Essays on Confidence and Macroeconomics

PhD Thesis in Economics & Finance

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Introduction

Are "animal spirits" quantitatively important for house price movements? Rational expectation models typically fail to deliver enough volatility in house prices and the recent macroeconomic literature relied in reduced form "housing preference" shock or in ad-hoc shocks to expectations in order to generate the right amount of volatility[1]. This thesis stresses the importance of higher order beliefs and confidence: Chapter 1 shows that in the data, about fifty percent of house prices' forecast error variance decomposition can be attributed to confidence shocks. Moreover, using a historical decomposition exercise, I show that confidence was particularly important both in the building and in the burst of the housing bubble we experienced before the last financial crisis, confirming evidence in Case and Shiller (2003) and in Piazzesi and Schneider (2009). Based on this evidence, Chapter 2 proposes a dynamic stochastic general equilibrium model with housing, financial frictions and higher order beliefs (confidence) shocks modeled as in Angeletos et al. (2015). In the model, consistently with the empirical evidence, a positive one standard deviation confidence shocks generate an increase in house

[1]See Iacoviello (2005) and Justiniano et al. (2015) for the housing preference shock and Berger et al. (2015) for the shock to expectations.

prices. The magnitude of the increase, even in the absence of financial frictions, is high enough to generate the right amount of house price volatility, differently from other shocks typically used in the literature. A simulation exercise where the model is fed with the series of confidence innovations estimated in the VAR for the 2003-2015 period delivers a bubble in house prices close to the one observed in the data. This results suggest that "animal spirits" are quantitatively important for house price movements and, especially, that they were particularly important in the housing market bubble which led to the last financial crisis, suggesting that incorporating "animal spirits" in DSGE models in the form of shocks to higher order beliefs is a step forward in solving the volatility puzzle for house prices. Chapter 3 (intends to) explore the role of higher order and financial frictions through the eyes of an incomplete market model with heterogenous agents.

Chapter 1

1.1 Introduction

The 2007-08 financial crisis and the following Great Recession have renewed the interest by macroeconomists in the role of credit and housing in understanding the business cycle. In particular, since financial crises are usually preceded by episodes of credit booms, it is important to understand what drives the excess of credit in the first place, even more if such booms are able to predict the severity of the subsequent recessions, as it is showed for instance in Jordà, Schularick and Taylor (2013 and 2015b).
The last financial crisis makes no exception; Figure 1.1 shows the evolution of the Mortgages-to-GDP ratio for the US since the early 1990s. The size of the boom is unprecedented, as well as the subsequent bust.

The macroeconomic literature has identified two main narratives of the credit boom and bust of the 2000s. The first one one identifies the boom episode in house prices as the primary driver of the credit bubble and look at monetary policy; Taylor (2007) argues that a prolonged period of low in-

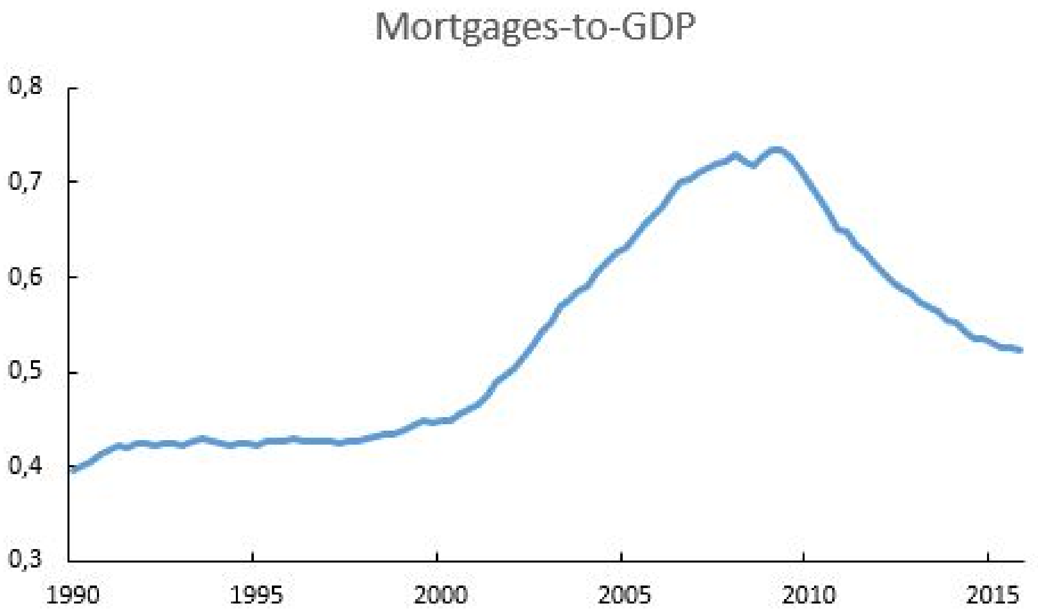

Figure 1.1: **U.S. Mortgages-to-GDP ratio.**

terest rates during the Great Moderation, made housing finance very cheap and attractive; an increase in housing demand led to an increase in house prices and thus to more favorable credit conditions.
The second narrative builds on Mian and Sufi (2010), who look instead at the so-called "credit liberalization", arguing that an overall loosening of credit standards delivered an increase in credit supply, which allowed more borrowing even against unchanged collateral value.

Starting from these two narratives, the macroeconomic literature has developed models incorporating housing, financial frictions and financial shocks in order to understand plausible mechanisms behind large house price/credit swings and their quantitative importance for the recent financial crisis. Theoretical work in Hall (2011) shows how the response of the household sector to the credit tightening that followed the financial crisis is a key ingredient for explaining the Great Recession. In Guerrieri and Lorenzoni (2011) a leverage shock in a Bewley-type model is able to push the economy in a liquidity trap, as the one we are currently experiencing. However, Justiniano, Primiceri and Tambolotti (2015) show that a change in credit conditions, modeled as a leverage shock, is not able to reproduce the large increase in house prices we observed before the financial crises and the subsequent significant drop. Iacoviello (2005) and Guerrieri and Iacoviello (2015) consider, instead of a leverage shock, a housing preference affecting directly households' demand for housing. Justiniano, Primiceri and Tambolotti (2015) show that such a shock is able to reproduce the housing boom and bust as we observe in the data, but the magnitude of such a shock does not seem to be realistic. Nevertheless it is hard to think of such a shock as the main driver for changes in house prices.

Recently a third narrative looked more seriously at the role of expectations and beliefs in determining house prices, starting from the evidence shown in Case and Shiller (2003) and Piazzesi and Schneider (2009)[1]. The two Handbook of Macroeconomics chapters by Piazzesi and Schneider (2016) and Guerrieri and Uhilg (2016) stress the importance of expectations and sentiments in the housing and credit markets.

[1]Case and Shiller (2003) show, for instance, that in 2003 homebuyers were expecting house prices to appreciate up to 15% per year, while Piazzesi and Schneider (2009) show that still in 2007, just before the occurence of the finacial crisis, the fraction od people believing that house prices would continue to increase doubled with respect to the previous year.

Two recent papers, through the eyes of realistic equilibrium models of the housing markets, have succeeded in qualitatively and quantitatively characterize the importance that expectations and beliefs may have played in the 2000s boom-bust episode in house prices. Berger, Guerrieri, Lorenzoni and Vavra (2015) modify the way households build expectations in future house prices, departing then from rational expectations, and show that one can calibrate the exogenous process governing the expectation forming mechanism to generate a realistic housing boom and bust in an incomplete market model with heterogenous agents. In a similar setting Kaplan, Moll and Violante (2017) introduce a belief shock for house prices and show, in a calibrated version of the model, that this shock was the dominant force behind the house price bubble. Although they call it belief shock, this shock is actually a news shock on the housing preference parameter mentioned before. Importantly, Kaplan et al. show that this news shock is preferable to the standard preference shock as it induces the right positive comovent in house prices and quantities as we observed in the building of the bubble.

In this thesis I propose *confidence* as an alternative driver of house prices, trying to go at least one step deeper in rationalizing the ad-hoc expectations in Berger et al. (2015) or the belief shock in Kaplan et al. (2017) by enriching the higher order beliefs structure of agents in the model and exploring how this enriched belief structure that allows for periods of optimism and pessisism interacts with financial frictions.

In order to see how beliefs and confidence can be important to understand movements in house prices it is important to understand how aggregate economic activity in general can be driven by changes in confidence and expectations; this is controversial debate in macroeconomics. The so-called rational expectations revolution started in the seventies relies on the assumption that agents have probability beliefs which coincide with the "real" probabilities. This leaves almost no space for any alternative assumption about expectations of economic agents. Nevertheless, several attempts to relax the rational expectations assumption have been pursued by macroeconomists[2].

At the same time, the suggestion that confidence can affect economic outcomes was always present in economic thinking[3] and even more in the popular press and the business community; for example recessions are almost always associated to periods of low confidence and low confidence is always blamed for late recoveries. Looking at the recent financial crisis, the boom and bust of house prices can also be framed inside a confidence story where house prices increased as long as there were beliefs about future higher prices and after a reversal in these beliefs house prices dropped. Shiller (2005) and Akerlof and Shiller (2009) provide a lot of anedoctal and scientific evidence for this.

