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# *Inflation Expectations and Monetary Policy Surprises*

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# Inflation Expectations and Monetary Policy Surprises*

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**Abstract**

We use monthly data across fifteen euro-area economies for the period 1985:1-2015:3 to obtain monetary policy changes that can be regarded as surprises for different types of consumers. A novel feature of our empirical approach is the estimation of monetary policy surprises based on changes in monetary policy that were unanticipated according to the consumers stated beliefs about the economy. We go on to investigate how these monetary policy surprises affect consumers' inflation expectations. We find that such monetary policy surprises can have the opposite impact on inflation expectations to those obtained under the assumption that consumers are well informed about a set of macroeconomic variables describing the state of the economy. More specifically, when we relax the assumption of well informed consumers by focusing instead on their stated beliefs about the economy, unanticipated increases in the interest rate raise inflation expectations. This is consistent with imperfect information theoretical settings where unanticipated increases in interest rates are interpreted as positive news about the state of the economy by consumers that know policymakers have relatively more information. This impact changes sign since the Crisis.

**Keywords:** Inflation, expectations, unanticipated, monetary policy, beliefs, Crisis.

**JEL Classification: E31, E52, F41**

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# 1 Introduction

Expectations play a central role in the macroeconomy. Monetary policymakers consider both the direct impact of their policies on economic activity or inflation as well as the indirect effect via private-sector expectations responding to changes in monetary policy, while economic agents' current economic decisions are affected by their expectations of future economic developments. Because of the resulting self-fulfilling effects on realized inflation and economic activity, inflation expectations should be taken into account especially in periods characterized by high uncertainty.

The question of how monetary policy affects inflation expectations addressed in this paper is an important one from a policy and theory perspective alike. On the policy side, the European Central Bank has repeatedly stated publicly over the past few years that its policies have been aiming at raising inflation expectations in line with its inflation objective, so as to boost current consumption and avoid a deflationary spiral.[1] Consistent with this, Yellen (2016) makes the point that "*t*heory and evidence suggest that th*e inflation* trend is strongly influenced by inflation expectations that, in turn, depend on monetary policy" and that "the broader question of how expectations are formed has taken on heightened importance."

The importance of the question regarding how monetary policy affects inflation expectations from the theory perspective is reflected in the attention it has received in a number of recent papers. Cochrane (2015), Garcia-Schmidt (2015), Garcia-Scmhidt and Woodford (2015), Del Negro, Giannoni and Patterson (2013), and Campbell, Evans, Fisher and Justiniano (2012) suggest different theory-implied impact of monetary policy on inflation expectations depending on the theoretical model being considered. While "textbook channels" and a neo-Keynesian approach like that in Garcia-Schmidt and Woodford (2015) would associate expansionary monetary policies with a rise in inflation and inflation expectations, imperfect information-based approaches such us the above-mentioned ones and the neo-Fisherian approach of Cochrane (2015) associate lower interest rates with a fall in inflation expectations[2].

In general, monetary policy can have two different types of effects on inflation expectations. First, if viewed by individuals as a credible action that will directly impact upon economic activity and inflation, then this would lead them to revise inflation expectations accordingly. In this case, an announcement to raise interest rates would reduce inflation expectations. Such a policy could then

[1] In fact, the ECB has repeatedly stated its goal of achieving a two percent inflation rate in line with its mandate. To the extent that inflation expectations have not been revised upwards in line with the ECB's stated goal and interest rate policies, this would then reflect lack of credibility and absence of anchoring of inflation expectations.

[2] The latter positive link between interest rates and inflation expectations is an equilibrium outcome where the Central Bank changes rates in a manner compatible with a (rational expectations) long-run sustainable equilibrium. This rules out the possibility that the Central bank can merely fool people into increasing their inflation expectations by raising rates temporarily in a non-sustainable manner incompatible with economic fundamentals.

have a direct negative effect on economic activity and an indirect negative effect to the extent that inflation expectations affect economic activity. Lower inflation expectations could affect economic activity via a fall in consumption of households that postpone purchases in anticipation of lower prices. Alternatively, lower inflation expectations could affect consumption decisions by affecting the expected nominal and real wage. That is, consumers expecting deflation would anticipate that firms will need to reduce wages in order to maintain profits and could thus reduce their consumption exacerbating the deflationary spiral.[3] Finally, inflation expectations are a direct determinant of the expected real interest rate. If a given change in the nominal interest rate is not followed by a similar movement in inflation expectations going in the same direction in a neo-Fisherian manner, then the expected real interest rate would be affected and so would any investment plans. For example, an increase in the nominal interest rate followed by lower or unchanged inflation expectations would increase the expected real interest rate, increasing the real cost of borrowing and acting as a demand for loans suppressant which in turn would adversely affect investment and consumption decisions.

Second, if individuals initially possess less information than the policymaker then they could learn something new about economic fundamentals by observing the realization of the Central Bank's monetary policy, and revise inflation expectations accordingly.[4] Here, an unanticipated increase in interest rates could be interpreted by consumers as positive news about the state of the economy given that they are aware that the policymaker has relatively more information.[5] Thus, the latter's actions would merely reveal to these agents that the policymaker is no longer worried about deflation. In this case, the effect of an unanticipated increase of the interest rate is to increase inflation expectations.

Our paper empirically investigates the above theoretical propositions by examining directly how monetary policy surprises affect inflation expectations.[6] We use monthly data across fifteen euro-

[3] Given the uncertain nature of the deflationary process and its effect on firms' revenue and profits, firms will likely reduce nominal wages by more than the ex-post realized rate of deflation so as to minimize the possibility of negative profits being realized. This could lead to a fall in real wages not just nominal ones, affecting consumption decisions.

[4] This resembles the discussions in Campbell, Evans, Fisher and Justiniano (2012), Del Negro, Giannoni and Patterson (2013) and Garcia-Schmidt (2015) regarding the ways forward guidance might influence economic agents. The first of these papers defines the so called "Delphic" case where monetary policy affects inflation expectations by enabling individuals to predict economic activity based on the policymaker's superior information set revealed after the latter undertakes monetary policy action, rather than by its anticipated direct impact on economic activity.

[5] In line with this, Campbell, Evans, Fisher and Justiniano (2012) find that market participants infer that unexpected policy adjustments by the Central Bank are responses to non-public information about the future state of the economy. Similarly, Gurkaynak, Sack and Swanson (2005) find that market participants believe that Central Bank announcements contain not previously known or anticipated information about future monetary policy actions.

[6] As John Cochrane (2016) points out "The big question is expectations. Will people read higher interest rates as a warning of inflation about to break out, or as a sign that inflation will be even lower." Similarly, Garcia-Schmidt and Woodford (2015) ask "is there reason ... that a commitment to keep nominal interest rates low ... will be deflationary...?" and answer "*t*here is one way in which such an outcome could easily occur, and that is if the announcement of the policy change were taken to reveal negative information (previously known only to the central bank) about the outlook for economic fundamentals" so that individuals change their inflation expectations

area economies for the period 1985:1-2015:3 to obtain estimates of monetary policy surprises under different assumptions, and use these along with other variables to explain inflation expectations of different types of consumers before and since the recent Crisis.

A broad goal of our analysis is to investigate what factors affect inflation expectations. As monetary policy actions often-stated objective is to influence inflation expectations, we find it useful to focus on the effect of monetary policy surprises. Thus, we estimate the dynamic response of inflation expectations to unanticipated monetary policy controlling for other variables that might possibly affect these. The main focus of our study is to assess whether monetary policy surprises estimated using different assumptions have a similar impact on inflation expectations. In particular, we estimate the impact on inflation expectations for monetary policy surprises that were obtained under the assumption that consumers are well informed about the state of the macroeconomy, and the impact of monetary policy surprises obtained under the assumption that consumers are only as informed as revealed by their stated beliefs about the economy. The assumption that the individuals' information set is the one revealed by their stated beliefs about the macroeconomy rather than the complete set of macroeconomic variables history, provides a fertile ground within which to further assess the empirical relevance of imperfect information-based theoretical mechanisms discussed in Campbell, Evans, Fisher and Justiniano (2012), Del Negro, Giannoni and Patterson (2013) and Garcia-Schmidt (2015).[7] In an imperfect information setting, the impact of monetary policy surprises could be different in tranquil periods as compared to Crisis periods during which both the incentive to obtain information and the ability needed to obtain it are greater. We will thus be investigating how monetary policy impacts upon inflation expectations before and since the recent Crisis, considering how different types of consumers respond to these monetary surprises. These responses might differ due to heterogeneous costs and benefits of obtaining information and updating expectations.[8]

We define the unpredictable change in interest rates as a monetary policy surprise. The unpredictability of monetary policy changes and their subsequent interpretation as monetary surprises will depend on how much information we assume individuals to have. A change in monetary policy is a surprise to the extent that individuals have not observed the information set based on which

accordingly.

[7] In a similar spirit, Orphanides and Williams (2005) emphasize imperfect information in relation to monetary policy and inflation expectations in a different context where monetary policies that would be efficient under rational expectations may perform poorly when knowledge is imperfect, with the public's expectations of inflation becoming uncoupled from the policy objective.

[8] If costs and benefits of obtaining information and updating expectations vary across demographic subgroups, some types of consumers will be more responsive to a given monetary policy surprise or might be surprised by a broader set of monetary policy changes as compared to agents that have more information about macroeconomic fundamentals.

they could have forecasted it prior to its arrival.[9] We will consider monetary policy surprises obtained under the assumption that individuals have an information set comparable to that of the policymaker, which has been traditionally used in the literature. In addition, we estimate monetary policy surprises that allow for individuals to have potentially less information based on their stated beliefs.[10] It should be pointed out that the often used assumption that individuals are as informed as the Central Bank and can thus only be surprised by monetary policy changes that also surprise the policymaker (see, e.g., Christiano, Eichenbaum and Evans 1999), is questionable. For example, the Central Bank has more information about the state of the economy than private agents as it has private information about its policy goals and access to confidential data. Thus, one might want to consider monetary policy surprises pertaining to individuals that are less informed than policymakers, especially when the goal is to explain inflation expectations of consumers rather than those of professional forecasters. The latter has been the focus of the recent literature on inflation expectations, including work by Campbell, Evans, Fisher and Justiniano (2012), Andrade and Le Bihan (2013), and Coibion and Gorodnichenko (2015). Although consumer forecasts might be potentially less accurate than professionals' forecasts, consumer expectations provide a useful angle from which to understand the impact of monetary policy surprises on the economy, given the important role consumers play in the economy.[11] In any case, there is no strong theoretical argument for focusing on professional forecasters' rather than consumers' inflation forecasts. As Yellen (2016) recently points out, "*an* unresolved issue concerns whose *inflation* expectations–those of consumers, firms, or investors–are most relevant for wage and price setting, a point on which theory provides no clear-cut guidance." In focusing on consumers' expectations from survey data, our paper fits closely into a new and growing literature studying how people process macroeconomic developments with survey data (see, for example, Coibion and Gorodnichenko, 2012, Carvalho and Nechio, 2014, Dräger et al., 2016 and Geiger and Scharler, 2016).

As what is deemed to be a surprise will depend on the information an individual agent has, to understand the effect of monetary policy on the economy it is important that we allow for individuals' information sets to correspond to their stated beliefs, however imperfectly measured, rather than to the econometrician's assumptions. Consistent with the above rationale, we estimate monetary surprises for individual types relaxing the assumption that these have the complete set of macroeconomic information over time available to, say, the Central Bank. Such individuals could be subject

[9] Furthermore, it is a surprise relevant to particular types of individuals to the extent that these also have the incentive and ability to pay attention to the shock once it arrives, a point we do not pursue further in this paper.

[10] While focusing on monetary policy surprises allows us to consider consumers that might be subject to surprise by a broader set of events than well-informed agents, we note that recent monetary policy has been shifting towards forward guidance and other instruments which relate to anticipated rather than unanticipated monetary policy changes. This is thus an important current issue outside the scope of this analysis.

[11] Interestingly, Geiger and Scharler (2016) find that professional forecasters process monetary and other shocks differently than households.

to surprise by a broader set of events as compared to the set of events that can surprise a policymaker with full information about the state of the macroeconomy. Thus, type-specific surprises will be estimated as changes in monetary policy that were unanticipated according to the consumers' type-specific stated beliefs about the economy, rather than assume that these individuals have necessarily observed past values of a large set of macroeconomic variables. This empirical approach to estimating monetary policy surprises has not, to our knowledge, been previously considered in the literature.

We also estimate conventional monetary surprises assuming that individuals have access to information about the macroeconomy comparable to the policymaker's information set. In this case, consumers are assumed to have the econometrician's or Central banker's information set based on the set of macroeconomic variables that describe the state of the economy. Having estimated monetary policy surprises, we then investigate in the second stage of our empirical analysis how these impact upon inflation expectations of different types of consumers depending on their income, education, employment status, and age. We consider the impact of a conventional monetary surprise common to all types of consumers, as well as the impact of type-specific surprises based on the economic beliefs of each type of consumer.

