Effects of unconventional monetary policy on disaggregate Euro Area consumer inflation expectations

By Vlad Skovorodov *

Based on a time-varying factor-augmented vector autoregression, I find that the responses of inflation expectations in the Euro Area have become weaker in magnitude and less dispersed over time. The responses of inflation expectations after 2012 take more time to react (more than 6 quarters compared to 4 before 2008) and are weaker, on average, in the long run than the responses before 2008. Heterogeneity in responses of different EA countries and across various demographics is substantially reduced after 2012 with the implementation of unconventional monetary policy.
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Since 1999, the European Central Bank (ECB) has overseen the implementation of a single monetary policy (MP) over the Economic and Monetary Union (EMU), composed of a group of economies which are culturally, historically and demographically heterogeneous. One of the channels of monetary policy transmission goes through forming consumer expectations of future prices.

This article is motivated by the need for further research on inflation expectations, which is raised by the literature on subdued behaviour of inflation in the recent decade in the Euro Area (EA) (Coibion and Gorodnichenko, 2015*a*; Coibion, Gorodnichenko and Kamdar, 2017; Blanchard, Cerutti and Summers, 2015; Miles et al., 2017*a*). Understanding responses of inflation expectations is important policy task because its directly linked to changes in demand as demonstrated by Duca, Kenny and Reuter (2018). They document a positive relationship between consumer inflation expectations and readiness to spend in EA. The impact is found to be stronger during binding zero lower bound. Similarly, the unconventional monetary policy was shown to have a stronger impact on inflation and growth during ZLB Baumeister and Benati (2010). Therefore studying consumer inflation expectations is necessary for understanding the propagation of MP shocks to consumption, especially during the period of Unconventional Monetary Policy (UMP).

The contribution of this article is twofold: it finds declining heterogeneity in responses of consumer inflation expectations in EA and it includes the period of the financial crisis in the sample to assess the effectiveness of UMP post-2012 period. Additionally, this paper has focused on disaggregated consumer expectations, as opposed to market derived expectations, or professional forecasts. Consumer expectations are preferred to alternatives for three reasons. First, inflation expec-

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tations from consumers are less incentivised to provide disingenuous information about their opinion, and respondents reported opinions are correlated with their financial decisions (Arnold, Dräger and Fritsche, 2014; Armantier et al., n.d.; Coibion, Gorodnichenko and Kamdar, 2017). Second, consumer forecasts fit the Phillips curve better, as documented by Coibion and Gorodnichenko (2015*b*). Third, the inflation expectations data is segmented into age categories only at the level of consumer surveys, which allows for analysis of different demographics. For the remaining part of the paper, inflation expectations would refer to consumer inflation expectations.

This article addresses a gap in the literature by exploring how the formation of inflation expectations has evolved over time at the aggregate, country level and by demographic groups. I investigate MP transmission channels through consumer inflation expectations and their variation across various demographics, and 10 Euro Area (EA) countries. Figure A1 and A2 illustrates the diversity of inflation expectations disaggregated by age groups as well as by country. While the inflation expectations series remained relatively at the same level, the inflation index, overall, has dropped from 2.3 to 1.4 percent, and its standard deviation rose from 0.3938 to 1.0896.

For further discussion, it is useful to make a distinction between two terms: price perception and price expectations. The former is understood as being backwards-looking and underlines the ability to see past price changes effectively, while the latter are forward-looking describing consumer predictions about price level changes (Fuhrer and Moore, 1995; Malmendier and Nagel, 2015) provide evidence that inflation expectation formation is dependent on inflation the individual has observed in their lifetime. Malmendier and Nagel (2011) similarly find the link between observed stock market performance during the lifetime of the individual and their risk-taking activity. But these expectations are not always rational, beliefs may deviate from rationality as shown by Fuster, Laibson and Mendel (2010). These authors introduce the notion of natural expectations, which is defined as the weighted average of rational and intuitive expectations. Survey experiments suggest that rational inattention may be an important source of information frictions (Cavallo, Cruces and Perez-Truglia, 2017). They also show that even in the presence of accurate information, agents place significant weight on inaccurate sources of information. In addition, inflation expectations seem to vary by demographic groups and by the level of education (Inoue, Kilian and Kiraz, n.d.; Madeira and Zafar, 2015). Following this introduction, section 2 presents the methodology and covers the latest developments in incorporating inflation expectations into structural models. Section 3 describes the data and empirical analysis. Section 4 concludes and highlights the shortcomings and areas for further research.