Barski and Sims (2012) instead provide empirical evidence for confidence being able to affect aggregate economic activity: in a three-variable VAR with consumption, income and a measure of confidence they show that impulse responses of consumption and income to innovations in confidence have significant long-lasting effects and, importantly, that confidence does not seem to be Granger-caused by income or consumption, responding mostly to its own innovations.

[2]See Sargent (1993), Evans and Honkapohja (1999) and Woodford (2013) for surveys on the topic.

[3]See Pigou (1927) and Keynes (1936).

An important branch of literature recently explored the macroeconomic effects of frictions that agents face in the acquisition of information, relaxing complete information as a key feature in rational expectations model[4]. The main achievement of macroeconomic models incorporating deviations from perfect information is to provide a framework to understand non-fundamental driven business cycle fluctuations. For instance, in Lorenzoni (2009) the noise component from a public signal for long-run productivity leads to aggregate mistakes in agents' expectations about future productivity. These mistakes result in aggregate fluctuations similar to the ones following an aggregate demand shock. Empirical evidence for the presence of informational frictions and for "news shocks" as the ones considered in Lorenzoni (2009) is provided in Carrol (2003), Coibion and Gorodnichenko (2012), Beaudry and Portier (2006) and Barski and Sims (2011).

Within this framework, the literature has identified two ways through which confidence can affect aggregate economic activity; in a "news" approach, confidence can be viewed as containing fundamental information about the future state of the economy. The second way, instead, posits that fluctuations in macroeconomic activity can be actually driven by autonomous fluctuations in agents' beliefs, possibly completely unrelated to fundamentals. This apporach is usually labelled the "animal spirits" view.
Attempts to rationalize animal spirits have usually been done in a multiple equilibria setting, where beliefs are self-fulfilling and pin down the equilibrium path of a model; Benhabib and Farmer (1994) and Farmer (2012, 2013). are important contributions in this sense. Recently, two important con-

[4]See for instance Mankiw and Reis (2002), Sims (2003), Woodford (2001).

tributions developed a framework which is able to model confidence as a force akin to animal spirits without abandoning rational expectations nor equilibrium uniqueness. In Angeletos and La'o (2013) an aggregate shock, which the authors call "sentiment shock", affects the beliefs that an economic agent forms about the choices of other agents; this shock rationalizes shifts in optimistic (or pessimistic) beliefs. For instance, after positive sentiment shock a firm expects the demand for its product to increase and thus raises its demand for labor and capital, stimulating employment and output even without any increase in fundamentals.

Angeletos, Collard and Dellas (2015), hereafter ACD, propose a similar mechanism for enriching the beliefs structure of economic agents though being very tractable as it bypasses some technical difficulties typical of the noisy information literature, such as Kalman filtering. The mechanism is interpreted as confidence, since it affects the uncertainty that economic agents face about one another's choices. Such a confidence shock embedded in a textbook RBC model generates realistic business cycle patterns and a series for this shock filtered from an estimated medium scale DSGE model is very close to the University of Michigan Sentiment Index, which is one of the most used measure for consumer confidence.

Surprisingly there is no paper, to the best of my knowledge, exploring the asset pricing implications of such a richer higher order belief structure. Housing is an asset and its price is then determined by the present value of future flow of dividends (housing services); it is then natural to think that a mechanism enriching higher order beliefs of agents, and thus affecting expectations of current and future economic activity by strategic complementarity, may have important implications for asset prices.

1.2 Empirical Evidence

1.2.1 The University of Michigan's Consumer Sentiment Index

In this section I want to assess the ability of innovation to consumer confidence to affect the housing market.

Before going through the empirical analysis, it is useful to have an insight on the empirical measure of confidence I use in this section, which is the University of Michigan's Consumer Sentiment Index. It is one of the most used measure of U.S. consumer confidence by both the academic and business sector. The index is based on five questions that are part of the broader Michigan Survey of Consumers. Two of the five questions are related to present conditions, while the remaining three regard expectations about future economics conditions over the next year and five years from the time the survey is conducted. The survey is conducted on a monthly basis from 1978 and is performed by phone with 500 respondents each month. The University of Michigan publishes a mid-month release of the index, which is based on the responses given within the first two weeks of the month.

As mentioned before, Barski and Sims (2012) in a three-variable VAR with consumption, income and this measure of confidence show that impulse responses of consumption and income to innovations in confidence have significant and long-lasting effects on the other two variables.

1.2.2 Empirical Results

I use seven US monthly time series from January 1983 to June 2015:

Conf: The mid-month release of the University of Michigan Consumer Sentiment Index, which was described in the previous section.

HP: the Case-Shiller U.S. National Home Price Index deflated by CPI as a real measure for house prices.

Borr: the Consumer Credit as a measure of household debt.

ResInv: the Value of Construction Put in Place (VIP) from the Census Survey as a measure of residential investments.

IP: the Industrial Production Index as a measure of economic activity.

Infl: CPI inflation.

FFR: the shadow FFR constructed in Xu and Wia (2016), which coincides with the effective FFR until 2009 and then is allowed to go negative in order to take into account the effects of unconventional monetary policy at the zero lower bound.

All the variables with a trend (industrial production, consumer credit and residential investments) are de-trended by HP-filtering with a smoothing parameter of 129600 as suggested in Ravn and Uhligh (2002) for monthly data, while the other variables enter the sample in levels.

I estimate a VAR on the sample constructed in this way and identify a confidence shock through a recursive identification scheme (Choleski) assuming that confidence is not affected contemporaneously by shocks to other variables [5]. This assumption is justified by the fact that the mid-month release of the Michigan Survey is based on responses given during the first two weeks of the month when economic data for that month are not yet released; it is then reasonable to assume that the measure does not react contemporaneously to other economic data. Moreover, the mid-month index has an almost one correlation with the final one, suggesting that confidence does not react much within the month[6].

Figure 1.2 shows the response of the variables in the system to a one standard deviation confidence shock.

A positive shock to confidence increases significantly and for a prolonged period of time (about 36 months) house prices. The increase in house prices is associated to an increase in borrowing, though barely significant, and in residential investments; the positive correlation of house prices and residential investments is a typical feature of housing cycles.

Table 1 shows the Forecast Error Variance Decomposition for house prices at different horizons. Each column of the table regards a shock and gives the portion of variance attributable to that shock for movements in house prices at the horizon given by the row.

Notice how confidence is by far the most important shock for movements

[5] This implies that confidence is ordered first in the VAR.

[6] A robustness check with lagged confidence delivered no changes in results, providing more evidence for the validity of the identification assumption.

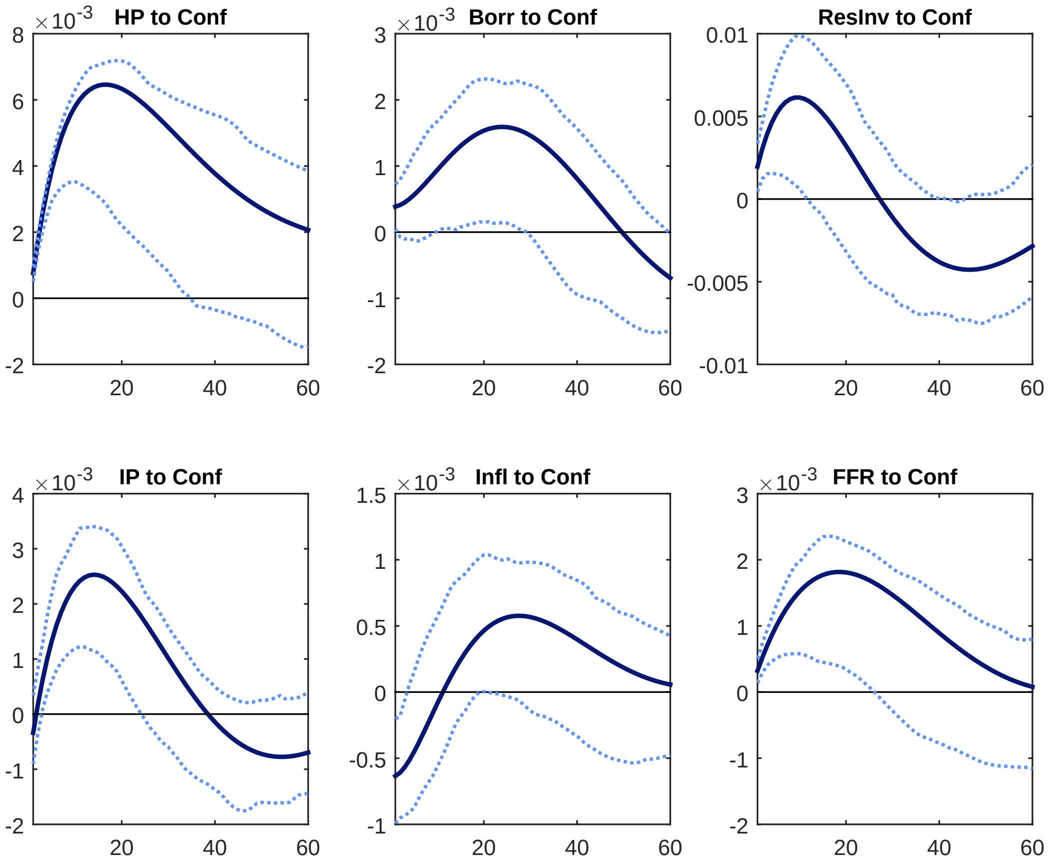

Figure 1.2: **Impulse response of economic variables to a one standard deviation positive confidence shocks. 90% confidence intervals delimited by dashed lines.**