We find that surprises based on the assumption that individuals are well informed about the state of the macroeconomy and surprises obtained allowing for consumers to face costs in obtaining or processing information reflected in their stated beliefs about the economy, have different impact on inflation expectations. The latter typically have a positive impact on inflation expectations. That is, an unanticipated increase in the interest rate raises inflation expectations. This is consistent with imperfect information mechanisms discussed, e.g., in Campbell et al. (2012) where individuals have less information than the policymaker prior to an unanticipated monetary policy change. The estimated impact of beliefs-based monetary policy surprises is often negative after the arrival of the Crisis in line with "textbook" or Neo-Keynesian channels. This reversal would suggest that in a Crisis period where the incentive to pay attention to the macroeconomy is greater, individuals become rationally attentive so that their response to surprises becomes more consistent with them observing the full set of macroeconomic variables histories.[12]

Our study is organized as follows. Section 2 describes the data and preliminary analysis. Section 3 describes the general structure of our econometric model. In its two subsections we describe each stage of analysis separately, where in the first stage we identify two types of monetary policy sur-

[12] As the ability needed to decipher macroeconomic information during the Crisis is presumably also greater, it is striking that in the period since the Crisis we find consumer types we would a priori expect to have higher ability to extract signals from a given realization (e.g. high-educated individuals) react more to monetary policy surprises than those with potentially lower ability to extract signals, and moreover that they react more in the period since the Crisis as compared to before and in a manner consistent with them being well informed in this case.

prises using a time-series model, and in the second stage we work with a panel model to investigate the impact of these monetary surprises on inflation expectations for the 15 Eurozone economies in our sample. Section 4 illustrates the estimation results of the second stage, including a set of robustness checks. The last section briefly concludes.

# 2 Data and preliminary analysis

## 2.1 Description of data

### Inflation expectations

Data for inflation expectations are from the Joint Harmonized EU Programme of Business and Consumer Surveys database, which is published monthly by the European Commission (Economic and Financial Affairs) for 28 member countries. The inflation expectations for consumers used in our study are obtained from the answers of this consumer survey. The sample size of the survey varies across countries and is generally positively related to their respective population size. The consumer survey is mainly qualitative although, as of 2003, two quantitative questions are asked concerning perceived and expected price changes. In our analysis, we concentrate on qualitative data that come from around 40,000 consumers who are currently surveyed every month across the EU.

The database categorizes inflation expectations data according to respondents income, education, occupation and age, and we will be considering two subcategories for each of these categories. We will thus be using monthly data across fifteen euro-area economies[13] for the period 1985:1-2015:3 and potentially 5445 observations for each of the eight consumer subcategories. Given that for some countries these data are only available at a later starting date, in practice we will have less than 5445 observations for each consumer subgroup.[14] The consumer subgroups (abbreviations to be used in the tables) we focus on are: low income consumers (Low inc), high income consumers (High inc), low educated consumers (Low edu), high educated consumers (High edu), unemployed consumers (unem), full-time working consumers (full-time), consumers with ages between 30 and 49 (30-49), and consumers with ages between 50 and 64 (50-64). Moreover, we examine the inflation expectations of total consumers (total con). The latter category includes some other subcategories that we do not examine in detail (e.g. the 2nd and 3rd quartile of income, ages between 16 - 29, secondary education, etc.). We compare expectations of consumers based on their education

[13] These are the 19 euro-area countries minus Cyprus, Malta, Latvia and Lithuania.

[14] We have 4532 observations for total consumers, 4219 observations for low income and high income consumers, 4316 observations for low and high educated consumers and for full time workers, 3970 observations for unemployed consumers, and 4291 observations for consumers of ages 30-49 and ages 50-64.

and income, given that the formation of inflation expectations might well depend on the ability of the respondents to gather and interpret information. We also consider occupation status and age of consumers since the economic situation and particular point in their life cycle might lead to differences in the formation of inflation expectations.

As mentioned above, the data that the European Commission uses for inflation expectations are qualitative and are obtained from the question "By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will..." Consumers have six options to answer this question as follows: prices will increase more rapidly (PP), increase at the same rate (P), increase at a slower rate (E), stay about the same (M), fall (MM), and don't know (N). Since the data obtained from the consumer questionnaire is qualitative, they have to be quantified. To quantify these qualitative data, we obtain the simple balance statistic defined as the difference between the proportions of respondents considered, e.g., in Nielsen (2003) and Kyziak (2005).The simple balance statistic is given as the difference between positive and negative answering options measured as percentage points of total answers, and is calculated as $B = (PP + \frac{1}{2}P) - (\frac{1}{2}M + MM)$ on the basis of weighted averages that add up to 100, $PP+P+E+M+MM+N = 100$. Thus, values range from -100, when all respondents choose the negative option to +100, when all respondents choose the positive option. The Commission calculates and seasonally adjusts the balance series that we use in our analysis.

A similar procedure is followed to calculate balances for responses to other questions that form our set of consumer type-specific beliefs. The following questions are considered for each of which consumers are given six response options: "How has the financial situation of your household changed over the last 12 months? It has ... " got a lot better (PP), got a little better (P), stayed the same (E), got a little worse (M), got a lot worse (MM), don't know (N). "How do you expect the financial position of your household to change over the next 12 months? It will ... " get a lot better (PP), get a little better (P), stay the same (E), get a little worse (M), get a lot worse (MM), don't know (N). "How do you think the general economic situation in the country has changed over the past 12 months? It has ... " got a lot better (PP), got a little better (P), stayed the same (E), got a little worse (M), got a lot worse (MM), don't know (N). "How do you expect the general economic situation in this country to develop over the next 12 months? It will ... " get a lot better (PP), get a little better (P), stay the same (E), get a little worse (M), get a lot worse (MM), don't know (N). "How do you think that consumer prices have developed over the past 12 months? They have ... " risen a lot (PP), risen moderately (P), risen slightly (E), stayed about the same (M), fallen (MM), don't know (N). Finally, we consider the question "How do you expect the number of people unemployed in this country to change over the next 12 months? " and responses to it "The number will ... increase sharply (PP), increase slightly (P), remain the same (E), fall slightly

(MM), fall sharply (M), don't know (N)".

Figure 1 plots the time series for expected inflation of total consumers over the period 1985:1-2015:3 across 15 euro area countries and the euro area as a whole. This is the 12-month forward-looking inflation expectations derived from the European Commission's Business and Consumer Surveys database. Although expected inflation over the next 12 months varies considerably in each country, we can see from Figure 1 that the recent Crisis arrival has a similar impact on inflation expectations for the countries in our sample.

**CPIs and Inflation rates**

Consumer price indices and inflation rates were obtained from OECD Stat.[15] The OECD calculates four area totals for the following product groups: all items, food (excluding restaurants), energy (Fuel, electricity & gasoline) and all items excluding food and energy.[16] Monthly changes of these provide an indication about the acceleration or deceleration of inflation but may also reflect seasonal variation. It should be noted that the majority of OECD countries do not produce seasonally adjusted CPIs because seasonal effects are not generally significant enough to warrant it.

Data for short term interest rates is taken from OECD's Monthly Monetary and Financial Statistics.[17] Short term interest rates are usually either the 3-month interbank offer rate attached to loans given and taken amongst banks for any excess or shortage of liquidity over several months, or the rate associated with Treasury bills, Certificates of Deposit or comparable instruments, each of three month maturity. For all Euro Area countries, the 3-month "European Interbank Offered Rate" is used as of the date the country joined the euro. We note that short term interest rates are identical for all 15 euro area countries that we examine as of January 2011, and identical for 11 of the 15 countries (i.e., excluding Estonia, Greece, the Slovak Republic and Slovenia) as of January 1999.[18]

Comparing the averages of short term interest rates before and since the Crisis for the euro area, we find that the average has decreased from 6.36 to 0.91. Short term interest rates have realizations of less than one percent for the first time on July 2009 and continue decreasing taking very low values up until May 2010. From May 2010, interest rates are increasing from a low of 0.7 percent until March 2012. From March 2012, short term interest rates have been decreasing gradually from

[15] Data available at http://stats.oecd.org/index.aspx?queryid=22519

[16] Energy refers to items "electricity, gas and other fuels" as defined under the classification of individual consumption according to purpose (COICOP 04.5) and "fuel and lubricants for personal transport equipment" (COICOP 07.2.2).

[17] The link is http://stats.oecd.org/Index.aspx?DatasetCode=MEI_FIN

[18] As of January 2001 short term interest rates become identical for 12 countries including Greece. As of January 2007 these were identical for 13 of the countries including Slovenia, and since January 2009 they were identical for 14 of the 15 countries excluding Estonia.

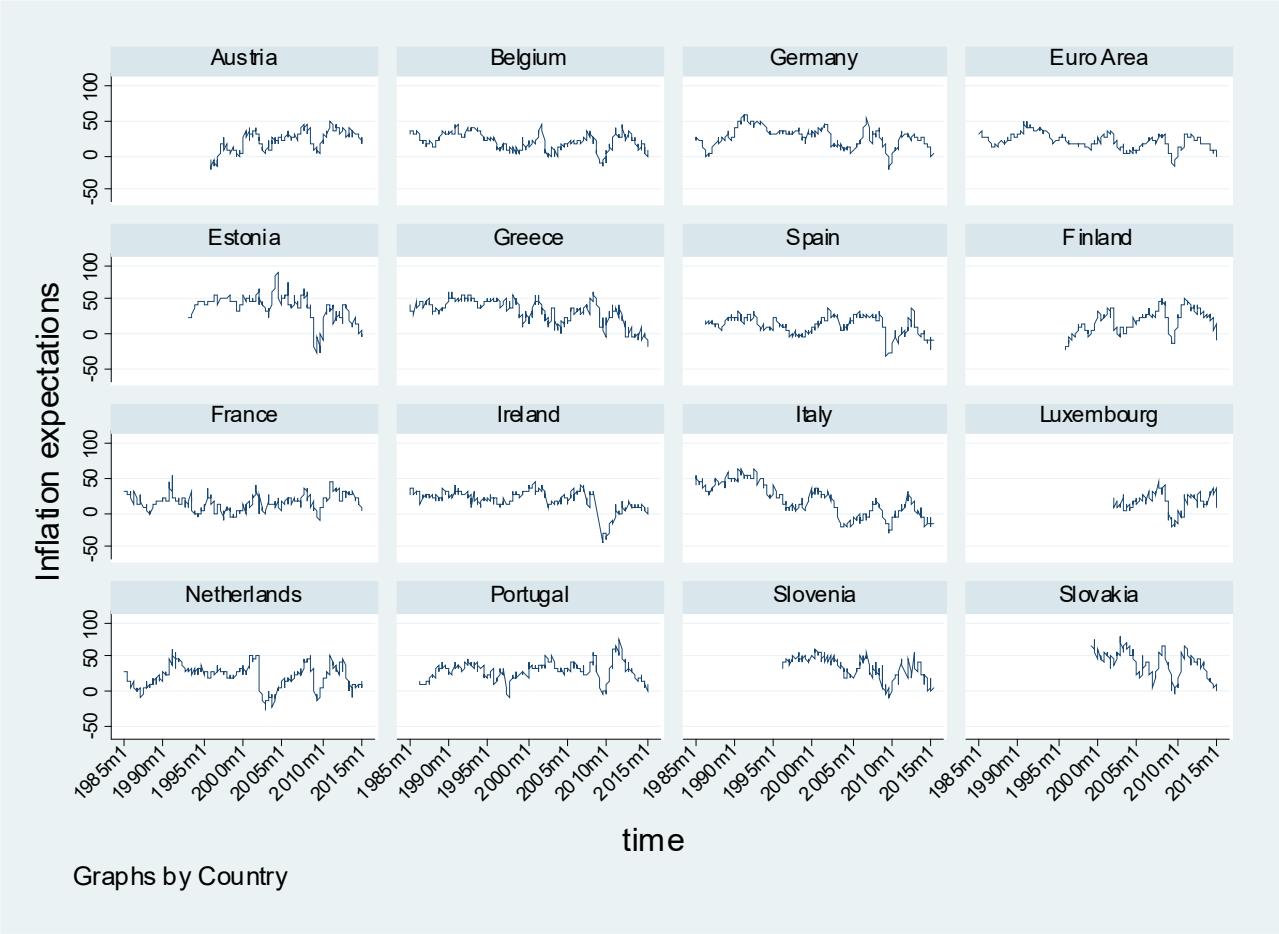


Figure 1: 12-month forward-looking inflation expectations for total consumers across 15 euro area economies and the euro area as a whole. Countries included are: Austria, Belgium, Germany, Estonia, Greece, Spain, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Slovenia and the Slovak Republic.

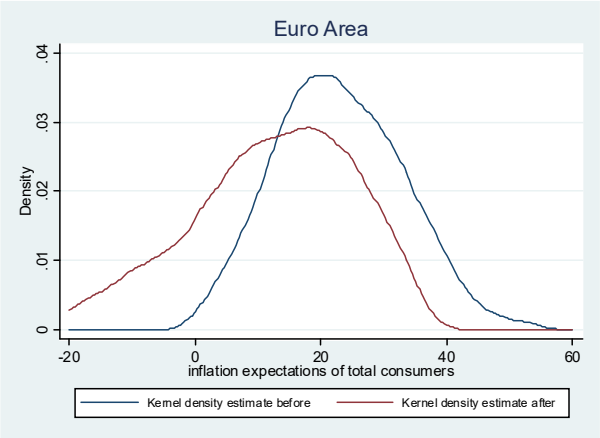


Figure 2: Distribution of inflation expectations of total consumers for the Euro Area as a whole, before and after the incidence of the recent crisis.

values slightly less than one percent to values very close to zero. By April 2015, short term interest rates are exactly equal to zero, and they take negative values since that date. Our empirical analysis focuses on the sample 1985:1 until 2015:3, thus, the negative short term interest rates regime is excluded from our analysis.

Other variables used in our analysis are the Harmonized Unemployment rate for all persons, and Industrial Production. Both are available monthly in seasonally adjusted form from the OECD's Short-Term Economic Indicators.[19] The Food Price Index used includes Cereal, Vegetable Oils, Meat, Seafood, Sugar, Bananas and Oranges Price Indices. The data for commodity prices were obtained from the IMF's Primary Commodity Prices.[20] We also utilize the Europe Brent Spot Price FOB (Dollars per Barrel) from the THOMSON REUTERS database.[21]

## 2.2 Preliminary analysis and testing

In this subsection we analyze the statistical properties of two of the main variables we use in our estimations.