I. Methodology

Traditionally small-scale VARs have been used for MP analysis (as for instance in Christiano, Eichenbaum and Evans (1998)). However, this methodology has two shortcomings: One, it incorporates only a few macroeconomic variables, and two, omitted variables can lead to biases. Bernanke, Boivin and Eliasz (2005) (BBE) outline the issue of econometricians using a smaller data set than the one used by the MP authority. BBE argues that it potentially leads to structural shocks being misspecified because MP reacts to variables which are omitted in a small scale model. Benati and Surico (2009) make a case for MPs contribution to the period of Great Moderation and conclude that omitted variable bias may be present in the VAR estimates of MP shock impact.

The shortcoming of omitted variable bias also noted in the literature as non-fundamentalness Sargent and Hansen (1981); Lippi and Reichlin (1994); Canova and Hamidi Sahneh (2017), is particularly acute in the context of estimating effects of a structural MP shock on inflation expectations, because methodology should be able to accommodate key macroeconomic variables as well as variables for inflation expectations. Section 3.3 demonstrates the failure of small VAR with zero and sign restrictions to identify shocks precisely. Therefore, there are two requirements which an empirical model should be able to fulfil. Firstly, there is a large number of variables to estimate the disaggregate series for inflation expectations. Secondly, the empirical model should be able to capture the time variation of inflation expectations, to be able to test the hypothesis that the formation of inflation expectations has changed in the last two decades. It is difficult to justify a constant relationship between inflation expectations and inflation given the sample from 1990Q1 to 2017Q4 includes financial and sovereign debt crises. Factor-Augmented Vector Auto Regression (FAVAR) with time-varying coefficients and stochastic volatility has the fits the above criteria because it would be able to address both the issue with a number of variables, and changing inflation expectations behaviour. Furthermore, this methodology allows estimating disaggregated series in a unified framework.

In the same seminal paper which outlined shortcomings of small VARs, BBE introduced a factor-augmented vector autoregression model, which summarises the dynamics of a large data set into a smaller number of common factors. Building on BBE, Baumeister, Liu and Mumtaz (2013) (BLM) proposes a time-varying version of the FAVAR model. The model incorporates all necessary components for estimating MP transmission channels. It can handle large numbers of variables, includes observed factors, and allows for coefficients to vary over time.

Since the introduction of methodologies which can handle large data sets, the literature on MP transmission channels has used this methodology to include disaggregate series. Namely, in the case of inflation, researchers have included breakdowns of the widest available CPI data breakdown. For instance, Altissimo, Mojon and Zaffaroni (2009) examined the period from 1985 to 2005 with 404 CPI indices in the US with a dynamic factor model.

BLM estimated the effects of MP on disaggregate price dynamics with the FAVAR model, taking 138 US series over a certain period from 1975Q1 to 2008Q1. They report the price puzzle to be present only for some of the series, diminishing gradually since the 1980s. BLMs findings coincide with the findings of the decline of the real effects of MP surprises at the aggregate level. The studies, adopting FAVAR methodologies, mostly concentrate on US data, for instance, see Bernanke, Boivin and Eliasz (2005); Favero, Marcellino and Neglia (2005); Stock and Watson (2005). Among the studies focusing on European data are McCallum and Smets (2007); Eickmeier (n.d.); Galariotis, Makrichoriti and Spyrou (2018).