	Shocks						
Months	Conf	HP	Borr	ResInv	IP	Infl	FFR
6	49.90	38.09	0.43	0.47	7.20	3.23	0.68
12	58.96	21.13	0.39	1.05	13.98	3.33	1.15
24	54.94	15.59	0.19	1.73	23.52	2.09	1.94
36	47.76	15.53	0.95	1.95	29.21	1.46	3.13

Table 1.1: Forecast Error Variance Decomposition for House Prices (percent).

in house prices at different horizons, explaining from 50% to almost 60% of house price movements depending on the horizon.
Figure 1.3 plots instead the historical decomposition for house prices during the sample period. Historical decomposition is an interesting device as it answers to question: "How would house prices have been if we shut all shocks but one?"
Such an analysis gives a sense on which shock was important for a movement of a variable for a specific period. In Figure 1.3 the solid blue line represents the observed value of house prices in each panel, while the line determining the red areas, for example in the top left panel, shows instead how much house prices would have been if only the Confidence shock was in action. The Confidence shock by itself is able to explain about 40% of the boom during the early 2000s and more or less 30% of the subsequent bust.

From this analysis we understand that confidence is an important driver for house prices and can explain a significant portion of the boom-bust episode we observed in the 2000s. As mentioned in the introduction, there are two possible alternative drivers for house prices which I could not be taking into account properly in this VAR analysis: the monetary policy story proposed in Taylor (2007) and the credit easing one. Moreover the Sentiment index considered here, being built on questions both about current and future economic conditions, could entail something different than confidence intended as 'animal spirits' (i.e. unrelated to fundamentals) such as news or uncertainty. In the following sections I am going to address each of these issues, showing that confidence survives as an important driver for house prices.

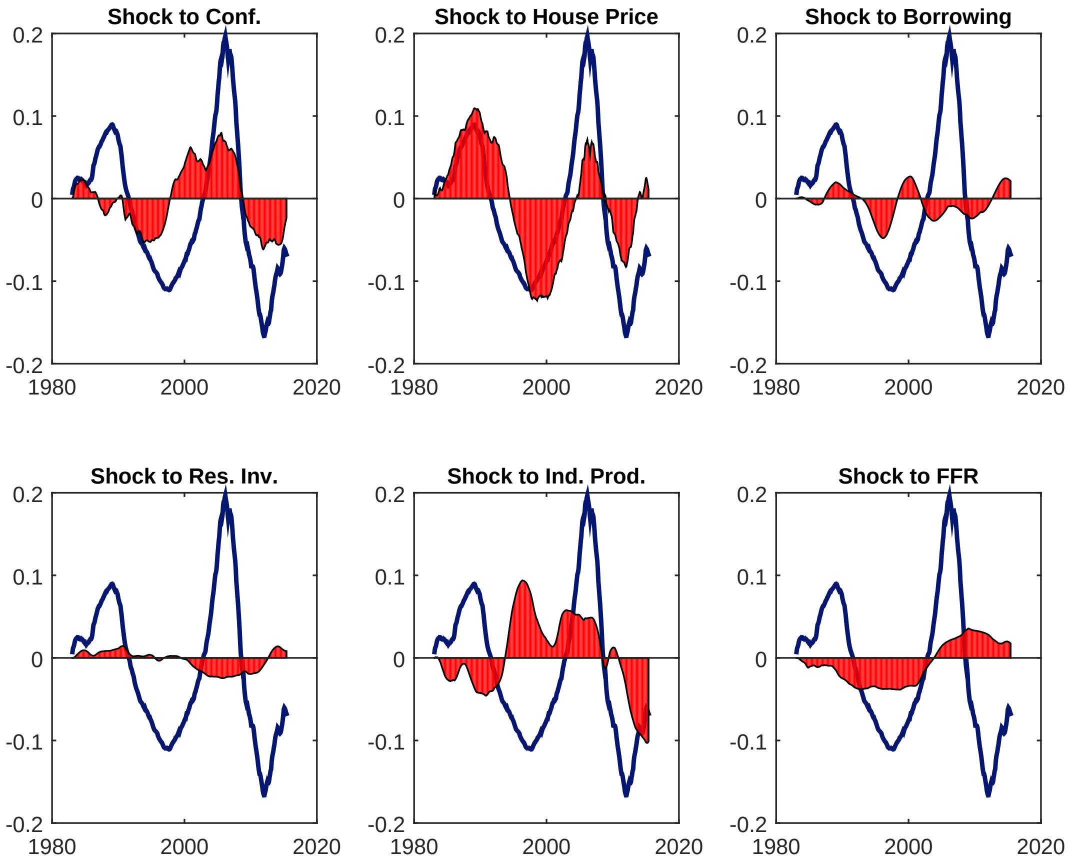

Figure 1.3: **Historical decomposition for house prices. In solid blue line the actual, observed value for house prices. The line delimiting the red areas represent the level of house prices when only one particular shock is active.**

	Shocks	
Months	R&R MP	Conf
6	0.06	49.70
12	0.32	54.91
24	1.48	46.92
36	3.27	35.95

Table 1.2: Forecast Error Variance Decomposition for House Prices (percent) when including Romer and Romer narratively identified confidence shocks.

1.2.3 Adding Monetary Policy Shocks

Taylor (2007) argues that a prolonged period of low interest rates during the Great Moderation, made housing finance very cheap and attractive driving up their prices. If monetary policy was responsible for movement in house prices, then we should see this once properly incorporating monetary policy shocks in the VAR. I then add the narratively identified monetary shocks derived of Romer and Romer (2004) to the VAR and re-run the analysis. Table 2 shows that confidence does not lose its relative importance in explaining house price movements at different horizons.

1.2.4 Is It News?

One could argue that the University of Michigan Consumer Sentiment Index, containing information on household's expectation about future economics activity, could not be driven by 'animal spirits', but by news shocks. As a first check, I build the Confidence Index considering only the questions of the survey regarding current economic conditions and re-run the experiment. Results are very close[7], but this is not enough since, as the news shock

[7]This is not a surprise as already Curtin(2002) showed that the two "disaggregated" indexes, current economic conditions and future ones, are really close.

	Shocks	
Months	News	Conf
6	0.18	50.08
12	0.38	59.13
24	0.92	54.93
36	1.67	47.62

Table 1.3: Forecast Error Variance Decomposition for House Prices (percent) when including a measure for news.

literature has argued, in the presence of forward-looking agents a news shock has an effect on current economic activity and then also on expectations about it. Fortunately, the Michigan Survey has a question, outside the sample of five questions used to build the Sentiment Index, that could address the issue. The question is: "During the last few months, have your heard of any favorable or unfavorable changes in business conditions?"
Even if this not exactly a news shock, a news shock is going to affect the answer of a consumer to this question. I can then build the index based on this question on the survey and add it to the VAR. If news shocks were the only responsible for movements in house prices, the performance of my identified confidence shock in driving house prices should be significantly affected. Figure 1.4 and Table 3 show that this is not the case.