We begin by examining the distribution of inflation expectations. Figure 2 presents the Gaussian kernel density estimates of inflation expectations for the period before the Crisis (1985:1 - 2008:6) and for the period since the Crisis (2008:10 - 2015:3) separately. The choice of regimes was based

[19] Available respectively at http://stats.oecd.org/?queryid=21760 and
and http://stats.oecd.org/index.aspx?DatasetCode=KEI#
[20] Available at http://www.imf.org/external/np/res/commod/index.aspx
[21] Available at http://www.eia.gov/dnav/pet/pet_pri_spt_s1_m.htm

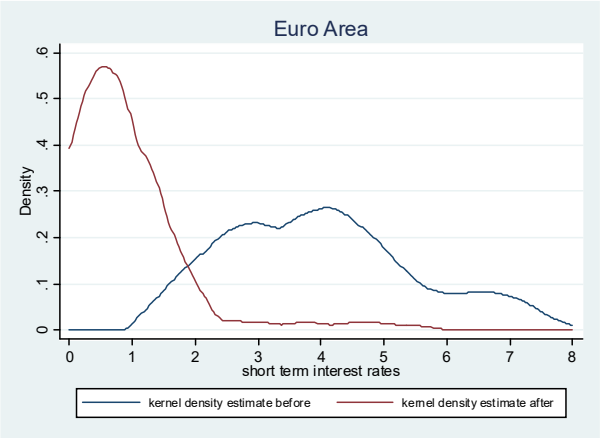


Figure 3: Distribution of short term interest rates for the Euro Area as a whole, before and after the incidence of the recent crisis.

on endogenous structural breaks tests (Andrews, 1993) and the estimated break is related to the chronology of Crisis events in Europe. Details on this structural break test analysis are discussed in the next section. Comparing the kernel densities for the period before and since the recent Crisis, we see that there has indeed been a large change since the arrival of the recent Crisis. We observe that before the Crisis the mass of the distribution is concentrated to the right, indicating that the distribution of inflation expectations is positively skewed, while since the Crisis the distribution ranges from (-20) to (+40). This suggests that since the Crisis, the number of consumers that believe that prices will decrease in the next 12 months, has increased considerably.

Figure 3 illustrates the distributions of short term interest rate for the period before the Crisis (1985:1 - 2008:6) and for the period since the Crisis (2008:10 - 2015:3) separately. Comparing these densities we find that since the Crisis, short term interest rates for the Euro Area have not only decreased substantially but that the shape of the probability distribution has also changed considerably.

To correctly specify our first and second stage regression model specifications, we evaluated the unit root hypothesis for the variables involved in our models. Performing the Im–Pesaran–Shin (2003) panel unit root test, we find that industrial production, the unemployment rate, and commodity prices (oil and food) contain unit roots. We thus take first differences of the log of industrial production and the unemployment rate and use these transformed variables for estimating our models. In line with previous related research (e.g. Christiano, Eichenbaum and Evans, 1999), we smooth the log of commodity prices by removing the trend using a Hodrick–Prescott time-series filter. We take the smoothed change of these commodity prices as an explanatory variable in our first

stage model estimation exercise. The first stage regression model employs a time series approach to obtain the monetary policy surprise for each country separately, by regressing short-term interest rates on a number of explanatory variables and identifying the monetary policy surprise as the residual. We performed a unit root test for these monetary policy surprises as well as for the actual inflation rate and for the inflation expectations of the different consumer types considered in our paper. Our findings strongly reject the null hypothesis of the existence of a unit root for all three of these variables. The same holds for the short-term interest rate. Performing the Im-Pesaran-Shin panel unit-root test in this case, we strongly reject the unit root null in favor of trend stationarity.

# 3 A statistical model

This section describes the statistical model we used in order to estimate the monetary policy surprises and investigate their impact on inflation expectations. Our analysis is split in two stages.

In the first stage we use a time-series regression model to estimate the monetary policy surprises for each country separately, given the heterogeneity of these surprises across countries as well as the potentially different dates of crisis regimes in each country. Here, we make similar assumptions to Christiano, Eichenbaum and Evans (1999). We assume that the instrument of monetary policy is the short term interest rate and that monetary policy is based on a set of macroeconomic variables that determine the policy stance. One of our main assumptions is that the policy surprise is orthogonal to the information set of the policymaker. Thus, the recursiveness assumption is implemented to identify the monetary policy surprise. Assuming that the Central Bank controls the short term interest rate and sets it according to a reaction function which depends on a set of macroeconomic variables, then the monetary policy surprise is a deviation from the usual reaction based on the policymaker's information about macroeconomic conditions. In our first specification, we assume that the individuals' information set is similar to that of the policymaker. The monetary policy surprise identified in this case will be based on the assumption that individuals are well informed about macroeconomic conditions.

In our second specification, we allow for the fact that individuals may have a smaller information set than that of the policymaker due to costs associated with collecting and identifying information. In this second case, we include in the individual's information set type-specific beliefs about the economy along with lagged interest rates, rather than the complete set of past realizations of the variables in the Central Bank's reaction function. The monetary policy surprise identified in this case will be relevant for potentially less informed consumers surprised by a wider set of monetary events as compared to agents that are well-informed about macroeconomic fundamentals. In the first subsection below, we describe in detail how we identify these monetary policy surprises.

In the second stage, we investigate how these monetary policy surprises impact upon inflation expectations of different types of consumers before and since the recent Crisis, using monthly data and a panel model of 15 European economies for the period 1985:1-2015:3. In the second subsection, we will thus consider the formation of inflation expectations across the Euro Area and investigate the impact of these monetary policy surprises on inflation expectations of different types of consumers depending on their income, education, occupation and age.

In both the first and second stages, we estimate the model for the total sample 1985:1 - 2015:3 and refer to this as the "model without regimes". Additionally, we distinguish between the period before and since the Crisis in both stages, in what we label as the "model with regimes". We define the period before the Crisis from the beginning of the sample, January 1985 until June 2008. The period since the incidence of the Crisis is from October 2008 until March 2015. We split the sample in this way for the following reasons. First, the Eurozone Crisis has been taking place at least since 2009 with some European economies e.g. Ireland, having already faced difficulties since 2008, especially after the Lehman brothers collapse in September of that year. Second, we performed a Sup Wald test for an unknown break date (Andrews, 1993) for each country which, as expected, estimated break points in the summer and autumn months of 2008 for the different EU countries in our sample. For Euro area inflation expectations, the Andrews (1993) test estimated the endogenous date to be in August 2008. Moreover, estimating the reaction function of monetary policy, the break date for most countries is November 2008. Taking all the above results into account, we consider that the pre-Crisis period ends in the first semester of 2008. Finally, we terminate our sample in March 2015 to avoid negative values for the short-term interest rate and a potentially new regime with a very small sample that might bias our results. Our analysis will thus concentrate on the period where short term interest rates take positive values across the euro area, to alleviate potential problems associated with the zero lower bound.

### 3.1 Identification of monetary surprises in the first stage

In the first stage, we specify time-series models for each country separately to estimate the exogenous surprise to monetary policy. We take the operating instrument of the policymaker to be the short term interest rate. In addition, one needs to make some assumption about the nature of the interaction of the policy surprise with the variables in the feedback rule. Thus, we assume that the monetary surprise is orthogonal to the information set and that time $t$ variables in the information set do not respond to time $t$ realizations of the monetary policy surprise following Christiano et al. (1999) and a number of other authors before us. The recursiveness assumption along with the linearity of the feedback rule, allow us to estimate monetary policy surprises from the fitted residuals of the ordinary least squares regression of the short term interest rate on the variables in

the policymaker's information set or alternatively, on the economic beliefs of individuals.

Thus, we identify a monetary policy surprise with the disturbance term from equation

$$r_{t,i} = f(\mathbf{X}_{t,i}) + \sigma_i v_{t,i} \tag{1}$$

where $r_{t,i}$ is the short term interest rate at time $t$ in country $i$, $f$ is a linear function that represents the feedback rule, and $\mathbf{X}_{t,i}$ is the monetary authority's information set at time $t$ in country $i$ which may coincide with that of the individual's. The random variable $\sigma_i v_{t,i}$ is a monetary policy surprise. We assume that $v_{t,i}$ is orthogonal to the information set $\mathbf{X}_{t,i}$ i.e. at time $t$, $v_{t,i}$ does not affect the elements of this information set. The information set $\mathbf{X}_{t,i}$ will differ depending on whether we assume individuals to be as informed or potentially less informed than the policy maker. We analyze each of these two cases for each country separately in the next two subsections.

### 3.1.1 Well-informed agents

In the first specification, we consider that $\mathbf{X}_{t,i}$ contains a number of macroeconomic variables observed by informed individuals and the policymaker alike. We assume that these are industrial production, unemployment, CPI for all items excluding food and energy, and commodity prices. This resembles the specification in, e.g., Christiano, Eichenbaum and Evans (1999). Based on this information set, we will be obtaining monetary policy surprises relevant to well informed consumers.

We first estimate equation (1.1) below for the whole sample period 1985:1-2015:3 to obtain the monetary policy surprise $\widehat{u}_{t,i}^{whole}$ which is implied by the unpredicted component from an interest rate policy reaction function. We estimate for each country $i$ separately the interest rate policy reaction function given by the regression equation below

$$r_{t,i} = a_{0,i} + a_{1,i}\, trend + \sum_{j=1}^{n_i} a_{2j,i} r_{t-j,i} + \sum_{j=0}^{\mathbf{n}_i} \mathbf{a}_{3j,i} \mathbf{X}_{t-j,i} + u_{t,i}^{period} \tag{1.1}$$

where $r_{t,i}$ is the short term interest rate at time $t$ for country $i$, $trend$ is a deterministic time trend[22], and $\mathbf{n}_i$ is the vector with the number of country-specific lags[23] that corresponds to each variable in the information set $\mathbf{X}_i$ where $\mathbf{X}_{t,i}$ denotes the information set vector at time $t$ in country $i$. The latter includes both contemporaneous and lagged values of the following variables: the differenced

[22] This is significant only for Belgium, Germany, Ireland, the Netherlands, Portugal and Slovenia for the period before the Crisis, and Austria, Finland and the Slovak Republic for the period since the Crisis. We thus end up including a time trend only for these countries in the time series estimation before and after the incidence of the crisis respectively, and exclude the time trend when estimating equation (1.1) for all remaining cases.

[23] Estimation of the above equation differs from country to country since the lag lengths for each variable differ. For each country, we use an optimal lag length selection approach based on the Bayesian Information Criterion (BIC).

log of Industrial Production, the differenced unemployment rate, the log of the Consumer Price Index for all items excluding food and energy, the smoothed change in the log of the price of crude oil, and the smoothed change in the log of the price of food.[24] [25]We obtain the monetary policy surprise, $\widehat{u}_{t,i}^{whole}$, implied by the unpredicted component of the short-term interest rate $u_{t,i}^{period}$ for the whole sample period.

In addition, we estimate equation (1.1) for the period before (1985:1-2008:6) and since (2008:10-2015:3) the Crisis separately to obtain monetary policy surprises for the period before ($\widehat{u}_{t,i}^{pre}$) and for the period since ($\widehat{u}_{t,i}^{post}$) the incidence of the recent Crisis for each country $i$. Here, we allow for the general structural change hypothesis where all parameters may change in the two regimes. Noting that the recent Crisis caused a structural change in major macroeconomic variables typically found in the policy reaction function and a structural shift downwards for the short-term interest rate, we deem it essential to estimate monetary policy surprises for separate subsamples in this manner. The actual regimes for each country were determined based on the endogenous break analysis in the previous section.

Given that there is a regime change in our sample following the recent Crisis which implies that our sample needs to be split into two subsamples, one is faced with a relatively smaller sample since the recent Crisis in order to be able to estimate a VAR. As a result, we estimate single equation dynamic models which are more parsimonious relative to the overparameterized VARs. While the analysis centers on these single equation dynamic models, which are directly related to the VAR equations, the robustness section shows that our results are mostly robust to the case of estimating a VAR. In particular, the estimates are fully robust for the relatively large sample before the Crisis. Moreover, the results are robust in the case of the well informed both before and after the Crisis.[26]

The time series estimation results of equation (1.1) for Belgium, France and Ireland are shown in Table 1 for the periods before and since the Crisis.[27] To summarize the results in this first stage model specification, we note first that the impact of variables included in the information set $\mathbf{X}_{t,i}$

[24] We note that all data are monthly and seasonally adjusted.

[25] We note that by including contemporaneous values of the variables in the information set, we are effectively assuming that the policymaker can observe the current values of industrial production, the unemployment rate, the CPI and commodity prices. This assumption is consistent, with Christiano, Eichenbaum and Evans (1999) and Bernanke and Mihov (1995) but comes in contrast with the specification of Sims and Zha (1995) where only lagged values are included. The empirical results show that for all the countries studied, contemporaneous variables are often statistically significant and thereby constitute relevant information for estimating the unpredictable component of monetary policy.

[26] This might be due to the fact that the first-stage VARs for the well informed involve somewhat less variables than the VARs using type-specific beliefs. It's worth mentioning here that for the smaller time-series sample since the arrival of the Crisis, beliefs-based monetary shocks appear to be generated with higher imprecision in the first-stage VARs and are as a result insignificant determinants of the inflation expectations in the second stage.

[27] For brevity, we present only results for a representative EZ country (Belgium), a major EZ economy (France) and a Crisis-hit economy (Ireland), with results for the remaining twelve countries to be made available upon request.