Bils and Klenow (2004) also found that the frequency of price changes varies significantly across goods. They compared results of sticky-price models to find that actual inflation rates are far more volatile and transient for sticky-price goods. Balke and Wynne (2007) estimated the disaggregate producer price index (PPI) response to MP shock, which has a significant relative price response. Similarly, Clark (2006) found the average persistence of disaggregate prices to be lower than the persistence of aggregate inflation, with US data covering the period: 19842002.

Altissimo, Mojon and Zaffaroni (2009) aggregated Euro Area 404 sub-indices of inflation to the dynamics of inflation persistence. They found that idiosyncratic shocks explained most of the variance of sectoral prices. However, one common factor was found to be the main driver of aggregate dynamics. Additionally, they found that the slow propagation of MP shock in prices for services explains persistence in aggregate series. Boivin, Giannoni and Mihov (2009) found that disaggregate prices respond quickly to sector-specific shocks, but aggregate shocks produce effects only in the medium to long run. Boivin, Giannoni and Mojon (2008) estimated a Euro Area-wide structural model. Lastrapes (2006) and Balke and Wynne (2007) demonstrated that money supply shocks have long-run effects on commodity price distribution.

De Graeve and Walentin (2015) consider sectoral pricing behaviour and estimated the dynamic factor model to produce the result that both variance and persistence of inflation are driven by aggregate and sector-specific shocks. Bianchi and Civelli (2015) investigated the globalisation hypothesis, pinning down inflation stability using a time-varying parameter - VAR. They found that the contribution of global effect has increased over time in some countries inflation, but cannot explain recent inflation dynamics.

There are, however, some criticisms of the FAVAR methodology. Boivin and Ng (2006) (NG) outlined criticisms of rich data models and showed that including too many variables in a factor model can produce distorted factor estimates. The justification of a large model in this article is based on the assumption that consumers form their expectations about inflation based on observing policy rate, and extracting information from a number of key published macroeconomic and financial variables. NG developed a test for the identification of a number of factors, which I discuss further in the empirical application.

Most of the papers adopting this methodology rely on US data (Bernanke, Boivin and Eliasz, 2005; Favero, Marcellino and Neglia, 2005; Boivin, Giannoni and Mihov, 2009). The literature on the implementation of FAVAR models in the EU is relatively scarcer than in the US. For instance, Galariotis, Makrichoriti and Spyrou (2018) estimate the effects of conventional and unconventional monetary policy using FAVAR and two alternative models. They find a weaker effect of both MPs on peripheral EA countries compared to the core group.

Recent literature extensively takes advantage of time-varying models. Variation in time is used both in time-varying factor loadings and time-varying factor dynamics. Del Negro and Otrok (2008) introduced a model incorporating time-varying factor loadings and stochastic volatility. Mumtaz and Surico (2008) estimated time-varying factor dynamics to analyse the changes in common components of inflation in the industrialised world. Baumeister, Liu and Mumtaz (2013) is another example of the implementation of time-varying factor dynamics into a model.

A. A time-varying FAVAR model with stochastic volatility

FAVAR models incorporate extra information into traditional VAR models by assuming there are a number of factors (smaller than a number of variables) which capture most of the co-movement of the series. Furthermore, recent extensions of these models incorporate time variation within coefficients and stochastic volatility. Ellis, Mumtaz and Zabczyk (2014); Baumeister, Liu and Mumtaz (2013) describe the methodology of TVP FAVAR with stochastic volatility. The model in consideration has the following form:

$$X_{i,t} = \Gamma_i Z_t + e_{i,t} \tag{1}$$

$$Z_t = \phi_{1,t} Z_{t-1} + \phi_{2,t} Z_{t-2} + \; + \phi_{L,t} Z_{t-L} + v_t \tag{2}$$

Where $X_{i,t}$ is a panel of N variables over T time horizon; $Z_t = F_t^1, F_t^j, R_t$ is a matrix that includes j latent factors that summarise co-movement of variables of interest and an observed factor R_t; $e_{i,t}$ are idiosyncratic components with variance covariance diagonal matrix $\mathbb{E}[e_{i,t}^{'} e_{i,t}] = \Sigma$; Γ_i is a vector of factor loadings. A model, which incorporates a large amount of information, is less likely to suffer from omitted variable bias. Since the focus of this paper is to examine impulse responses of consumer expectations across time, the model is further extended with time-varying coefficients and stochastic volatility. Time variation allows for changes in the dynamic of shock propagation, coming from changes in consumer behaviour. Stochastic volatility incorporates the variation in volatility of the underlying series.