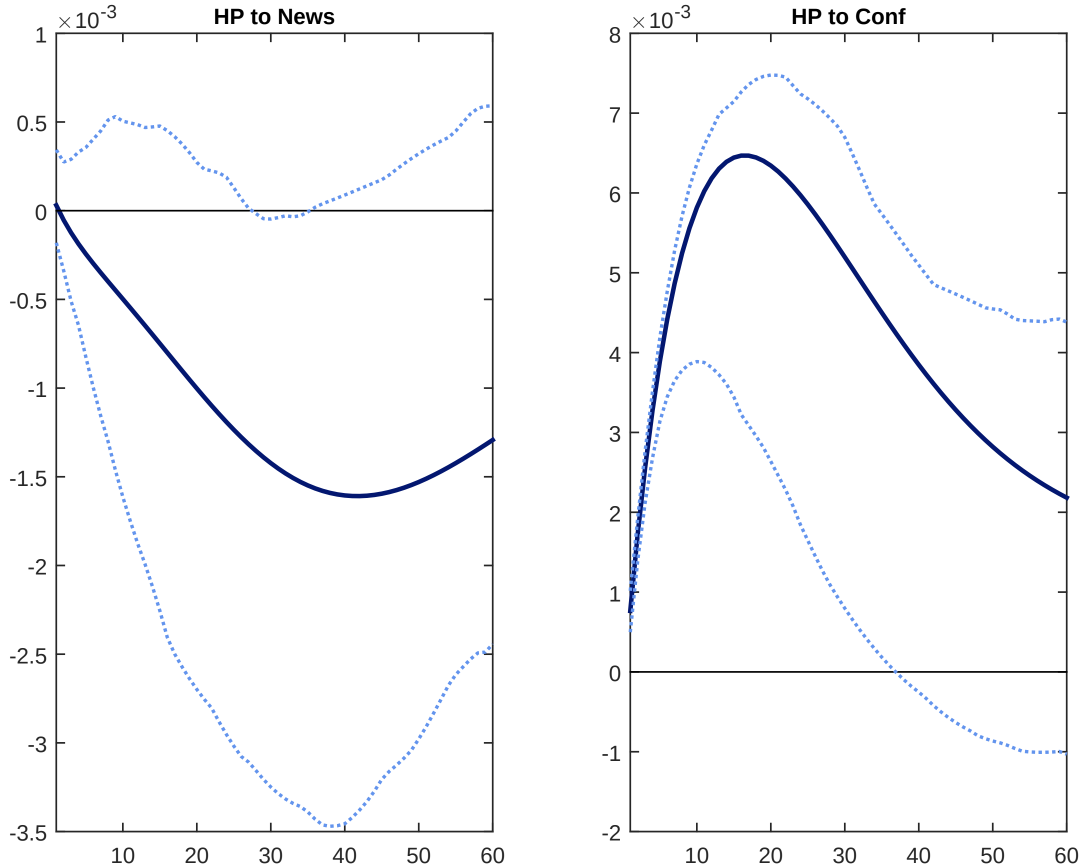

Figure 1.4: **Impulse response functions of house prices to a proxy for a news shock (left) versus a confidence shock (right). 90% confidence intervals delimited by dashed lines.**

Chapter 2

2.1

In the previous Chapter we have seen how expectations and beliefs have been identified as a potentially crucial driver of house prices, particularly during the boom-bust episode that characterized the last financial crisis in the United States. The Chapter provided some new empirical evidence exploiting the design of the Michigan Survey to identify exogenous movements in Confidence and showing that they indeed played an important role in the financial crisis. In this Chapter I present a DSGE model with exogenous confidence shocks, housing and financial frictions; a calibration of the model[1] shows that indeed innovations to confidence can generate large swings in house prices, differently from other shocks considered by the literature.

[1] The calibration exercise is soon to be replaced by a Bayesian estimation.

2.2 The Model

In this section I present a real business cycle model with heterogenous agents, credit constraints and a confidence shock. The introduction of financial frictions builds on Iacoviello (2005), Liu et al. (2013) and Justiniano et al. (2015); households have heterogeneous desires to save coming from a different patience rate and this generates borrowers and savers in equilibrium. The confidence shock builds instead on the mechanism introduced in ACD.
The economy consists in a continuum of islands indexed by $i \in [0, 1]$. Each island is inhabited by two representative households and a firm using capital and labor provided by the households to produce a differentiated intermediate good. Moreover, there is a mainland where the final good is produced using as input the intermediate goods produced by each island and where a market for the final good operates. All markets are competitive.

2.2.1 Households

The two representative households in an island differ by their discount factor. Hereafter I am going to call the more impatient household *borrower* as it ends up borrowing in equilibrium and to index it by the subscript b. Similarly, the patient household is called *saver* and indexed by s. With this notation the discount factors are $0 < \beta_s < 1$ and $0 < \beta_b < 1$, and it is assumed that:

$$\beta_b < \beta_s.$$

The representative household $j \in \{b, s\}$ in island i at time 0 maximizes the intertemporal utility function:

$$E_0 \sum_{t=0}^{\infty} Z_t \beta_j^t \left[\frac{(c_{i,j,t} - H_C C_{j,t-1})^{1-\gamma}}{1-\gamma} + J_t \log(h_{i,j,t} - H_{j,t-1}) - \chi \frac{n_{i,j,t}^{1+\eta}}{1+\eta} \right],$$

where $c_{i,j,t}$ denotes consumption of the final good, $C_{j,t}$ aggregate consumption by representative agent of type j, $h_{i,j,t}$ the stock of houses, $H_{j,t}$ aggregate housing for type j and $n_{i,j,t}$ hours worked. The parameters H_C and H_H determine the degree of habit persistence[2], χ determines households' disutility from working and η is the inverse of the Frisch elasticity of labor supply. Z_t and J_t are two exogenous state variables allowing respectively for an intermporal preference shock and a preference shock that increases the demand for housing by affecting the marginal rate of substitution between durable and non-durable consumption.

Savers in island i at time t choose consumption $c_{i,s,t}$, labour $n_{i,s,t}$, housing $h_{i,s,t}$, loans to the borrowers $b_{i,t}$ and investments $ii_{i,s,t}$ in order to maximize lifetime expected utility subject to the flow of real budget constraint[3]:

$$c_{i,s,t} + q_{i,t} h_{i,s,t} + b_{i,t} + ii_{i,t} = w_{i,s,t} n_{i,s,t} + q_{i,t} h_{i,s,t-1} + b_{i,t-1} R_{i,t-1} + rk_{i,t} k_{i,t-1}$$

where $q_{i,t}$ is the relative price of houses in island i, $R_{i,t}$ is the gross real interest rate, w_{ist} is the real wage[4] and $rk_{i,t}$ is the real rental rate of capital. There

[2] The presence of habit persistence is just present to ease the estimation as it allows for persistence in consumption of non-durables and durables that we do observe in the data and it is completely irrelevant for the qualitative results in the model.

[3] b enters in the budget constraint in the way that they can be intended as saving. In equilibrium then borrowers will hold a negative b and savers a positive b.

[4] The real wage is indexed by the type of household since I am going to assume that

are convex adjustment costs for investment ii, so that the low of motion of capital is given by:

$$k_{i,t} = (1-\delta)k_{i,t-1} + ii_{i,t} - \Phi\frac{(ii_{i,t} - ii_{i,t-1})^2}{\bar{ii}}.$$

Borrowers do not accumulate capital and then choose consumption, labour, housing and loans from the savers subject to a slightly different budget constraint:

$$c_{i,b,t} + q_{i,t}h_{i,b,t} + b_{i,t} = w_{i,b,t}n_{i,b,t} + q_{i,t}h_{i,b,t-1} + b_{i,t-1}R_{i,t-1}$$

Importantly, households' ability to borrow is limited by a collateral constraint à la Kiyotaki and Moore: households can borrow up to a fraction of the expected future value of housing stock. To improve on realism on debt dynamics, as in Guerrieri and Iacoviello (2015), I impose some sluggishness on b_t; this translates formally in the following borrowing constraint:

$$b_{i,t} \leq \rho_D b_{i,t-1} + (1-\gamma)M_t q_{i,t}h_{i,b,t}]. \tag{2.1}$$

Housing services are available in aggregate fixed supply for the moment.

the labor supplies from the two types of households are not perfect substitutes for the firm's production function. This assumption is standard in this literature, see for instance Iacoviello (2005) and Justiniano et al. (2015). Iacoviello and Neri (2010) show that perfect substitutability yields similar results, but it quite complicates the solution of the model.

2.2.2 Firms

The intermediate firm in island i hires labor supplied by the two types of households and rents capital from savers to maximize profit:

$$\pi_{it} = y_{i,t} - w_{i,s,t}n_{i,s,t} - w_{i,b,t}n_{i,b,t} - rk_{i,t}k_{i,t-1},$$

where y_{it} is the quantity of intermediate good produced using the following technology:

$$y_{it} = A_t k_{i,t-1}^{\alpha} n_{i,t}^{1-\alpha},$$

where technology A_t is stochastic and common across islands and $n_{it} = n_{i,b,t}^{\sigma} n_{i,s,t}^{1-\sigma}$ is a basket of labor services from borrowers and savers. The parameter σ then determines the share of labor income attributable to impatient households.

The final good is produced on the mainland using intermediate goods produced by each island using a Cobb-Douglas technology:

$$\log Y_t = \int_0^1 \log y_{it}\,\mathrm{d}i.$$

Given this technology, it follows that the demand that the firm in island i is facing is given by:

$$y_{i,t} = \left(\frac{p_{i,t}}{P_t}\right)^{-1} Y_t$$

Appendix A lists the equilibrium conditions of the model.

2.2.3 Introducing Confidence

The model just described is, for now, a standard macroeconomic model with housing and financial frictions; in the following I am going to introduce an exogenous state variable affecting higher order beliefs of the agents through the mechanism introduced in ACD.

Each period is divided in two stages; technology A_t, which is stochastic and follows an $AR(1)$ process is not perfectly observed in stage 1 and each island observes a private signal[5] for it of the form:

$$x_{it} = A_t + \epsilon_{it},$$

where ϵ_{it} is an island-specific error.