Table 1: Estimation results for equation (1.1) before and since the Crisis for Belgium, France and Ireland.

| VARIABLES | BEL pre | BEL post | FRA pre | FRA post | IRL pre | IRL post |
|---|---|---|---|---|---|---|
| time trend | 0.011** | | | | -0.057*** | |
| | (0.005) | | | | (0.015) | |
| Indl Production | 1.176 | -0.198 | 0.566 | 0.022 | 0.540 | -0.128 |
| | (0.766) | (0.403) | (1.930) | (1.032) | (1.332) | (0.223) |
| Unem. rate | -0.152* | 0.056 | -0.621** | 0.086 | 1.543 | -0.057 |
| | (0.086) | (0.108) | (0.261) | (0.094) | (1.125) | (0.050) |
| CPI excl f&e | -2.266 | 0.450 | 18.669** | 0.866 | -2.829 | 4.076** |
| | (6.829) | (4.642) | (8.625) | (1.959) | (23.109) | (2.024) |
| Price of crude oil | -0.055 | 0.178 | -0.324 | 0.232* | -0.661 | 0.180 |
| | (0.164) | (0.112) | (0.201) | (0.128) | (0.865) | (0.127) |
| Price of food | 0.233 | -1.038* | 0.574 | -1.063* | -3.935 | -1.036 |
| | (0.834) | (0.610) | (0.865) | (0.632) | (4.802) | (0.655) |
| Interest rate lags | 0.948*** | 0.925*** | 0.975*** | 0.918*** | 0.638*** | 0.928*** |
| | (0.020) | (0.037) | (0.026) | (0.035) | (0.113) | (0.036) |
| Indl production lags | -0.285 | 0.171 | -1.355 | 1.001 | 1.433 | -0.194 |
| | (0.685) | (0.345) | (2.099) | (1.194) | (1.120) | (0.120) |
| Unem. rate lags | 0.038 | -0.106 | 0.186 | 0.090 | -0.648 | 0.105* |
| | (0.106) | (0.110) | (0.246) | (0.132) | (0.957) | (0.058) |
| CPI excl f&e lags | -5.106 | -1.220 | -19.016** | -2.454 | 19.027 | -5.256*** |
| | (5.821) | (4.707) | (8.885) | (1.626) | (25.593) | (1.931) |
| Price of crude oil lag | -0.046 | 0.071 | -0.010 | 0.048 | 0.111 | 0.031 |
| | (0.179) | (0.119) | (0.195) | (0.156) | (0.705) | (0.146) |
| Price of food lags | -0.260 | 1.041* | -0.388 | 0.929 | 7.295 | 0.673 |
| | (0.803) | (0.568) | (1.108) | (0.594) | (4.562) | (0.619) |
| Constant | 30.871** | 3.616 | 1.619 | 7.378* | -58.526*** | 5.501 |
| | (15.115) | (2.212) | (2.727) | (4.414) | (17.617) | (4.271) |
| Observations | 208 | 78 | 208 | 78 | 207 | 78 |
| $adj.R^2$ | 0.986 | 0.990 | 0.980 | 0.988 | 0.746 | 0.989 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses. We identify the monetary policy shock based on the assumption that individuals are more informed and have the same information set as the Central Bank. We are estimating equation (1.1), regressing short term interest rates on the information set of the Central Bank which includes current and lagged values of differenced log industrial production, differenced unemployment rate, the log of the CPI (all items excluding food and energy) and on smoothed changes of the log price of oil and the log price of food. We present results for the period before the Crisis1985:1-2008:6 and for the period after the incidence of the Crisis 2008:10-2015:3 for Belgium, France and Ireland.

on short term interest rates can differ across the fifteen countries. Moreover, comparing the results between the two regimes, we note that contemporaneous effects as well as the aggregated effect of the lagged variables included in the information set are significant for a relatively larger number of countries (not shown in Table 1) since the recent Crisis. This finding suggests that the instrument of monetary policy is affected more by the state of the macroeconomy since the recent Crisis.

### 3.1.2 Consumer type-specific surprises

Consumers are more likely than other economic agents to face some cost in obtaining information. For example, they are often simply unable to have access to the same information set as a Central Banker. We allow for such a possibility by considering that specific consumer types will be surprised by monetary policy changes which are unrelated to their type-specific beliefs about the macroeconomy. We estimate

$$r_{t,i} = \ a_{0,i} \ + a_{1,i}\, trend + \ \sum_{j=1}^{n_i} a_{2j,i} r_{t-j,i} + \ \sum_{j=0}^{\mathbf{n}_i} \mathbf{a}_{3\kappa,j,i} \mathbf{B}_{\kappa,t-j,i} + u_{\kappa,t,i}^{period} \tag{1.2}$$

where $\mathbf{B}_{\kappa,t,i}$ denotes a set of individual beliefs regarding the economy based on the information set of consumer type $\kappa$ at time $t$ in country $i$, *trend* is again a deterministic time trend[28], $r_{t,i}$ the short term interest rate at time $t$ for country $i$, and $\mathbf{n}_i$ is the vector with the number of country-specific lags corresponding to each variable in the beliefs vector $\mathbf{B}$.[29] Here, $\kappa$ stands for consumer type $\kappa =$ [total con, Low edu, High edu, Low inc, High inc, unem, full-time, 30-49, 50-64].

The set of type-specific beliefs $\mathbf{B}_{\kappa,t,i}$ contains balances based on the responses to the following questions: "Q1 How has the financial situation of your household changed over the last 12 months?", "Q2 How do you expect the financial position of your household to change over the next 12 months?", "Q3 How do you think the general economic situation in the country has changed over the past 12 months?", "Q4 How do you expect the general economic situation in this country to develop over the next 12 months?", "Q5 How do you think that consumer prices have developed over the past 12 months?", and "Q7 How do you expect the number of people unemployed in this country to change over the next 12 months?".

Interestingly, model (1.2) involves variables that can be considered as leads of certain macroeconomic variables (in contrast to the model in equation (1.1)). We argue that these are relevant not only because they capture the household beliefs about the current and future state of the macroeconomy but also because our objective is to estimate the unpredictable component of interest rates.

[28] Depending on the period that we examine, we include a time trend for each country based on the BIC.

[29] The number of country-specific lags for each variable is determined based on the "total consumers" beliefs variables and not allowed to vary across consumer types $\kappa$.

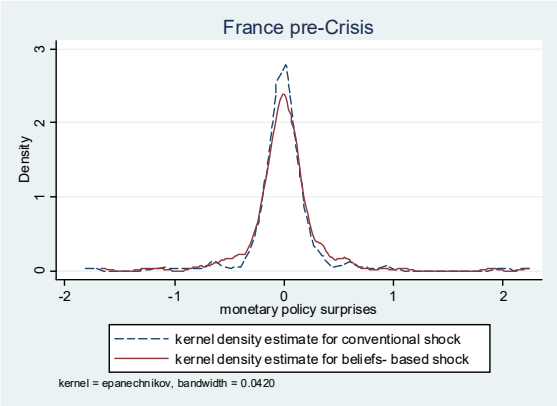


Figure 4: Kernel density estimates for conventional versus beliefs-based (total consumers) monetary surprises

We obtain the beliefs-based monetary policy surprises $\widehat{u}^{whole}_{\kappa,t,i}$ specific to each consumer type $\kappa$ and country $i$ for the whole sample period 1985:1-2015:3, but also estimate equation (1.1) for the period before (1985:1-2008:6) and since (2008:10-2015:3) the Crisis separately to obtain beliefs-based monetary policy surprises for the period before ($\widehat{u}^{pre}_{\kappa,t,i}$) and since ($\widehat{u}^{post}_{\kappa,t,i}$) the recent Crisis.

The time series estimation results of equation (1.2) for three of the fifteen countries (Belgium, France and Ireland) are illustrated in Table 2 for the period before and for the period since the Crisis incidence, with the results for the remaining twelve countries to be made available upon request. We can see in Table 2 that beliefs do a comparable job to macroeconomic variables, results for which were presented in Table 1, in terms of relevance to the interest rate. This should come as no surprise given the close relation between these beliefs and the respective macroeconomic variables we report in Table 3.

Below, we show kernel densities of the common monetary surprise and the type-specific monetary surprise (only for total consumers for the sake of brevity) before and after the incidence of the Crisis for the indicative case of France, noting that these densities resemble those for Germany and most other EZ economies. Comparing Figures 4 and 5, we see that the variance of surprises since the Crisis is larger than before the Crisis.

Finally, before turning to our second-stage estimation, in Table 4 we compare the before and after Crisis distributions of the monetary surprises using a Smirnov-Kolmogorov test for the null of equality of distributions. As we can see, for the great majority of cases we reject the null that these densities are identical before and after the incidence of the recent Crisis.[30]

[30]For Austria and Luxembourg, we cannot reject this null while for Finland we cannot reject it for type-specific monetary surprises.

Table 2: Estimation results for equation (1.2) before and since the Crisis for Belgium, France and Ireland.

| VARIABLES | BEL pre | BEL post | FRA pre | FRA post | IRL pre | IRL post |
|---|---|---|---|---|---|---|
| time trend | -0.004*** | | | -0.005*** | | |
| | (0.001) | | | (0.001) | | |
| $\pi^e$ last 12 months | 0.014*** | 0.006** | -0.007 | 0.002 | -0.121 | 0.001 |
| | (0.005) | (0.003) | (0.009) | (0.002) | (0.085) | (0.002) |
| general situation past 12 months | 0.004 | -0.004 | -0.006 | 0.003 | -0.056 | 0.001 |
| | (0.005) | (0.003) | (0.012) | (0.003) | (0.049) | (0.002) |
| fin. situation last 12 months | 0.027** | -0.004 | -0.013 | 0.005 | -0.073 | 0.004 |
| | (0.012) | (0.009) | (0.027) | (0.005) | (0.052) | (0.004) |
| exp. fin. situation next 12 months | -0.015 | 0.002 | 0.009 | -0.010 | -0.006 | -0.001 |
| | (0.014) | (0.010) | (0.031) | (0.010) | (0.060) | (0.003) |
| exp. general situation next 12 months | -0.005 | 0.004 | -0.005 | -0.002 | 0.008 | -0.004** |
| | (0.006) | (0.003) | (0.009) | (0.003) | (0.029) | (0.002) |
| unem. exp. next 12 months | -0.002 | -0.001 | 0.002 | -0.000 | 0.004 | -0.002 |
| | (0.003) | (0.002) | (0.003) | (0.003) | (0.016) | (0.002) |
| interest rate lags | 0.880*** | 0.861*** | 0.988*** | 0.827*** | 0.718*** | 0.974*** |
| | (0.028) | (0.051) | (0.008) | (0.057) | (0.083) | (0.026) |
| $\pi^e$ last 12 months lags | -0.003 | -0.006** | 0.007 | -0.003 | 0.114 | -0.004** |
| | (0.004) | (0.003) | (0.009) | (0.002) | (0.075) | (0.001) |
| general situation past 12 months lags | -0.008 | 0.001 | 0.013 | -0.004 | 0.113*** | -0.003 |
| | (0.005) | (0.002) | (0.011) | (0.004) | (0.041) | (0.002) |
| fin. situation last 12 months lags | 0.025* | -0.008 | -0.015 | -0.018*** | -0.143*** | -0.007** |
| | (0.014) | (0.009) | (0.022) | (0.007) | (0.045) | (0.003) |
| exp. fin. situation next 12 months lags | -0.015 | 0.035*** | 0.019 | 0.017** | 0.175*** | -0.001 |
| | (0.017) | (0.013) | (0.022) | (0.008) | (0.065) | (0.003) |
| exp. general situation next 12 months lags | 0.002 | -0.007** | 0.001 | -0.006* | -0.041 | 0.001 |
| | (0.008) | (0.003) | (0.008) | (0.003) | (0.031) | (0.002) |
| unem. exp. next 12 months lags | -0.004 | -0.004* | -0.002 | -0.009** | 0.025* | -0.007*** |
| | (0.004) | (0.002) | (0.003) | (0.004) | (0.014) | (0.002) |
| Constant | 1.126*** | 0.048 | -0.020 | 1.671*** | -0.010 | -0.161** |
| | (0.255) | (0.082) | (0.116) | (0.451) | (0.476) | (0.065) |
| Observations | 280 | 78 | 280 | 78 | 276 | 65 |
| $adj.R^2$ | 0.988 | 0.990 | 0.986 | 0.990 | 0.826 | 0.990 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Robust standard errors in parentheses. We identify the type specific monetary policy shock based on individual beliefs regarding the economy based on the information set of consumer type k, at time t in country i. We are estimating equation (1.2), regressing short term interest rates on individual type specific beliefs that contains balances based on the responses to the following questions: Q1 How has the financial situation of your household changed over the last 12 months? Q2 How do you expect the financial position of your household to change over the next 12 months? Q3 How do you think the general economic situation in the country has changed over the past 12months? Q4 How do you expect the general economic situation in this country to develop over the next 12 months? Q5 How do you think that consumer prices have developed over the past 12 months? and Q7 How do you expect the number of people unemployed in this country to change over the next 12 months? We present results for the period before the Crisis1985:1-2008:6 and for the period after the incidence of the Crisis 2008:10-2015:3 for Belgium, France and Ireland.