In recent literature, time variation has been applied in two ways: first, to factor loadings, and, second, to factor dynamics. Del Negro and Otrok (2008) studied changes in the international business cycle and were the first to incorporate time-varying factor loadings and stochastic volatility. They found a decline in the volatility across 19 countries. Mumtaz and Surico (2012) applied a dynamic factor model with time variation in the dynamics of the factors, to study the evolution of the common and country-specific components in inflation. The time-varying FAVAR model estimated in this paper is closely related to Del Negro and Otrok (2008); Mumtaz and Surico (2012); Baumeister, Liu and Mumtaz (2013). The observation Equation 1 of time-varying FAVAR can be written as the following:

$$(3)\qquad \begin{pmatrix} X_{1,t} \\ \vdots \\ X_{N,t} \\ R_t \end{pmatrix} = \begin{pmatrix} \Lambda^{11} & \cdots & \Lambda^{1j} & \Psi^{11} \\ \vdots & \cdots & \vdots & \vdots \\ \Lambda^{N1} & \cdots & \Lambda^{Nj} & \Psi^{N1} \\ 0 & \cdots & 0 & 1 \end{pmatrix} \begin{pmatrix} F_{1,t} \\ \vdots \\ F_{N,t} \\ R_t \end{pmatrix} + \begin{pmatrix} e_{1,t} \\ \vdots \\ e_{N,t} \\ 0 \end{pmatrix}$$

Where are factor loadings and are loadings on the observed variable. Note that the structure of the loadings matrix allows for observed variables to be loaded, and the transition Equation 2 would have the following form:

$$(4)\qquad Z_t = \sum_{l=1}^{L} \phi_{l,t} Z_{t-l} + v_t$$

Where Z_t is $F_t^1, F_t^2, , F_t^j, R_t$ and L is a lag length. I adopt the number of lags $L = 2$, following the works of Cogley and Sargent (2005); Primiceri (2005). The law of motion for $\phi_t = \phi_{t-1} + \eta_t$ and innovation for $VAR(v_t) \equiv \Omega_t = A_t^{-1} H_t (A_t^{-1})'$, where H_t and A_t evolve as random walks.

There are two alternative specifications to implement time variation. Del Negro and Otrok (2008) allow for time variation in factor loadings and . Alternatively, time variation has been implemented by Mumtaz and Surico (2012); Baumeister, Liu and Mumtaz (2013) to allow for the changing dynamic of the transition equation. This paper follows the latter approach. Time-varying factor loadings would imply time-invariant coefficients in the transition equation, which determines the dynamics between the state of the economy and the policy rate. This assumption would be highly implausible with the sample that covers the 2007-08 crisis and a sovereign debt crisis. On the contrary, time-varying dynamics of the factors have the flexibility to allow for structural breaks in factor dynamics.

I estimate joint posterior density of the parameters of interest through sampling iteratively, from conditional densities using Markov Chain Monte Carlo (MCMC). The Model is estimated with Bayesian methods and details on algorithms are covered in the Appendix.1. After discarding the first 100,000 iterations, the results presented in Figure 8 are based on 100 iterations of Gibbs sampling algorithm. The evidence of convergence is presented in the Appendix. The model is estimated using Bayesian methods described in Kim, Nelson et al. (1999).