Now, to get variation in higher order beliefs, ACD relax the common prior assumption on the expected value of the island-specific error ϵ_{it} in the following way:

$$E_{it}[\epsilon_{jt}] = \begin{cases} 0 & if\ i = j \\ \xi_t & if\ i \neq j \end{cases},$$

where ξ_t is an exogenous state variable commonly known at t which follows an $AR(1)$ stochastic process. Hence, each island gets and knows to get an unbiased signal for A_t, but it has biased beliefs about other islands' signals. For example, if the state variable ξ_t is positive, each island thinks that other islands receive, on average, an higher signal for technology.

The variance of the island-specific error is assumed to be zero. As dis-

[5]The two representative households and the firm inside each island have access to the same signal.

cussed in ACD, this is a technical assumption in order to get tractability as it guarantees a finite and small state space. However, even when the variance of the noise is zero, the presence of the state variable ξ enriches the higher order belief structure bypassing the technical difficulties that usually arise when accomodating higher-order uncertainty in dynamic models. By letting the variance to be zero, agents are sure to have the correct signal and that other islands have incorrect signals. This assumption also guarantees that there is no heterogeneity in equilibrium since every island receives the same signal and has the same fundamentals. In this way it is not necessary to resort on Krusell-Smith type algorithms[6] in order to deal with aggregate uncertainty. Nevertheless, as we are going to see in the following, the aggregate implications of the enriched higher order beliefs structure are important, even for the zero-variance case.

After observing the signal firms decide the demanded quantity of capital and labour from the two different types of households, while households decide how much of these factors to supply.
In stage 2 the actual level of technology is publicly revealed, the final consumption good is produced, the final good market operates and households make their consumption, housing and saving/borrowing decisions.

Let's now consider the interpretation of the exogenous variable ξ_t and the narrative that it encapsulates. In this economy, a negative shock to ξ_t translates into a belief, for each agent, that the other agents have developed

[6] See Krusell and Smith (1998).

a pessimistic outlook about the short-term prospects of the economy; confidence about the current and, depending on how much persistent is ξ, about the next few periods' state of the economy has worsened. The long-term outlook about the state of the economy does not change if the process governing ξ_t is stationary[7].

In stage 1 firms must decide their demand for labor and capital. In order to do this they need to forecast the demand they will face in stage 2 this period; after a negative shock to ξ_t they will expect the demand for their products to be low and thus will lower demand for labor and capital. This will result in a fall in wages and rents of capital, translating into lower total income for households which, if there is no sufficiently strong wealth effect on labor supply, will then work less and cut consumption. At the end of the day we could observe aggregate fluctuations very similar to the ones produced by a textbook RBC model, but without any change to fundamentals as a trigger. It is then crucial for the solution of the model to differentiate decisions made in stage 1, which are based on expectations on current variables $E_1[\cdot] := E[\cdot|x_{i,t}, \psi_t, \ldots]$, and decisions in stage 2, based on expectations of future variables $E_2[\cdot] := E[\cdot|A_t, \psi_t, \ldots]$. Notice that expectations in stage 1, $E_1[\cdot]$, are formed given the private signal the island receives, the level of confidence and the values of other state variables in the model, while expectations in stage 2 are formed given the current true level of technology, confidence and other state variables. In the following section I present the loglinear approximation of the equilibrium conditions of the model, where the distinction

[7]The fact that uncertainty regards short-term economic outlook is probably what differentiates most this mechanism from the news shock literature, since in that literature uncertainty relates to signals about future technology and thus concerns long-term prospects.

between the two different expectations appears explicitly, and I briefly describe the solution method proposed in ACD, to which I refer the reader for further details.

Starting from the loglinear approximation just shown, I solve the model using the algorithm described in the appendix in ACD to get to the following linear representation for the aggregate variables in the economy:

$$Z_t = \Lambda_x X_t + \Lambda_s s_t + \Lambda_c \xi_t, \tag{2.2}$$

where Z_t is a vector containing all the aggregate variables in the economy, X_t contains the endogenous state variables, s_t the exogenous state variables and ψ_t is the exogenous state variable introduced in the previous section. ACD show that the matrixes Λ_x and Λ_s are the same matrixes governing the evoultion of the model without any higher order belief perturbation (belief-free model) and that the matrix Λ_c can be recovered from the aforementioned matrixes using a method of undetermined coefficients style algorithm, where the linear policy functions in the two different stages are imposed to be consistent one with each other.

2.3 Calibration and Dynamics

I calibrate the parameters of the model having a quarterly frequency in mind and aiming at replicating some facts of the US data at the beginning of the 2000s. β_s is set to 0.995 implying a 2% annual real interest rate in steady state. β_b is set to 0.9912 in order to have a steady state debt-to-output ratio equal to 0.57, which is approximately the US mortgage-to-gdp ratio at the beginning of the housing bubble (see Figure 1.1). The housing preference parameter in steady state is set such that the housing wealth-to-consumption ratio is 2.3 in steady state, which is the value reported in Iacoviello (2011). The capital share α and depreciation δ are set in order to have a steady state capital-to-output and investment-to-output ratios equal to, respectively, 2.1 and 0.21, which are standard ratios in the RBC literature. The values of the wage share for the borrowers σ, the inertia of the borrowing constraint ρ_D and of the investment adjustment cost parameter ϕ are set to the median values estimated on US data in Guerrieri and Iacoviello (2017) on a similar model. The inverse of Frisch elasticity is assumed to be 2. The persistence and the standard deviation of the confidence state variable ξ are the ones obtained from the VAR estimation of the previous section. Table 4 lists the parameter values resulting from this calibration. The standard deviations of the competing shocks (the financial and the housing preference ones) are set so that they deliver the same response of output in absolute valus as the one standard deviation confidence shock in order to make them comparable in size[8].

Dynamics

Figure 2.1 shows impulse functions of some endogenous variables in the model to a one standard deviation confidence shock. The dotted red line is the base-

[8] This will not be a concern in the estimated version as these values are going to be estimated.

	Description	Value
β_s	Savers' discount factor	0.995
β_b	Borrowers' discount factor	0.985
γ	El. of intertemporal substitution	1
$\bar{J}$	SS Housing weight in utility	0.04
$\bar{M}$	SS Maximum LTV ratio	0.9
Φ	Investment adjustment cost	2.036
σ	Borrowers' wage share	0.5
ρ_D	Debt inertia	0.565
δ	Capital depreciation	0.025
α	Capital share	0.271
ν	Inverse of Frisch el.	2
H_C	Non-durable habit persistence	0.71
H_H	Housing habit persistence	0.6
ρ_A	Persistence of technology shock	0.9
σ_A	Standard deviation of technology shock	0.04
ρ_ξ	Persistence of confidence shock	0.7
σ_ξ	Standard deviation of confidence shock	0.6

Table 2.1: Calibrated Parameter Values

line model using the calibration described above, while the solid blue line is the case where financial frictions play no role and housing is just a durable good. In both cases, as in ACD, a confidence shocks boosts output, hours and consumption. However, the fact that housing can be used as collateral, amplifies fluctuations of real variables as underlined by the macro-finance literature. In the baseline model debt decreases on impact given the increase of the real interest rate, but then it starts increasing well above steady state as high house prices expand the borrowing constraint. Remember that we are analyzing linear local dynamics around a steady state where the borrowing constraint is always binding.