Table 3: The relation of forward and backward-looking Beliefs variables with macroeconomic variables leads and lags.

| | Belgium pre-Crisis | | | | | | Belgium post-Crisis | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ | $Q7_t$ | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ |
| Indl prod. | -0.114 | -0.264 | 0.354 | 0.164 | 0.603** | 0.547* | 1.209*** | 0.817 | 1.453*** | 0.672 | -1.038** |
| | (0.186) | (0.220) | (0.231) | (0.292) | (0.255) | (0.293) | (0.331) | (0.492) | (0.258) | (0.587) | (0.492) |
| Unem. | -0.502*** | -0.285*** | -1.066*** | -0.669*** | 0.183* | 0.829*** | -0.444*** | -0.617*** | -0.782*** | -0.547*** | -0.657*** |
| | (0.081) | (0.087) | (0.084) | (0.124) | (0.099) | (0.101) | (0.137) | (0.161) | (0.096) | (0.164) | (0.174) |
| CPI excl f&e | 0.234*** | 0.602*** | 0.011 | 0.242*** | 0.169** | -0.143** | 0.511*** | -0.021 | 0.419*** | 0.118 | -0.125 |
| | (0.059) | (0.056) | (0.056) | (0.051) | (0.068) | (0.059) | (0.092) | (0.146) | (0.075) | (0.158) | (0.163) |
| Observations | 275 | 276 | 275 | 276 | 275 | 276 | 72 | 72 | 72 | 72 | 72 |
| adj. $R^2$ | 0.103 | 0.295 | 0.333 | 0.128 | 0.007 | 0.155 | 0.377 | -0.004 | 0.597 | -0.039 | -0.049 |
| | France pre-Crisis | | | | | | France post-Crisis | | | | |
| | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ | $Q7_t$ | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ |
| Indl prod. | -0.458* | -0.999*** | 0.016 | -0.691*** | -0.735** | 1.041*** | 0.830*** | 0.316 | 0.483 | 0.380 | -0.941** |
| | (0.272) | (0.255) | (0.217) | (0.249) | (0.285) | (0.235) | (0.283) | (0.425) | (0.313) | (0.460) | (0.418) |
| Unem. | -0.657*** | -0.604*** | -0.910*** | -0.807*** | -0.183* | 0.926*** | 0.229 | -0.376 | -0.688*** | -0.538 | -0.718*** |
| | (0.099) | (0.075) | (0.079) | (0.068) | (0.098) | (0.059) | (0.219) | (0.333) | (0.209) | (0.376) | (0.265) |
| CPI excl f&e | -0.114* | 0.053 | -0.147*** | 0.145** | 0.443*** | -0.095* | -0.826*** | -0.785*** | -0.097 | -0.213 | -0.385*** |
| | (0.067) | (0.062) | (0.052) | (0.058) | (0.059) | (0.049) | (0.103) | (0.116) | (0.111) | (0.127) | (0.137) |
| Observations | 275 | 276 | 275 | 276 | 275 | 276 | 72 | 72 | 72 | 72 | 72 |
| adj. $R^2$ | 0.142 | 0.153 | 0.398 | 0.312 | 0.174 | 0.402 | 0.484 | 0.325 | 0.344 | 0.079 | 0.007 |
| | Ireland pre-Crisis | | | | | | Ireland post-Crisis | | | | |
| | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ | $Q7_t$ | $Q1_t$ | $Q2_t$ | $Q3_t$ | $Q4_t$ | $Q5_t$ |
| Indl prod. | 0.422* | 0.664** | 0.122 | 0.292 | -0.261 | -0.365 | 2.124*** | 1.181* | 2.010*** | 1.919*** | -0.923** |
| | (0.253) | (0.311) | (0.238) | (0.291) | (0.307) | (0.331) | (0.524) | (0.606) | (0.280) | (0.437) | (0.353) |
| Unem. | -0.648*** | -0.635*** | -0.957*** | -0.828*** | 0.482*** | 0.691*** | -0.190 | 0.180 | -0.638*** | -0.394*** | -0.401** |
| | (0.059) | (0.069) | (0.069) | (0.075) | (0.077) | (0.087) | (0.194) | (0.207) | (0.111) | (0.144) | (0.163) |
| CPI excl f&e | 0.677*** | 0.574*** | 0.401*** | 0.197*** | 0.216*** | -0.382*** | 0.568*** | 0.242** | 0.504*** | 0.345*** | 0.599** |
| | (0.036) | (0.044) | (0.042) | (0.049) | (0.049) | (0.043) | (0.124) | (0.104) | (0.072) | (0.084) | (0.1050 |
| Observations | 275 | 276 | 273 | 276 | 273 | 276 | 72 | 72 | 71 | 72 | 71 |
| adj. $R^2$ | 0.611 | 0.460 | 0.546 | 0.363 | 0.194 | 0.324 | 0.523 | -0.068 | 0.805 | 0.579 | 0.620 |

Notes: We consider six monthly leads or lags depending on whether the beliefs variable to be explained is forward or backward looking. The beliefs variables Q1 to Q7 are as described in section 3.1.2.

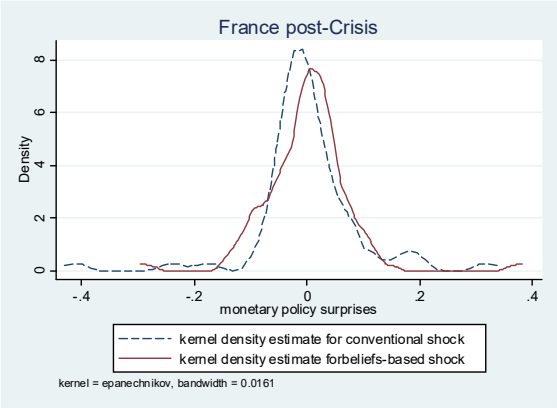


Figure 5: Kernel density estimates for conventional versus beliefs-based (total consumers) monetary surprises

Table 4: Kolmogorov-Smirnov test for equality of distribution functions of pre-Crisis period versus post-Crisis period shocks.

| | common | total con | Low inc | High inc | Low edu | High edu | unem | full-time | 30-49 | 50-64 |
|---|---|---|---|---|---|---|---|---|---|---|
| p-values: | | | | | | | | | | |
| Austria | 0.327 | 0.522 | 0.537 | 0.325 | 0.374 | 0.687 | 0.633 | 0.374 | 0.188 | 0.592 |
| Belgium | 0.010 | 0.001 | 0.004 | 0.005 | 0.002 | 0.003 | 0.003 | 0.002 | 0.002 | 0.000 |
| Estonia | 0.044 | 0.000 | 0.612 | 0.507 | 0.878 | 0.740 | 0.671 | 0.661 | 0.402 | 0.795 |
| Finland | 0.001 | 0.741 | 0.612 | 0.452 | 0.427 | 0.690 | 0.476 | 0.517 | 0.708 | 0.741 |
| France | 0.001 | 0.002 | 0.001 | 0.000 | 0.000 | 0.008 | 0.003 | 0.000 | 0.001 | 0.001 |
| Germany | 0.131 | 0.001 | 0.033 | 0.002 | 0.037 | 0.011 | 0.021 | 0.020 | 0.004 | 0.044 |
| Greece | 0.026 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ireland | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Italy | 0.000 | 0.000 | 0.006 | 0.020 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Luxembourg | 0.725 | 0.593 | 0.659 | 0.799 | 0.855 | 0.637 | 0.317 | 0.829 | 0.838 | 0.958 |
| Netherlands | 0.072 | 0.043 | 0.023 | 0.065 | 0.035 | 0.102 | - | 0.049 | 0.031 | 0.024 |
| Portugal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Slovak Rep. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Slovenia | 0.067 | 0.092 | 0.258 | 0.038 | 0.038 | 0.196 | 0.233 | 0.068 | 0.367 | 0.162 |
| Spain | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Notes: Reported are the KS test p-values.

### 3.2 Estimation of inflation expectations in the second stage

What happens to inflation expectations after an unanticipated change in monetary policy? Our goal will be to answer this question in relation to different types of consumers and different time periods using a panel data model.[31]

We examine the impact of the two different kinds of monetary policy surprises, $\hat{u}$ and $\hat{u}_\kappa$, that we identified in the first stage pertaining to more versus less informed agents for each country $i$, on inflation expectations of total consumers and some basic demographic consumer subgroups. Costs of updating inflation expectations might differ across economic agents and our analysis here allows us to examine this possibility. We will thus consider inflation expectations of consumers grouped based on their income, education, occupation and age.

Curtin (2010) argues that the formation of inflation expectations depends on the ability of individuals to gather and interpret information. Moreover, the economic situation and personal experiences are different over the life cycle. For this reason, we include in our analysis inflation expectations of low and high income consumers, low and high educated consumers, unemployed and full-time workers, and consumers of ages 30 to 49 and ages 50 to 64. Comparing the results between these demographic subgroups we can have a more complete picture of different types of consumers and their ability to interpret the information that they get.

#### 3.2.1 Well informed agents

In general, expectations formation depends on the information set consumers have and on the model of transforming this information into expectations. First, we consider the case where consumers are assumed to have an information set of macroeconomic indicators resembling that of the Central Bank. We consider panel models across 15 European economies and over time, for each consumer type $\kappa$. In this setting, inflation expectations are explained by lagged values of inflation expectations, current and lagged values of actual inflation and by lagged values of monetary policy surprises obtained from equation (1.1), in separate panel regressions for each consumer type $\kappa$ as follows:

[31] We note that we abstract from issues relating to the interplay and close connection between fiscal and monetary policies. This would deserve center stage in a study designed to capture the joint impact of monetary and fiscal policies on inflation expectations by allowing for the interplay between them as well as for unconventional monetary policies that have strong fiscal features.

$$\begin{aligned}\pi^{e}_{\kappa,t,i} \;=\; & \sum_{j=1}^{n^{pre}_{\pi^e}} b_{1\kappa,j}\pi^{e\ pre}_{\kappa,t-j,i} + b_{2\kappa}\pi^{pre}_{t,i} + \sum_{j=1}^{n^{pre}_{\pi}} b_{3\kappa,j}\pi^{pre}_{t-j,i} + \sum_{j=1}^{n^{pre}_{u}} b_{4\kappa,j}\ \widehat{u}^{pre}_{t-j,i} + \\ & \sum_{j=1}^{n^{post}_{\pi^e}} b_{5\kappa,j}\pi^{e\ post}_{\kappa,t-j,i} + b_{6\kappa}\pi^{post}_{t,i} + \sum_{j=1}^{n^{post}_{\pi}} b_{7\kappa,j}\pi^{post}_{t-j,i} + \sum_{j=1}^{n^{post}_{u}} b_{8\kappa,j}\ \widehat{u}^{post}_{t-j,i} + \\ & b_{9\kappa}dpost + b_i + b_t + \varepsilon_{\kappa,t,i}\end{aligned} \tag{2.1}$$

where $\pi^{e}_{\kappa,t,i}$ captures inflation expectations for type $\kappa$ at time $t$ in country $i$, $b_i$ and $b_t$ are country and period dummies respectively, $\pi_t$ is the actual inflation rate at time t, $j$ is the lag length, $\widehat{u}^{pre}$ and $\widehat{u}^{post}$ are the monetary surprises for the period before and since the Crisis respectively obtained in the first stage using equation (1.1), and $\varepsilon_t$ is the error term. Moreover, *dpre* is a dummy variable for the period before the Crisis, and *dpost* is a dummy variable for the period since the Crisis. Superscripts *pre* and *post* indicate that the variables included in the estimation are multiplied with dummies *dpre* and *dpost* respectively. Given the endogenous break analysis, we construct the corresponding dummy variables that define the two regimes, where *dpre* takes value 1 from 1985:1 until 2008:6 and zero otherwise, while *dpost* takes value 1 from 2008:10 until 2015:3 and zero otherwise. We are particularly interested in evaluating how the estimated model in (2.1) differs with the recent Crisis arrival and to achieve this we create interaction terms by multiplying each variable with the pre and post dummies. This will help us assess the role played by the recent Crisis in how inflation expectations are being formed or react to monetary policy changes.

We also estimate a version of this relation which imposes that the estimated coefficients remain the same for the complete period under study rather than allowing them to change before and since the Crisis. In this case, we utilize the monetary policy surprise $\widehat{u}^{whole}$ which was estimated using the whole period time sample for equation (1.1) in the first stage.

The optimal lag length for each demographic subgroup was selected according to the BIC. Our results imply that only one lag of actual inflation should be included in equation (2.1) for both types of surprises and for all demographic subgroups. This indicates that current inflation expectations of all types of consumers are affected only from contemporaneous inflation and the inflation value they observed in the previous month. We do not get this clear result for other variables that we use in equation (2.1). The optimal lag length for monetary policy surprises or inflation expectations differs across the demographic subgroups that we examine.

### 3.2.2 Consumer type-specific surprises

In our second specification, we explain inflation expectations of different types of consumers with lagged values of inflation expectations, contemporaneous and lagged values of actual inflation, and with lagged values of a monetary policy surprise obtained by estimating equation (1.2) which allows for the possibility that consumers might have specific macroeconomic beliefs based on a smaller information set as compared to the policymaker. Thus, we consider a panel model to explain type-specific inflation expectations with lagged values of inflation expectations, current and lagged values of actual inflation and lagged values of monetary policy surprises for each consumer type $\kappa$ separately as follows:

$$\begin{aligned}\pi^{e}_{\kappa,t,i} \quad = \quad & \sum_{j=1}^{n^{pre}_{\pi^e}} b_{1\kappa,j}\pi^{e\ pre}_{\kappa,t-j,i} + b_{2\kappa}\pi^{pre}_{t,i} + \sum_{j=1}^{n^{pre}_{\pi}} b_{3\kappa,j}\pi^{pre}_{t-j,i} + \sum_{j=1}^{n^{pre}_{u}} b_{4\kappa,j}\ \widehat{u}^{pre}_{\kappa,t-j,i} + \\ & \sum_{j=1}^{n^{post}_{\pi^e}} b_{5\kappa,j}\pi^{e\ post}_{\kappa,t-j,i} + b_{6\kappa}\pi^{post}_{t,i} + \sum_{j=1}^{n^{post}_{\pi}} b_{7\kappa,j}\pi^{post}_{t-j,i} + \sum_{j=1}^{n^{post}_{u}} b_{8\kappa,j}\ \widehat{u}^{post}_{\kappa,t-j,i} + \\ & b_{9\kappa}dpost + b_i + b_t + \varepsilon_{\kappa,t,i}\end{aligned} \tag{2.2}$$

where $\pi^{e}_{\kappa,t,i}$ are inflation expectations for type $\kappa$ at time $t$ for country $i$, and $\widehat{u}^{pre}_{\kappa}$ and $\widehat{u}^{post}_{\kappa}$ are type-specific monetary surprises for the period before and since the Crisis respectively, obtained using equation (1.2). Again, we also estimate a version of the above relation which imposes unchanged coefficients for the period under study rather than allowing these to be different before and since the Crisis. In this case, we utilize the type-specific monetary surprise $\widehat{u}^{whole}_{\kappa}$ which was estimated using the whole sample period for equation (1.2) in the first stage.

