM.

2. Carbo-Valverde, S., & Rodríguez-Fernández, F. (2010). The relationship between mortgage markets and house prices: does financial instability make the difference?. Federal Reserve Bank of Atlanta CenFIS Working Paper, 10-02.

Valverde and Fernández (2010) follow similar approach but add more explanatory variables. They find evidence of structural break in credit financing of housing before 2011 when the extent of mortgage securitization rose.

3. Hejlová, H. (2011): Effciency of regulation on Spanish housing market. Charles University in Prague, Bachelor Thesis.

Hejlová (2011) also explains house price dynamics using a VECM, but concentrates on the accelerating effects of credit and real economic activity and the role of dynamic provisioning. She founds that these mutually reinforcing powers tend to work in the upturn, while in the downturn, rigidities may be present on the market.

4. Genesove, D., & Mayer, C. (2001). Loss aversion and seller behaviour: Evidence from the housing market. The Quarterly Journal of Economics, 116(4), 1233-1260.

Genesove and Mayer (2001) try to explain the general stickiness of house prices on the downward part of the house price cycle. They find that sellers are unwilling to realize nominal losses by selling their housing bellow the initial purchase price and call this aversion to loss.

5. Rosen, R. J. (2008). What are covered bonds?. Chicago Fed Letter, (Dec).

Rosen (2008) presents covered bonds and discusses their characteristics. He finds that issuance of covered bonds leads to higher capacity of banks to grant new mortgages by increasing their liquidity.

6. Carbó-Valverde, S., Rosen, R. J., & Rodríguez-Fernández, F. (2011). Are covered bonds a substitute for mortgage-backed securities?. Federal Reserve Bank of Chicago Working Paper.

Valverde, Rosen and Fernández (2011) examine whether the systematic use of mortgage backed securities and covered bonds vary across banks, finding that their usage differs. While the covered bonds are issued when banks need to rise liquidity, while the mortgage backed securities are more used for credit risk management.

7. Martín, R. A. & Sevillano, J. M. & González, R. (2013): Covered bonds: The renaissance of an old acquaintance. Banco de Espana, Financial Stability Report, 13, 67-87.

Martín et al. (2013) describe evolution of the covered bond markets in time concerning quality of regulation governing their issues, volumes of covered bonds issued and traded and their yields. They concentrate on the last episodes of financial and sovereign crises, showing that resilience of the covered bond markets compared to markets with alternative instruments varied across countries and along the duration of the crisis.

8. Terasvirta, T. (1994). Specification, estimation, and evaluation of smooth transition autoregressive models. Journal of the American Statistical Association, 89(425), 208-218.

Terasvirta (1994) departs from existing transition autoregressive models, considering two families of them, i.e. a one-threshold model with logistic transition function and a two-threshold model with exponential function. The author also proposes a four-step procedure for model specification, estimation and evaluation and the models.

9. Skalin, J., Terasvirta, T. (1999). Another look at Swedish business cycles, 1861-1988. Journal of Applied Econometrics, 14(4), 359-378.

Skalin and Terasvirta (1999) develope a way of testing for pairwise non-granger causality in a nonlinear autoregressive framework.

10. Camacho, M. (2004). Vector smooth transition regression models for US GDP and the composite index of leading indicators. Journal of Forecasting, 23(3), 173-196.

Camacho (2004) proposes a multivariable extension to these models as well as to existing tests for nonlinearity and choice of transition function. As such, his work currently represents the most complex approach to transition autoregressive modelling.

IV. Žádost o uznání **

a) diplomové práce jako práce rigorózní

Název práce	**Impact of Securitization on House Price Dynamics in Spain**
Obhájena dne	**25.6.2014**
Na fakultě	**Fakulta sociálních věd Univerzity Karlovy v Praze**

b) disertační práce jako práce rigorózní

Název práce	
Obhájena dne	
Na fakultě	

c) státní doktorské zkoušky jako ústní části rigorózní zkoušky

Datum vykonání zkoušky	
Na fakultě	
Studium doktorského studijního programu zahájeno dne	

Přílohy:
Teze rigorózní práce
Doklad o publikování diplomové práce jako knižní monografie

Prohlášení:
Prohlašuji tímto, že jsem nezískal/-a titul doktor podle § 22 zákona č. 172/1990 Sb., o vysokých školách

V ………………… dne……………….. **......................................**
podpis uchazeče

VYPLŇUJE INSTITUT:

Vyjádření garanta:	**Schváleno** ☐	**Neschváleno** ☐
Důvody případného neschválení práce:	**Téma je již zpracované** ☐ **Špatně formulované téma a cíl** ☐ **Špatně zvolená metoda práce** ☐ **Nedostatečná rešerše literatury** ☐ **Nevhodně zvolené prameny** ☐ **Nedostačující úroveň tezí** ☐ **Jiné:**	
Navržený konzultant:		

V ………………… dne……………….. **…………………………………**

podpis garanta