Justiniano et al. (2015) show that, in a DSGE model with financial fric-

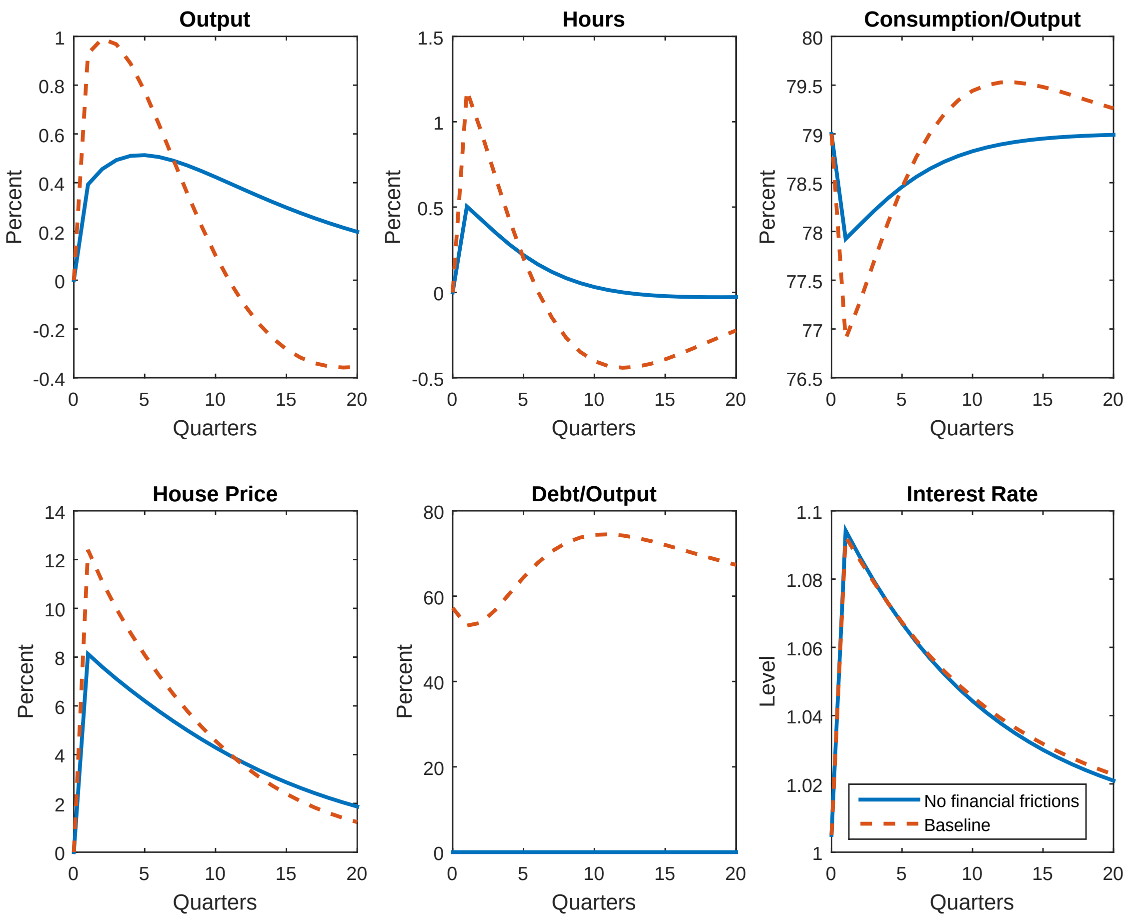

Figure 2.1: **Impulse response functions of endogenous variables to a one standard deviation confidence shock.**

tions very similar to the one analyzed here, it is difficult to obtain large endogenous movements in house prices for a reasonable calibration. This is not the case here: in the baseline calibration a positive confidence shock increases house prices by more than 12% and this number is not small. Figure 2.2 indeed compares the impulse response functions of house prices in the baseline model to different shocks used in the literature as possible drivers for house prices. The solid blue line is the response of house prices to a leverage (financial shocks) that *permanently* increases the maximum LTV ration from 0.8 to 0.9. House prices in this case, permanently increase by just five percent that is consistent with the numbers resulting from the credit liberalization experiment in Justiniano et al. (2015). The red dotted line consider instead the housing preference shock considered in Iacoviello (2005) and Guerrieri and Iacoviello (2015) . The shock is one standard deviation and the standard deviation is the one estimated in the latter. House prices by only two percent as a response to such a shock. The response of house prices to a one standard deviation confidence shock is instead much bigger, peaking on impact at about three times the impact of the financial shock. House prices slightly move then smoothly back to steady state, given that the confidence shock is temporary. Remember that the confidence shock entails no change in fundamentals; such an *animal spirit* shock implies large movements in house prices as opposed to other fundamental shocks considered in the literature.

Given the ability of the confidence shock to significantly affect house prices one could run an experiment to see whether the baseline model is able to replicate the boom-bust in house prices preceding the Great Recession.

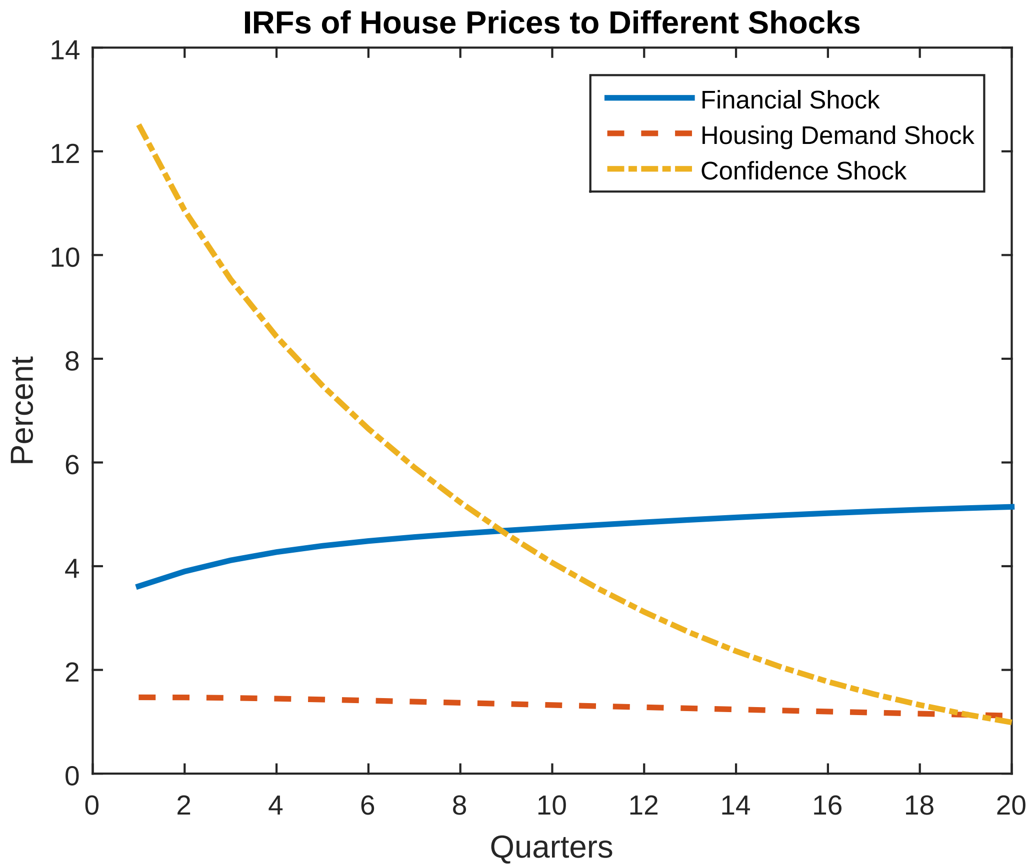

Figure 2.2: **Impulse response functions of house prices to different shocks.**

ACD show that in an estimated medium scale DSGE with a confidence shock as the one presented here, the filtered series of the confidence shock turns out to be very close to the University of Michigan Sentiment Index. If this is the case, it makes sense to use the structural innovations estimated through the VAR in the empirical sections as a proxy for a series of confidence shocks. I then feed int the model that series of innovations starting from 2003 to 2015Q2[9] and assuming that the model is in steady state at 2003Q1. Figure 2.3 shows what comes out from this simulation while Figure 2.4 shows the series of the innovations used. Remarkably, the order of magnitude of both the boom and the bust of house prices in the 2000s is consistent with the one generated by confidence innovations. Of course there are differences; the response of house prices in the model are much wilder than the data. This happens because, as already mentioned, in the model the borrowing constraint is always binding. This results in borrowers being forced to borrow as house prices increase and to deleverage as they decrease causing house prices to increase or decrease even more. This is probably the reason why in 2003 and 2004 house prices increase in the model is steeper than in the data. Notice that in the period where several studies[10] show that the borrowing constraint was likely to binding as it is in the model (2007-2009), the slope of house price drop in the model and in the data are remarkably similar. A solution of the model with an occasionally binding borrowing constraint would probably deliver a better picture where the boom phase is smoother as it is in the data, given the fact that as house prices increases the borrowing

[9]The VAR innovations are aggregated to a quarterly frequency in order to be consistent with the quarterly calibration of the model'.

[10]See for example Mian and Sufi (2010) and Guerrieri and Iacoviello (2015)

constraint becomes slacker, but still delivering a similar bust phase where the borrowing constraint is actually binding. To the best of my knowledge the ability of a simple, reasonably calibrated, dynamic macroeconomic model with financial frictions to deliver a house price boom-bust episode comparable to the one we experienced in the 2000s is new to the literature. Justiniano et al. (2015) show that in a similar macro-finance DSGE framework, one needs a extraordinarily big shock to housing preferences in order to obtain a boom-bust picture comparable to the one we observe in the data. Berger et al. (2015) are able to obtain a similar boom-bust episode by modifying expectations of the households about future house prices in a very ad-hoc way.

2.4 Estimation

To be written.