In the following section, we discuss the results of the second stage estimation. In the first subsection, we discuss results based on the monetary surprise obtained under the assumption that individuals are as informed as the policymaker, while in the second subsection we discuss results based on the monetary surprise obtained under the assumption that individuals are less informed. In all cases, we present and discuss standardized coefficients[32] that enable comparability of the estimates in Tables 5 to 12.

[32] We standardize variables by subtracting the mean and dividing with the standard deviation.

# 4 Estimation Results for the second stage

## 4.1 The case of well informed agents

In Table 6, we show estimation results based on equation (2.1) where we allow the impact of the variables to differ over the two periods. That is, we explain inflation expectations of total consumers and consumer subcategories with lagged values of inflation expectations, current and lagged values of actual inflation and lagged values of the monetary surprise that was constructed in the first stage assuming that individuals are informed about a set of basic variables that describe the macroeconomy. We also estimate an equation that includes the same variables but imposes that the estimated coefficients are unchanged over the period under study. Results for the latter estimation are shown in Table 5. In all cases, we consider panel regressions with time and country effects. Given that the panel models described in sections 3.2.1 and 3.2.2 involve monetary policy surprises which are generated as regressors from a first step regression model, we report Murphy and Topel (1985) corrected standard errors.

As we can see in Table 5 where we report standardized coefficients, an unanticipated change in the interest rate has a negative impact on inflation expectations which is statistically significant at the five percent level for low-income consumers, low-educated consumers and ages 30-49, and significant at the ten percent level for high-income consumers and the unemployed. That is, inflation expectations for these types of consumers decline after an unanticipated increase in interest rates, in line with "textbook" or neo-Keynesian channels.

Moreover, we note that the contemporaneous actual inflation rate has a positive impact on inflation expectations. The significance of the contemporaneous actual inflation rate on inflation expectations of all types of consumers that we are looking at, indicates that consumers obtain information about current inflationary trends from sources other than the official announcements that pertain to previous periods realized values of the series (see Curtin, 2010).

Estimation results of equation (2.1) in Table 6 take into account possible changes in the estimated relationships before and since the Crisis for surprises estimated from equation (1.1) obtained under the assumption that individuals are informed about a variety of variables describing macroeconomic conditions.[33] For the period before the Crisis, the monetary surprise is negatively significant at the 5% significance level for the inflation expectations of low-income consumers, and at the 10% for ages 30-49. For the period since the arrival of the Crisis, the impact of the monetary surprise is negative and statistically significant at the 5% level for high-income and high-educated consumers, for full-

[33] We note that in the period before the crisis, monetary surprises obtained under the assumption that consumers are well informed about a basic set of macroeconomic variables, affect consumers' expectations at time t-1, t-2, and t-3, while since the Crisis only the shock of the previous month affects current inflation expectations.

Table 5: Explaining inflation expectations with the variables in equation (2.1) without regime change.

| VARIABLES | total con | Low inc | High inc | Low edu | High edu | unem | full-time | 30-49 | 50-64 |
|---|---|---|---|---|---|---|---|---|---|
| | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ | $\pi_t^e$ |
| m surp lags | 0.006 | -0.022** | -0.013* | -0.017** | -0.012 | -0.016* | -0.011 | -0.016** | -0.013 |
| | (0.007) | (0.009) | (0.007) | (0.008) | (0.009) | (0.009) | (0.007) | (0.007) | (0.009) |
| $\pi^e$ lags | 0.900*** | 0.865*** | 0.880*** | 0.888*** | 0.889*** | 0.822*** | 0.895*** | 0.896*** | 0.887*** |
| | (0.009) | (0.010) | (0.011) | (0.010) | (0.009) | (0.015) | (0.009) | (0.009) | (0.010) |
| $\pi_t$ | 0.033*** | 0.031*** | 0.032*** | 0.035*** | 0.030*** | 0.039*** | 0.033*** | 0.033*** | 0.034*** |
| | (0.006) | (0.008) | (0.009) | (0.007) | (0.006) | (0.010) | (0.006) | (0.006) | (0.007) |
| lagged $\pi$ | 0.008 | 0.022*** | 0.012 | 0.015** | 0.014** | 0.016 | 0.014** | 0.011* | 0.015** |
| | (0.006) | (0.008) | (0.008) | (0.007) | (0.006) | (0.011) | (0.006) | (0.006) | (0.007) |
| Observations | 3,519 | 3,513 | 3,491 | 3,532 | 3,553 | 3,229 | 3,553 | 3,553 | 3,553 |
| *adj.* $R^2$ | 0.910 | 0.848 | 0.860 | 0.871 | 0.882 | 0.734 | 0.892 | 0.897 | 0.883 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the monetary shock (constructed under the assumption that individuals are well informed), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

time working consumers, and for ages 30-49. These results are in line with individuals with different costs and benefits of obtaining information and updating inflation expectations or with different ability to use information, reacting differently to monetary policy surprises. Consumer types that we would a priori expect to have higher ability to extract signals from a given realization such us high-income, high-educated or full-time working consumers as compared respectively to low-income, low-educated and unemployed consumers, appear to be reacting more to a given monetary policy surprise since the Crisis, a period during which signal extraction is presumably more difficult and the incentive to extract signals is greater. For high-income, high-educated and full-time working consumers we get respective statistically significant estimates (at the five percent level) of $-.033$, $-.031$, and $-.030$ as compared to statistically indistinguishable from zero estimates of $-.022$, $-.010$, and .003 for the low-income, low-educated and unemployed consumers. Moreover, individuals with a longer horizon (ages 30-49) react more to a given monetary policy surprise as compared to individuals with a shorter horizon (ages 50-64). For the period since the Crisis, we get a statistically significant estimate of $-.031$ for ages 30-49 as compared to a statistically indistinguishable from zero $-.009$ for ages 50-64. We also note that those consumer types we would a priori expect to have higher ability to extract signals from a given realization (high-income, high-educated and full-time working) or with a longer horizon (ages 30-49), respond more to monetary surprises since the Crisis

Table 6: Estimation results of equation (2.1) with the monetary policy shock obtained from equation (1.1).

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m surp lags pre-Cr | 0.013 | -0.020** | -0.014 | -0.014 | -0.011 | -0.016 | -0.011 | -0.015* | 0.011 |
| | (0.008) | (0.010) | (0.009) | (0.009) | (0.011) | (0.011) | (0.009) | (0.008) | (0.011) |
| m surp lag after | -0.014 | -0.022 | -0.033** | -0.010 | -0.031** | 0.003 | -0.030** | -0.031** | -0.009 |
| | (0.013) | (0.016) | (0.017) | (0.016) | (0.013) | (0.020) | (0.013) | (0.014) | (0.014) |
| $\pi^e$ lags pre-Cr | 0.847*** | 0.845*** | 0.796*** | 0.847*** | 0.836*** | 0.791*** | 0.831*** | 0.825*** | 0.826*** |
| | (0.009) | (0.012) | (0.010) | (0.010) | (0.010) | (0.016) | (0.010) | (0.009) | (0.010) |
| $\pi^e$ lags after | 0.951*** | 0.872*** | 0.955*** | 0.888*** | 0.951*** | 0.861*** | 0.956*** | 0.963*** | 0.962*** |
| | (0.014) | (0.018) | (0.022) | (0.018) | (0.016) | (0.029) | (0.016) | (0.016) | (0.017) |
| $\pi_t$ pre-Cr | 0.019*** | 0.024** | 0.016** | 0.024*** | 0.011 | 0.024** | 0.019*** | 0.020*** | 0.018** |
| | (0.006) | (0.010) | (0.007) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ after | 0.041*** | 0.031** | 0.035 | 0.037*** | 0.038*** | 0.046** | 0.036*** | 0.033*** | 0.047*** |
| | (0.011) | (0.013) | (0.021) | (0.013) | (0.012) | (0.021) | (0.012) | (0.013) | (0.014) |
| lagged $\pi$ pre-Cr | 0.002 | 0.011 | 0.008 | 0.002 | 0.006 | 0.005 | 0.007 | 0.005 | 0.003 |
| | (0.007) | (0.010) | (0.008) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.008) |
| lagged $\pi$ after | 0.006 | 0.021 | -0.000 | 0.018 | 0.001 | 0.020 | 0.002 | 0.004 | 0.019 |
| | (0.011) | (0.014) | (0.019) | (0.014) | (0.012) | (0.022) | (0.012) | (0.012) | (0.013) |
| after dummy | -0.408*** | -0.409*** | -0.457*** | -0.498*** | -0.427*** | -0.358*** | -0.431*** | -0.426*** | -0.424*** |
| | (0.051) | (0.066) | (0.075) | (0.066) | (0.054) | (0.082) | (0.051) | (0.055) | (0.057) |
| Observations | 3,348 | 3,364 | 3,364 | 3,405 | 3,405 | 3,065 | 3,440 | 3,405 | 3,380 |
| *adj.* $R^2$ | 0.911 | 0.850 | 0.864 | 0.875 | 0.884 | 0.733 | 0.895 | 0.898 | 0.886 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the monetary shock (constructed under the assumption that individuals are well informed), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

as compared to before. Finally, we note that looking only at the average effect on total consumers does not allow us to capture this impact which appears to exhibit meaninful heterogeneity across different types of consumers since the Crisis.

The contemporaneous actual inflation rate is positively related with inflation expectations before and since the Crisis. We note, however, that its impact is statistically significant for more (all) consumer subgroups and with much higher coefficient estimates for the period since the Crisis as compared to before the Crisis. This indicates that individuals rely more on their own information about inflation from their daily transactions since the Crisis as compared to before. We also note that the contemporaneous actual inflation rate has a significant positive impact on inflation expectations that is higher than that for the lagged inflation rate. The inflation realization of the previous month typically has no statistically significant impact on inflation expectations, implying that consumers did not rely on official announcements about inflation. Given the above results regarding the effect of current inflation and lagged inflation on inflation expectations, we infer that consumers obtain information about current inflationary trends from sources other than the official announcements that pertain to previous periods realized values of the series (see Curtin, 2010). In fact, consumers appear to rely more on their own contemporaneous information about inflation based on their daily transactions rather than on official announcements and publicly available information from previous periods e.g. regarding previous values of the inflation series.

Next, we present results from the second stage regression using the monetary surprise that was constructed in the first stage allowing for consumers to be less informed than the policy maker.

## 4.2 Considering consumer type-specific surprises

In Tables 7 and 8, we show estimation results based on equation (2.2). As we can see, inflation expectations rise in response to unanticipated increases in the interest rate when the latter are obtained by allowing the consumers' information set to be reflected in their beliefs about the economy that are potentially different than those of the policymaker. More specifically, in Table 7 where we consider the whole period under study without allowing for a break, the impact of such type-specific monetary surprises is significantly positive for all consumer types except for the unemployed. For example, a one standard deviation unanticipated increase in the interest rate leads to a .011 standard deviation increase in the inflation expectations of total consumers. For total consumers, high-income consumers, high-educated consumers, full-time working consumers and ages 50 to 64 this is statistically significant at the five percent level, and for low-income consumers, low-educated consumers and ages 30 to 49 this is significant at the ten percent level.

Allowing for the impact of the surprise to be different before as compared to since the Crisis as in

Table 7: Explaining inflation expectations with the variables in equation (2.2) without regime change.

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m surp lag | 0.011** | 0.013* | 0.011** | 0.011* | 0.017** | -0.000 | 0.013** | 0.009* | 0.015** |
| | (0.004) | (0.007) | (0.006) | (0.006) | (0.007) | (0.007) | (0.005) | (0.005) | (0.007) |
| $\pi^e$ lags | 0.909*** | 0.879*** | 0.887*** | 0.910*** | 0.899*** | 0.864*** | 0.905*** | 0.910*** | 0.904*** |
| | (0.008) | (0.012) | (0.011) | (0.009) | (0.009) | (0.013) | (0.009) | (0.009) | (0.009) |
| $\pi_t$ | 0.034*** | 0.031*** | 0.031*** | 0.033*** | 0.031*** | 0.033*** | 0.031*** | 0.030*** | 0.033*** |
| | (0.006) | (0.007) | (0.008) | (0.007) | (0.006) | (0.009) | (0.006) | (0.006) | (0.006) |
| lagged $\pi$ | 0.010* | 0.021*** | 0.012 | 0.013* | 0.015** | 0.020** | 0.013** | 0.011* | 0.013** |
| | (0.005) | (0.007) | (0.008) | (0.007) | (0.006) | (0.010) | (0.006) | (0.006) | (0.006) |
| Observations | 4,082 | 3,780 | 3,796 | 3,880 | 3,858 | 3,444 | 3,920 | 3,911 | 3,927 |
| *adj.* $R^2$ | 0.911 | 0.855 | 0.863 | 0.884 | 0.879 | 0.761 | 0.889 | 0.900 | 0.891 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the type specific monetary shock (constructed based on consumers beliefs), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

regression equation (2.2), we can see in Table 8 that the impact of these type-specific surprises is again estimated to be positive before the arrival of the Crisis. This positive impact of the monetary surprises before the Crisis, is significant at the five percent level for total consumers, high-income consumers and consumers with ages 50 to 64, and at the ten percent level for low and high educated consumers and for full-time working consumers. A one standard deviation unanticipated increase in the interest rate leads to a .011 standard deviation increase in the inflation expectations of total consumers. By contrast, since the Crisis this estimated impact is no longer positive, turning negative and statistically significant for high-income consumers and those with ages 30-49 at the one percent significance level, and for total consumers, low income consumers, high-educated consumers, full-time working consumers and those with ages 50-64 at the five percent significance level. For total consumers, a one standard deviation unanticipated increase in the interest rate leads to a .032 standard deviation fall in inflation expectations.