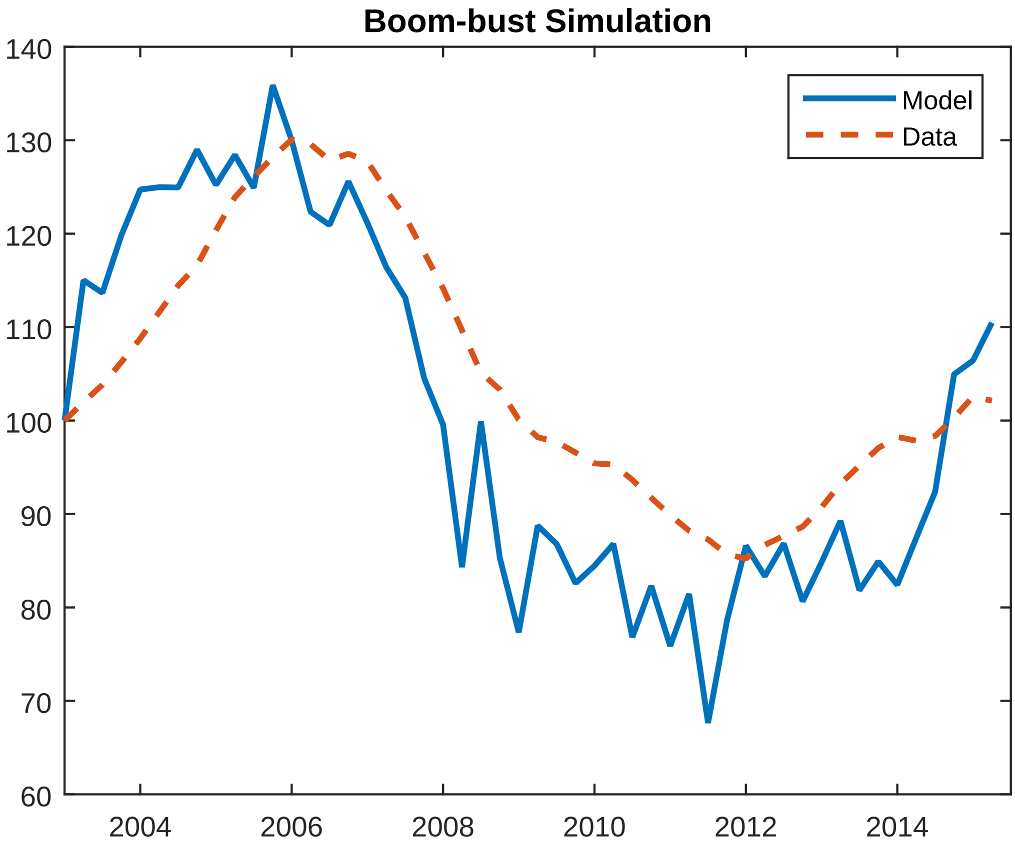

Figure 2.3: **House prices evolution for the boom-bust experiment: model vs data.**

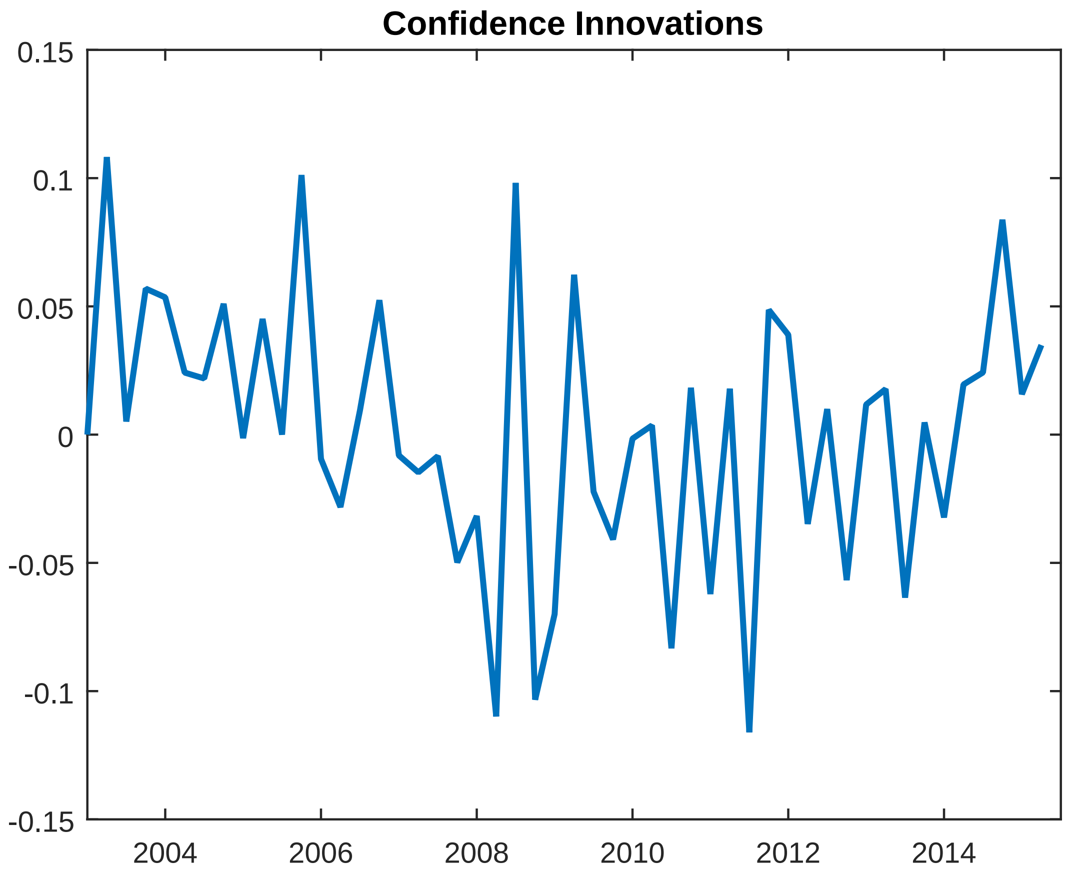

Figure 2.4: **Series of the confidence innovations used for the boom-bust simulation.**

Chapter 3

The previous Chapter presented a dynamic model with heterogeneous beliefs where exogenous belief fluctuations and their interaction with financial frictions have an important role in explaining house price volatility. The model is a standard DSGE with two representative agents, where financial frictions arise as one of the two agents ends up borrowing in equilibrium and his ability to borrow is limited by a borrowing constraint defined as in Kiyotaki and Moore (1997). The model is solved by linearly approximating its dynamics around the deterministic steady state; it is then linear implying that the borrowing constraint is assumed to be always binding as it is indeed binding at the steady state. Although this can be view as a decent approximation from an aggregate point view as only a fraction of agents is liquidity constraint while the remaining fraction is not and the parameter σ in the model allows us to calibrate this sort of intensive margin, the literature on financial frictions and aggregate activity has quite stressed the importance of non-linearities and heterogeneity that cannot of course be captured by a linear model. Guerrieri and Iacoviello (2017) consider a model similar to the one studied in the previous chapter where the collateral constraint can be occasionally binding and show that the constraint was indeed slack during the housing boom of the 2000s and that the collapse in house prices exacerbated the recession through the binding collateral constraint. This kind of asymmetries cannot be captured by a linear model. Moreover, a linear model can have difficulties in featuring big responses of real activity to changes in house prices as, for instance, levered economies are typically more fragile; Mian et al. (2013) find that the marginal propensity to consume out of a loss in housing wealth is typically higher for poorer and more levered household suggesting that an incomplete market model with heterogenous agents may be more appropriate in order to study the mechanisms through which changes in house prices affect consumption and the real activity in general. Berger et al. (2015) show that indeed such a model can deliver sizable consumption elasticity to house prices consistent with the evidence shown in Mian et al. (2013); with a similar model Kaplan et al. (2017) show with a counterfactual exercise that in the U.S. the boom and bust in house prices directly accounted for one half of the boom and bust in non-durable expenditures. It is then important to understand how a confidence shock of the kind of the one considered in the previous Chapter can also be a primary driver of real activity both indirectly, through its effects in house prices, and directly in a fully-fledged incomplete market model with heterogeneous agents.

3.1 The Complete Information Model

The setting is similar to the setting in Chapter 2, with the exception that now each island is populated by a unit mass of households. Agents are subject to idiosyncratic unemployment shocks $e_{i,t} \in \{0, 1\}$, where 0 stands for unemployed and 1 stands for employed. Employment status evolves as 2-state Markov Chain governed by a transition matrix $\mathcal{M}$. Agents hold bonds $b_{i,t}$, illiquid assets $h_{i,t}$ in fixed supply, which I am going to label housing as they deliver utility and are used as collateral for borrowing. Households preferences are represented by the utility function:

$$E\big[\sum_{t=0}^{\infty} \beta^t U(ci, t, h_{i,t}, l_{i,t})\big]$$

The household's budget constraint reads then as follows:

$$q_b b_t + q_t \phi(h_{t+1} - h_t) + c_t \leq b_t + w_t l_t e_t + \delta(1 - e_t),$$

where qb is the price of the liquid asset[1], q_t is price of housing, $\phi(h_t - h_t)$ is a cost function penalizing the reduction of housing stock, w_t is the wage and δ is home production if unemployed. As before, there is a borrowing constraint given by:

$$b_{i,t} \geq -Mqh_t h_{i,t},$$

where the parameter M determine the fraction of the value of housing that can be used as collateral.