We note again that consumer types we would a priory expect to have higher ability to extract signals from a given realization such us high-income, high-educated and full-time working consumers or have a longer horizon (ages 30-49), react more to a given monetary policy surprise as compared to low-income, low-educated, unemployed, and older consumers (ages 50-64) since the Crisis, a period during which signal extraction is presumably more difficult and the incentive to extract signals is

Table 8: Estimation results of equation (2.2) with the monetary policy shock obtained from equation (1.2).

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m surp lag pre-Cr | 0.011** | 0.014 | 0.013** | 0.012* | 0.014* | -0.001 | 0.012* | 0.007 | 0.016** |
| | (0.005) | (0.009) | (0.006) | (0.007) | (0.008) | (0.008) | (0.006) | (0.006) | (0.008) |
| m surp lag after | -0.032** | -0.037** | -0.049*** | -0.015 | -0.031** | -0.006 | -0.037** | -0.050*** | -0.035** |
| | (0.014) | (0.016) | (0.018) | (0.016) | (0.014) | (0.024) | (0.015) | (0.015) | (0.014) |
| $\pi^e$ lags pre-Cr | 0.856*** | 0.876*** | 0.826*** | 0.897*** | 0.852*** | 0.861*** | 0.866*** | 0.864*** | 0.870*** |
| | (0.008) | (0.014) | (0.012) | (0.010) | (0.010) | (0.013) | (0.010) | (0.010) | (0.010) |
| $\pi^e$ lags after | 0.958*** | 0.835*** | 0.932*** | 0.851*** | 0.935*** | 0.832*** | 0.924*** | 0.931*** | 0.920*** |
| | (0.014) | (0.017) | (0.021) | (0.017) | (0.015) | (0.028) | (0.015) | (0.015) | (0.016) |
| $\pi_t$ pre-Cr | 0.024*** | 0.025*** | 0.018** | 0.024*** | 0.015** | 0.015 | 0.018*** | 0.020*** | 0.022*** |
| | (0.006) | (0.009) | (0.007) | (0.008) | (0.007) | (0.009) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ after | 0.042*** | 0.029** | 0.035* | 0.037*** | 0.039*** | 0.044** | 0.037*** | 0.035*** | 0.043*** |
| | (0.011) | (0.012) | (0.021) | (0.012) | (0.011) | (0.021) | (0.012) | (0.012) | (0.013) |
| lagged $\pi$ pre-Cr | 0.006 | 0.012 | 0.009 | 0.002 | 0.009 | 0.012 | 0.007 | 0.006 | 0.004 |
| | (0.006) | (0.009) | (0.007) | (0.007) | (0.007) | (0.010) | (0.007) | (0.006) | (0.007) |
| lagged $\pi$ after | 0.007 | 0.021 | -0.000 | 0.018 | 0.003 | 0.018 | 0.005 | 0.006 | 0.013 |
| | (0.011) | (0.014) | (0.019) | (0.013) | (0.012) | (0.021) | (0.011) | (0.012) | (0.013) |
| after dummy | -0.460*** | -0.382*** | -0.455*** | -0.509*** | -0.450*** | -0.388*** | -0.428*** | -0.414*** | -0.422*** |
| | (0.053) | (0.065) | (0.076) | (0.063) | (0.055) | (0.080) | (0.051) | (0.056) | (0.056) |
| Observations | 3,940 | 3,662 | 3,678 | 3,762 | 3,740 | 3,309 | 3,815 | 3,750 | 3,765 |
| *adj.* $R^2$ | 0.913 | 0.859 | 0.866 | 0.887 | 0.882 | 0.765 | 0.891 | 0.902 | 0.893 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of type specific monetary shock (constructed based on consumers beliefs), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

greater. Notably, for high-educated and full-time working consumers we get statistically significant estimates of $-.031$ and $-.037$ respectively as compared to statistically indistinguishable from zero estimates of $-.015$ and .006 for low-educated and unemployed consumers.

*Robustness Analysis*

In this section, we evaluate the robustness of the above empirical results. First, we estimate the monetary surprise of the more informed individuals using a recursive Vector Autoregressive (VAR) model. Our VAR models employ the same variables as in equations (1.1) or (1.2) to compute VAR-implied monetary surprises.[34] Extracting the monetary surprises from the estimated interest rate equation of the VAR we then proceed to the second stage panel regression models and re-estimate models (2.1) and (2.2) as above, correcting the standard errors for the new generated regressor and estimating the optimal lag length with information criteria and LR tests.

Re-estimating model (2.1), the VAR-implied monetary policy surprise in the pre-Crisis period still yields a negative significant impact for low income consumers and those with ages 30-49 as shown in Table 9 as was the case for Table 6. Since the Crisis, high income consumers, high educated consumers, full-time working consumers and ages 30-49 exhibit a significant negative impact in Table 9 as was again the case in Table 6. However, this impact is bigger than was the case in Table 6. In addition, as we show in Table 9, a significant negative impact is now present for low income consumers at the ten percent level. We note yet again that since the Crisis, a period during which signal extraction is presumably more difficult and the incentive to extract signals greater, the impact of the monetary policy surprise is once again greater for high-income, high-educated, full-time working consumers and those with ages 30-49, as compared respectively to low-income, low-educated, unemployed consumers and those with ages 50-64. We also find again that those consumer types we would a priori expect to have higher ability to extract signals from a given realization (high-income, high-educated and full-time working) or with a longer horizon (ages 30-49), respond more to monetary surprises since the Crisis as compared to before. For high-educated and full-time working consumers in particular, we get respective significant estimates of $-.037$ and $-.046$ as compared to $-.022$ and $-.010$ for low-educated and unemployed consumers which are both statistically indistinguishable from zero.

Estimation results based on equation (2.2) are shown in Table 10. The beliefs-based VAR-implied

[34] We determine the lag length of the VAR using the Hannan and Quinn (HQ) criterion. The HQ estimated lag length is also similar to that of the AIC. The results in the second stage regressions are qualitatively the same whether we use the monetary surprise extracted from the VAR with the HQ or the AIC criteria. We report the HQ criterion results because this has a stronger penalty function and thus avoids the overparameterized VAR due to the AIC. This is a relevant issue especially for the post Crisis regime that has a smaller number of observations. Note that the BIC in the VAR model employs a strong penalty function and in general imposes one lag for all variables across equations and this may yield residuals which cannot be treated as unanticipated shocks in the VAR.

Table 9: Estimation results of equation (2.1) with VAR-implied shock shock.

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m.surp lags pre-Cr | -0.001 | -0.018* | -0.010 | -0.011 | -0.007 | -0.011 | -0.008 | -0.013* | 0.007 |
| | (0.009) | (0.009) | (0.009) | (0.009) | (0.011) | (0.012) | (0.007) | (0.008) | (0.011) |
| m.surp lags after | -0.030 | -0.034* | -0.055** | -0.022 | -0.037** | -0.010 | -0.046** | -0.044** | -0.028 |
| | (0.018) | (0.018) | (0.025) | (0.020) | (0.018) | (0.023) | (0.018) | (0.019) | (0.019) |
| $\pi^e$ lags pre-Cr | 0.846*** | 0.846*** | 0.796*** | 0.849*** | 0.836*** | 0.791*** | 0.834*** | 0.826*** | 0.827*** |
| | (0.009) | (0.012) | (0.010) | (0.010) | (0.010) | (0.017) | (0.010) | (0.009) | (0.010) |
| $\pi^e$ lags after | 0.950*** | 0.872*** | 0.958*** | 0.889*** | 0.950*** | 0.863*** | 0.961*** | 0.964*** | 0.965*** |
| | (0.014) | (0.018) | (0.022) | (0.018) | (0.016) | (0.029) | (0.016) | (0.016) | (0.017) |
| $\pi_t$ pre-Cr | 0.019*** | 0.026*** | 0.017** | 0.027*** | 0.013* | 0.024** | 0.019*** | 0.021*** | 0.019*** |
| | (0.006) | (0.010) | (0.007) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ after | 0.040*** | 0.031** | 0.035 | 0.037*** | 0.038*** | 0.045** | 0.038*** | 0.034*** | 0.046*** |
| | (0.011) | (0.013) | (0.021) | (0.013) | (0.011) | (0.021) | (0.012) | (0.013) | (0.013) |
| lagged $\pi$ pre-Cr | 0.004 | 0.011 | 0.009 | 0.003 | 0.008 | 0.010 | 0.008 | 0.005 | 0.005 |
| | (0.007) | (0.010) | (0.008) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.007) |
| lagged $\pi$ after | 0.006 | 0.021 | -0.001 | 0.018 | 0.002 | 0.019 | 0.004 | 0.004 | 0.019 |
| | (0.011) | (0.014) | (0.019) | (0.014) | (0.012) | (0.021) | (0.012) | (0.012) | (0.013) |
| after dummy | -0.419*** | -0.409*** | -0.460*** | -0.496*** | -0.429*** | -0.362*** | -0.439*** | -0.428*** | -0.425*** |
| | (0.051) | (0.065) | (0.075) | (0.066) | (0.054) | (0.082) | (0.051) | (0.056) | (0.057) |
| Observations | 3,367 | 3,356 | 3,356 | 3,397 | 3,397 | 3,059 | 3,397 | 3,397 | 3,372 |
| $adj.R^2$ | 0.913 | 0.851 | 0.864 | 0.875 | 0.884 | 0.734 | 0.894 | 0.898 | 0.887 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the monetary shock (constructed under the assumption that individuals are well informed), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

Table 10: Estimation results of equation (2.2) with VAR-implied shock based on consumers stated beliefs.

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m surp lag pre-Cr | 0.021*** | 0.017* | -0.004 | 0.010 | 0.022*** | -0.003 | 0.014* | 0.020*** | 0.015* |
| | (0.006) | (0.010) | (0.008) | (0.008) | (0.008) | (0.012) | (0.008) | (0.007) | (0.008) |
| m surp lag after | 0.005 | 0.003 | 0.033* | -0.001 | -0.010 | 0.015 | 0.010 | 0.001 | 0.005 |
| | (0.011) | (0.013) | (0.020) | (0.012) | (0.012) | (0.016) | (0.011) | (0.012) | (0.012) |
| $\pi^e$ lags pre-Cr | 0.855*** | 0.876*** | 0.824*** | 0.896*** | 0.850*** | 0.874*** | 0.862*** | 0.862*** | 0.867*** |
| | (0.008) | (0.014) | (0.012) | (0.010) | (0.010) | (0.013) | (0.010) | (0.010) | (0.010) |
| $\pi^e$ lags after | 0.960*** | 0.836*** | 0.939*** | 0.851*** | 0.940*** | 0.827*** | 0.933*** | 0.934*** | 0.927*** |
| | (0.014) | (0.017) | (0.021) | (0.017) | (0.015) | (0.023) | (0.015) | (0.015) | (0.016) |
| $\pi_t$ pre-Cr | 0.024*** | 0.027*** | 0.018** | 0.025*** | 0.017** | 0.015 | 0.019*** | 0.021*** | 0.023*** |
| | (0.006) | (0.009) | (0.007) | (0.007) | (0.007) | (0.010) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ after | 0.042*** | 0.031** | 0.037* | 0.037*** | 0.039*** | 0.046*** | 0.038*** | 0.035*** | 0.045*** |
| | (0.011) | (0.012) | (0.021) | (0.012) | (0.012) | (0.016) | (0.012) | (0.013) | (0.013) |
| lagged $\pi$ pre-Cr | 0.006 | 0.013 | 0.010 | 0.003 | 0.009 | 0.011 | 0.006 | 0.007 | 0.004 |
| | (0.006) | (0.009) | (0.007) | (0.007) | (0.007) | (0.010) | (0.007) | (0.006) | (0.007) |
| lagged $\pi$ after | 0.005 | 0.019 | -0.003 | 0.018 | 0.001 | 0.023 | 0.004 | 0.004 | 0.011 |
| | (0.011) | (0.014) | (0.018) | (0.013) | (0.012) | (0.020) | (0.012) | (0.012) | (0.013) |
| after dummy | -0.481*** | -0.399*** | -0.482*** | -0.514*** | -0.467*** | -0.407*** | -0.453*** | -0.444*** | -0.435*** |
| | (0.052) | (0.064) | (0.074) | (0.063) | (0.054) | (0.077) | (0.050) | (0.055) | (0.055) |
| Observations | 3,951 | 3,677 | 3,693 | 3,777 | 3,755 | 3,193 | 3,831 | 3,765 | 3,780 |
| $adj.R^2$ | 0.914 | 0.860 | 0.867 | 0.888 | 0.883 | 0.784 | 0.892 | 0.902 | 0.894 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the beliefs-based monetary shock, on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

monetary policy surprise still yields a positive significant impact for most groups of consumers in the pre Crisis period. Namely, for total consumers, high-educated consumers and ages 30-49 at the one percent level of statistical significance, and for low-income, full-time workers and ages 50-64 at the ten percent level. For the period since the Crisis, the VAR-implied monetary surprise has an impact which is insignificantly different from zero, except for the inflation expectations of high income consumers in which case it has a marginally significant impact. This lack of significance since the Crisis for the VAR-implied monetary surprise might be an artifact of the relatively smaller time-series available since the Crisis in conjuction with the more demanding nature of the VARs (in terms of parameters) in the first-stage.[35] We note that the first-stage VAR based on type-specific beliefs involves more variables than the corresponding VARs for the case of well-informed consumers, which might explain why we get significance in the latter case but not in the former.