The firm in the island produces the differentiated good using aggregate labor from households in the island L_t and according to the following linear production function:

$$y_t = A_t L_t^{1-\alpha},$$

[1] For the moment I assume, as in Kaplan et al. (2017), that the price of the liquid (safe) asset is exogenous and determined by the net supply of the rest of the world.

where A_t is the level of technology common to every island and follows a standard AR(1) process in logs:

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{A,t}$$

.

3.2 Solution Method

The model is solved using the limited history dependence method proposed in Le Grand and Ragot (2016). The idea is to approximate the infinite cross-sectional distribution over asset holdings and idiosyncratic employment status into a finite one of dimension 2^N, by assuming that all agents with the same employment history for the last N periods pool their resources and then make the same consumption-saving decisions. In each period there are thus 2^N families, characterized by their last N period history e^N, whose size S_{t,e^N} evolve according to a 2^N *by* 2^N Markov Chain depending on the primitive Markov Chain $\mathcal{M}$. Intuitively agents in family e^N at time t cannot come from any other family $\tilde{e}^N$ at time $t-1$. Say, for instance, that $N = 3$ so that only the last 3 periods matter; an agent with history (u, u, e), where e is today employment status, can only come from families with history (e, u, u) or (u, u, u) and the transition depends on the matrix M. The evolution of family sizes can then be derived as:

$$S_{t+1}(e^N) = \sum_{e^{\tilde{N}} \in \mathcal{E}^N} S_t(\tilde{e}^N) P(e^N | \tilde{e}^N), \tag{3.1}$$

where $P(e^N|\tilde{e}^N)$ is the probability of moving from family $\tilde{e}^N$ at t to family e^N at $t+1$.

At beginning of period t each agent brings its assets holding to the new family so that the per-capita liquid asset holdings of family e^N at the beginning of period t is:

$$\tilde{b}_{t,e^N} = \sum_{\tilde{e}^N \in \mathcal{E}^N} \frac{S(t-1, \tilde{e}^N)}{S_{t,e^N}} P(e^N|\tilde{e}^N) b_{t-1,\tilde{e}^N} \tag{3.2}$$

A similar formula holds for per-capita housing wealth of family e^N:

$$\tilde{h}_{t,e^N} = \sum_{\tilde{e}^N \in \mathcal{E}^N} \frac{S(t-1, \tilde{e}^N)}{S_{t,e^N}} P(e^N|\tilde{e}^N) h_{t-1,\tilde{e}^N} \tag{3.3}$$

The problem of the family e^N is then the following:

$$\max_{\{c_{t,e^N}, b_{t+1,e^N}, h_{t+1,e^N}, l_{t,e^N}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left[\sum_{e^N \in \mathcal{E}^N} S_{t,e^N} U(c_{t,e^N}, h_{t,e_N}, l_{t,e^N}) \right]$$

s.t.

$$q_b b_{t+1,e^N} + q_t \phi(h_{t+1,e^N} - \tilde{h}_{t,e^N}) + c_{t,e^N} \leq \tilde{b}_{t,e^N} + \mathcal{I}(e^N) w_t l_{t,e^N} + (1 - \mathcal{I}(e^N))\delta$$

$$b_{t+1,e^N} \geq -Mqh_t h_{t+1,e^N}$$

$$for\ given\ S_{-1,e^N},\ \tilde{b}_{-1,e^N},\ \tilde{h}_{-1,e^N}$$

A sequential equilibrium is then:

- a collection of allocations for each families

$$\{\mathcal{P}_{e^N}\}_{e^N \in \mathcal{E}^N} := \{c_{t,e^N}, l_{t,e^N}, b_{t+1,e^n}, h_{t+1,e^N}\}_{t \geq 0,\ e^N \in \mathcal{E}^\mathcal{N}},$$

- a collection of family sizes $\{S_{t,e^N}\}_{t \geq 0,\ e^N \in \mathcal{E}^\mathcal{N}}$
- a collection of aggregate quantities $\{L_t, B_t, H_t\}_{t \geq 0}$ and prices $\{qh_t, w_t\}_{t \geq 0}$

such that:

1. given prices, $\mathcal{P}_{e^N}$ solves the maximization problem of family e^N, for all $^N \in \mathcal{E}^N$.
2. family sizes and evolution of illiquid and safe assets are consistent with (3.1), (3.2) and (3.3).
3. Labor and asset markets clear.

The sequential equilibrium can be derived with projection methods and then dynamics for aggregate uncertainty can be solved using perturbation methods, that is finding an approximation for how the policy functions of families vary with the aggregate state.

3.3 Calibration and Results

To be written.

3.4 Adding Confidence shock.

To be written, but as dynamics around the aggregate state are linearly approximated the introduction of confidence and the solution method is exactly as in the previous Chapter.

3.5 Calibration and Results

To be written.

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Appendix A

- Local marginal utilities for savers and borrowers:

$$muc_{s,t} = Z_t(c_{s,t} - H_C C_{s,t-1})^{-\gamma}$$

$$muc_{b,t} = Z_t(c_{b,t} - H_C C_{b,t-1})^{-\gamma}$$

$$muh_{s,t} = Z_t J_t(h_{s,t} - H_H H_{s,t-1})^{-1}$$

$$muh_{b,t} = Z_t J_t(h_{b,t} - H_H H_{b,t-1})^{-1}$$

- Budget constraint for borrowers:

$$c_{b,t} + q_t(h_{b,t} - h_{b,t-1}) + r_{t-1}b_{t-1} = w_{b,t}n_{b,t}b_t$$

- Borrowing constraint:

$$b_t = (1 - \rho_B)M_t q_t h_{b,t} + \rho_B b_{t-1}$$

- Optimal local labor supply of savers and borrowers:

$$w_{s,t} muc_{s,t} = Z_t n_{s,t}^{\eta}$$

$$w_{b,t} muc_{b,t} = Z_t n_{b,t}^{\eta}$$

- Local production:

$$y_t = A_t (k_{t-1} u_t)^{\alpha} (n_{s,t}^{1-\sigma} n_{b,t}^{\sigma})^{1-\alpha}$$

- Optimal local labor demand for savers and borrowers:

$$w_{s,t} = (1-\alpha)(1-\sigma)\frac{Y_t}{n_{s,t}}$$

$$w_{b,t} = (1-\alpha)\sigma\frac{Y_t}{n_{b,t}}$$

- Optimal local demand for capital and capital utilization:

$$rk_t = \alpha\frac{Y_t}{k_{t-1}} - \psi_0(u_t^{\frac{1}{1-\psi}} - 1)$$

$$\frac{\psi_0}{1-\psi} u_t^{\frac{\psi}{1-\psi}} k_{t-1} = \alpha\frac{Y}{u_t}$$

- Local consumption Euler equations for savers and borrowers:

$$muc_{s,t} = \beta_s E_t[r_t muc_{s,t+1}]$$

$$muc_{b,t}(1-\lambda_t) = \beta_b E_t[(r_t - \rho_B \lambda_{t+1}) muc_{b,t+1}]$$

- Local housing Euler equations for savers and borrowers:

$$q_t muc_{s,t} = muh_{s,t} + \beta_s E_t[q_{t+1} muc_{s,t+1}]$$

$$q_t muc_{b,t} = muh_{b,t} + \lambda_t (1 - \rho_B) muc_{b,t} M_t q_t] + \beta_b E_t[q_{t+1} muc_{b,t+1}]$$

- Local optimal investment and price of capital:

$$qk_t muc_{s,t} = \beta_s E_t[muc_{s,t}(rk_{t+1} + qk_{t+1}(1 - \delta))]$$

$$qk_t muc_{s,t}(1 - \phi(\frac{i_t}{i_{t-1}} - 1)) = muc_{s,t} - \beta_s E_t[muc_{s,t+1} qk_{t+1} \phi(\frac{i_{t+1}}{i_t} - 1)]$$

- Local resource constraint:

$$Y_t = c_{b,t} + c_{s,t} + i_t + \frac{\psi_0}{1 - \psi}(u_t^{\frac{1}{1-\psi}} - 1)k_{t-1} + g_t$$

- Housing market clearing:

$$h_{s,t} + h_{b,t} = 1$$

- Law of motion for local capital:

$$k_t = (1 - \delta)k_{t-1} + i_t(1 - \frac{\phi}{2}(\frac{i_t}{i_{t-1}} - 1)^2)$$

- Exogenous state variables:

– Technology shock

$$A_t = A_{t-1}^{\rho_D} \varepsilon_{A,t}$$

– Intertemporal preference shock

$$Z_t = Z_{t-1}^{\rho_Z} \varepsilon_{Z,t}$$

– Housing preference shock

$$J_t = J_{t-1}^{\rho_J} \varepsilon_{J,t}$$

– Government spending shock

$$G_t = \bar{G}^{1-\rho_G} G_{t-1}^{\rho_G} \varepsilon_{G,t}$$

– Shock to ability to borrow

$$M_t = \bar{M}^{1-\rho_M} M_{t-1}^{\rho_M} \varepsilon_{M,t}$$

– Confidence shock

$$\xi_t = \xi_{t-1}^{\rho_\xi} \varepsilon_{\xi,t}$$