*Monetary surprises cleansed from inflation expectations lags in the first stage*

The second robustness check is to consider in the second stage beliefs-based monetary surprises that have been cleansed from the effect of inflation expectations in the first stage. That is, we augment the information set of the single equation model in (1.1) and (1.2) to add inflation expectations lags[36], and then consider the impact of the resulting monetary surprises in the second stage regression equations (2.1) or (2.2).[37]

Re-estimating all the models in the first and second stages, we find that adding inflation expectations lags in the first stage single equation models to obtain monetary policy surprises pertaining to well informed individuals, our second-stage results regarding the impact of these surprises on inflation expectations are not much changed as shown in Table 11. Pre-Crisis, we still get a negative significant impact for low-income consumers and ages 30-49 as in Table 6. In addition, we get significant negative impact for high-income consumers at the five percent significance level and marginally significant positive impact for total consumers. Since the Crisis, as in Table 6, we get negative significant impact for high-income, high-educated, full-time working consumers and those with ages 30-49 which is greater than the respective impact for the low-income, low-educated, unemployed and older consumers. Unlike in Table 6, we now also get a marginally significant negative impact for low-income consumers since the Crisis. Notably, once again, we obtain statistically significant estimates equal to $-.031$ for both high-educated and full-time working consumers as

[35] This results in less precise estimates of the monetary shocks as compared to estimates obtained from single equation dynamic models which are more parsimonious relative to the overparameterized VARs. As a result, this shock which is generated with higher imprecision in the first stage VARs, is associated with lower significance when it enters as a regressor in the second stage.

[36] As monetary policy plausibly takes into account inflation expectations when setting interest rates, we find it useful to include this variable in the policy reaction function.

[37] As for our baseline results, we perform a Likelihood Ratio test with the number of lags determined by the BIC.

Table 11: Estimation results of equation (2.1) with shock based on augmented form of equation (1.1).

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m.surp lags pre-Cr | 0.014* | -0.017* | -0.018** | -0.015 | -0.012 | -0.011 | -0.011 | -0.017** | 0.011 |
| | (0.008) | (0.011) | (0.009) | (0.010) | (0.010) | (0.012) | (0.010) | (0.008) | (0.010) |
| m.surp lags after | -0.015 | -0.025* | -0.038** | -0.009 | -0.031** | 0.001 | -0.031** | -0.023* | -0.018 |
| | (0.012) | (0.014) | (0.018) | (0.015) | (0.013) | (0.019) | (0.013) | (0.013) | (0.013) |
| $\pi^e$ lags pre-Cr | 0.846*** | 0.844*** | 0.784*** | 0.842*** | 0.831*** | 0.791*** | 0.830*** | 0.820*** | 0.827*** |
| | (0.009) | (0.012) | (0.010) | (0.010) | (0.010) | (0.016) | (0.010) | (0.009) | (0.010) |
| $\pi^e$ lags after | 0.950*** | 0.870*** | 0.949*** | 0.887*** | 0.946*** | 0.862*** | 0.953*** | 0.966*** | 0.961*** |
| | (0.014) | (0.018) | (0.021) | (0.018) | (0.016) | (0.029) | (0.016) | (0.016) | (0.017) |
| $\pi_t$ pre-Cr | 0.019*** | 0.024** | 0.017** | 0.024*** | 0.011 | 0.024** | 0.018*** | 0.020*** | 0.018** |
| | (0.006) | (0.010) | (0.007) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ after | 0.041*** | 0.030** | 0.034 | 0.037*** | 0.038*** | 0.046** | 0.036*** | 0.035*** | 0.046*** |
| | (0.011) | (0.013) | (0.021) | (0.013) | (0.011) | (0.021) | (0.012) | (0.013) | (0.014) |
| lagged $\pi$ pre-Cr | 0.002 | 0.011 | 0.009 | 0.001 | 0.007 | 0.006 | 0.006 | 0.003 | 0.002 |
| | (0.007) | (0.010) | (0.008) | (0.008) | (0.007) | (0.011) | (0.007) | (0.007) | (0.008) |
| lagged $\pi$ after | 0.006 | 0.020 | -0.001 | 0.019 | 0.001 | 0.020 | 0.002 | 0.007 | 0.019 |
| | (0.011) | (0.014) | (0.019) | (0.014) | (0.012) | (0.022) | (0.012) | (0.012) | (0.013) |
| after dummy | -0.407*** | -0.405*** | -0.448*** | -0.493*** | -0.421*** | -0.355*** | -0.427*** | -0.410*** | -0.418*** |
| | (0.051) | (0.065) | (0.075) | (0.065) | (0.054) | (0.082) | (0.051) | (0.055) | (0.057) |
| Observations | 3,342 | 3,357 | 3,357 | 3,398 | 3,398 | 3,060 | 3,432 | 3,372 | 3,372 |
| $adj.R^2$ | 0.911 | 0.850 | 0.863 | 0.874 | 0.884 | 0.732 | 0.895 | 0.897 | 0.886 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the monetary shock (constructed under the assumption that individuals are well informed), on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

Table 12: Estimation results of equation (2.2) with shock based on augmented form of equation (1.2).

| VARIABLES | total con $\pi_t^e$ | Low inc $\pi_t^e$ | High inc $\pi_t^e$ | Low edu $\pi_t^e$ | High edu $\pi_t^e$ | unem $\pi_t^e$ | full-time $\pi_t^e$ | 30-49 $\pi_t^e$ | 50-64 $\pi_t^e$ |
|---|---|---|---|---|---|---|---|---|---|
| m surp lag pre-Cr | 0.013** | 0.015* | 0.009 | 0.012 | 0.017** | -0.007 | 0.013** | 0.005 | 0.018** |
| | (0.005) | (0.009) | (0.006) | (0.007) | (0.009) | (0.008) | (0.006) | (0.006) | (0.008) |
| m surp lag after | -0.027** | -0.050*** | -0.053*** | -0.006 | -0.035*** | 0.011 | -0.028** | -0.044*** | -0.023* |
| | (0.012) | (0.015) | (0.015) | (0.014) | (0.012) | (0.022) | (0.013) | (0.013) | (0.013) |
| $\pi^e$ lags pre-Cr | 0.857*** | 0.877*** | 0.826*** | 0.897*** | 0.854*** | 0.861*** | 0.867*** | 0.864*** | 0.871*** |
| | (0.008) | (0.014) | (0.012) | (0.010) | (0.010) | (0.013) | (0.010) | (0.010) | (0.010) |
| $\pi^e$ lags after | 0.958*** | 0.836*** | 0.932*** | 0.851*** | 0.934*** | 0.831*** | 0.924*** | 0.930*** | 0.919*** |
| | (0.014) | (0.017) | (0.021) | (0.017) | (0.015) | (0.028) | (0.015) | (0.015) | (0.016) |
| $\pi_t$ pre-Cr | 0.024*** | 0.025*** | 0.018** | 0.024*** | 0.015** | 0.015 | 0.018*** | 0.020*** | 0.022*** |
| | (0.006) | (0.009) | (0.007) | (0.008) | (0.007) | (0.009) | (0.007) | (0.007) | (0.007) |
| $\pi_t$ infl. after | 0.042*** | 0.028** | 0.035* | 0.037*** | 0.039*** | 0.045** | 0.037*** | 0.034*** | 0.044*** |
| | (0.011) | (0.012) | (0.021) | (0.012) | (0.011) | (0.021) | (0.012) | (0.013) | (0.013) |
| lagged $\pi$ pre-Cr | 0.006 | 0.013 | 0.010 | 0.003 | 0.010 | 0.011 | 0.007 | 0.006 | 0.005 |
| | (0.006) | (0.009) | (0.007) | (0.007) | (0.007) | (0.010) | (0.007) | (0.006) | (0.007) |
| lagged $\pi$ after | 0.007 | 0.022 | 0.000 | 0.017 | 0.003 | 0.017 | 0.005 | 0.006 | 0.012 |
| | (0.011) | (0.014) | (0.019) | (0.013) | (0.012) | (0.021) | (0.012) | (0.012) | (0.013) |
| after dummy | -0.461*** | -0.379*** | -0.451*** | -0.512*** | -0.446*** | -0.391*** | -0.428*** | -0.418*** | -0.424*** |
| | (0.053) | (0.065) | (0.075) | (0.063) | (0.055) | (0.080) | (0.051) | (0.055) | (0.056) |
| Observations | 3,941 | 3,663 | 3,679 | 3,763 | 3,741 | 3,310 | 3,816 | 3,751 | 3,766 |
| *adj.* $R^2$ | 0.913 | 0.859 | 0.866 | 0.887 | 0.882 | 0.765 | 0.891 | 0.902 | 0.893 |

Notes: *** p<0.01, ** p<0.05, * p<0.1 Murphy-Topel standard errors in parentheses. All reported coefficients are standardized. We consider inflation expectations of total consumers and demographic subgroups of consumers which are: low and high income, low and high educated, unemployed and full time workers, ages between 30 - 49 and 50 - 64 on lagged values of the beliefs-based monetary shock, on lagged values of inflation expectations and on contemporaneous and lagged values of actual inflation for the period 1985:1-2015:3. We include yearly dummies and country dummies.

compared to statistically indistinguishable from zero estimates of −.009 and .001 for low-educated and unemployed consumers respectively.

In Table 12, we consider beliefs-based surprises. As we can see, the impact of these monetary surprises is once again estimated to be positive before the arrival of the Crisis. This impact is statistically significant at the five percent level for total consumers, high educated consumers, full-time working consumers and those with ages 50 to 64, and at the ten percent level for low-income consumers. As compared to the results in Table 8, high-income and low-educated consumers are no longer associated with a positive significant impact before the Crisis while low-income consumers now are. Since the Crisis, the estimated impact of monetary surprises on inflation expectations shown in Table 12 turns negative and statistically significant at the one percent for low-income, high-income, high-educated consumers and those with ages 30-49, at the five percent level for total consumers and full-time working consumers, and at the ten percent level for ages 50-64. These results exactly resemble those in Table 8. Once again, as in Tables 6, 8, 9 and 11, since the Crisis the significant impact of −.035 for the high-educated is notably greater in absolute terms than the statistically indistinguishable from zero impact of −.006 for the low-educated. The impact for full-time working consumers and ages 30-49 is also respectively greater than for the unemployed and ages 50-64 as was the case before, while the impact for high-income and low-income consumers is comparable in this case.

One robust finding of our analysis of inflation expectations formation, is that contemporaneous actual inflation rate is positively related with inflation expectations, especially so in the period since the Crisis. In addition, the inflation realization of the previous month has a lower and typically insignificant impact on inflation expectations. These results taken together imply that, in forming inflation expectations, consumers rely more on their own contemporaneous information about inflation based on their daily transactions rather than on official announcements about past values of inflation.

## 5 Conclusion

A novel feature of our approach is the estimation of monetary policy surprises based on changes in monetary policy that were unanticipated by consumers as per their stated beliefs about the economy. We have shown that such monetary policy surprises can have different impact on inflation expectations as compared to those obtained under the assumption that consumers are well informed about a set of macroeconomic variables that describe the state of the economy. More specifically, relaxing the assumption of well-informed consumers and focusing on their stated beliefs about the economy so that they may be surprised by a broader set of monetary policy changes, we showed

that consumers often lower their inflation expectations in response to lower interest rates. This is consistent with imperfect information theoretical settings where consumers learn from unanticipated interest rate cuts that the policymaker, based on her superior information set, is expecting a fall in inflation so that lowering the policy rate ends up lowering their inflation expectations.

Instead, considering monetary policy surprises under the assumption that individuals have information about the macroeconomy comparable to that of the policymaker, the impact of unanticipated changes in short-term interest rates on inflation expectations is often negative. This reflects textbook macroeconomic channels where a cut in short-term interest rates boosts economic activity so that inflation and inflation expectations increase.

Furthermore, the impact of monetary policy surprises based on the economic beliefs of each consumer type changes sign from positive to negative in the period since the recent Crisis. Such monetary policy surprises often affect inflation expectations negatively since the Crisis, consistent with the incentive to pay attention to the macroeconomy being greater since the Crisis inducing individuals to become rationally attentive so that their response to policy surprises becomes consistent with them observing the full set of macroeconomic variables histories.

When we allow the estimated relationships to differ before and since the Crisis, our results shed particular light on differences in inflation expectations formation across consumer types, irrespective of whether we consider conventional or beliefs-based surprises. Consumer types that we would a priori expect to have higher ability to extract signals from a given realization (such us the high-educated ones) or with a longer horizon (ages 30-49), typically react more to monetary policy surprises than those with potentially lower ability to extract signals (low-educated) or with a shorter horizon (ages 50-64) in the period since the Crisis, a period during which signal extraction is presumably more difficult and the incentive to extract information greater. Moreover, we find that they react more in the period since the Crisis as compared to before and in a manner consistent with them being well informed in this case.

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