B. Identification

Following Canova and Ciccarelli (2004); Uhlig (2005); Ellis, Mumtaz and Zabczyk (2014) the restrictions are imposed on the contemporaneous response of observed variables. The tightening monetary policy is identified as an increase in the interest rate, a decrease in output and inflation:

$$
\begin{aligned}
(IRF)^{R}_{(t,h=0)} &> 0 \\
(IRF)^{\pi}_{(t,h=0)} &< 0 \\
(IRF)^{Y}_{(t,h=0)} &< 0
\end{aligned}
$$

I calculate the impulse responses of factors $_i$ to the monetary shock R_t. A normalisation of the shock implies a change in the shadow rate by 100 basis points. As a robustness check, this paper also follows Bernanke and Blinder (1992); Bernanke, Boivin and Eliasz (2005); Baumeister, Liu and Mumtaz (2013) recursive identification, with the monetary policy variable ordered last. Cholesky identification achieves similar structural responses in inflation expectations, yet is more sensitive to the selection of lags and factors. Following the spirit of the previous literature, in my baseline specification, I allow for the contemporaneous effect of monetary policy on a group of fast-moving variables, such as equity indexes and foreign exchange.

Following BBE, the factors are identified by fixing $K \times K$ block of Δ^f as an identity matrix and the upper $K \times 1$ block of Ψ^R is zero.

II. Data and Empirical Analysis

A. Data

To have a balanced panel, I restrict the sample of inflation expectations to 10 EA countries (Belgium, Germany, Greece, Spain, France, Italy, the Netherlands, Austria, Portugal and Finland) . Following Bańbura, Giannone and Lenza (2015), I extend dataset with Area Wide Model dataset for the Euro Area (Fagan, Henry and Mestre, 2005). The extensions allow using the period from 1990q1 to 2000q1 as a training sample to set up priors, as in Baumeister, Liu and Mumtaz (2013) and Ellis, Mumtaz and Zabczyk (2014). The list of macroeconomic variables is presented in the Appendix Table 1. The results of the alternative specification which follows the data set of BBE, with a shorter sample from 2000Q1 and 148 variables are comparable to the baseline presented in the next section. Following

Galariotis, Makrichoriti and Spyrou (2018) I use Wu and Xia (2017) shadow rate for Europe (also see shadow rate for the US Wu and Xia (2016)) as a proxy for an MP stance. Data spans from 1990q1 to 2017Q4 and was chosen to maximise the number of observations for the selected countries. Several countries were not included due to a large number of missing observations.

Quantifying survey data on inflation expectations

Data on consumer surveys in the EA is provided by the European Commission (EC). Unlike data from the Survey of Professional Forecasters, EC data does not contain point estimates, and only presents proportions of the respondents making an open interval statement (prices would: increase more rapidly, increase at the same rate, increase at a slower rate, stay about the same or fall). The main two methodologies, which provide point estimates of expected inflation, are probability and regression approaches. Smith and McAleer (1995) compare the results from both approaches. Based on forecast root mean square error they conclude a regression approach as preferable for all variables, except prices for which the probability approach was superior. However, the results of both approaches require strong assumptions about perceived inflation, i.e. what inflation consumers have observed in the last 12 months in order to answer the survey question. To avoid making these assumptions I consider balance statistic. The statistic is presented within the European Commission data set.

$$Balance = PP + P/2 - M/2 - MM$$

Where PP, P, M, MM are answers regarding inflation: increase more rapidly, increase at the same rate, stay about the same and fall respectively. Additionally, I derive simplified balance, which is a sum between proportions of consumers expecting prices to go up:

$$InflationExpectations = PP + P$$

The reason for this simplification is so that impulse responses on this variable can be interpreted more easily. For instance, a positive (negative) value of 10 would imply that an additional 10% of consumers expect prices to rise (fall) in the next 12 months. Here, I follow the balance statistic in the EC survey in interpreting the stay the same answer with a negative connotation. For comparison and description of the probability, approach see Appendix.

Figure A2 illustrates the simplified balance statistic for the group of 10 EA countries. For the remaining part of the paper, I adopt a simplified balance for the measurement of inflation expectations, and it is going to be referred to as balance or inflation expectations. This figure illustrates some heterogeneity among the 4 age groups, which console, to some degree, during the financial crisis, and remained at the same level of heterogeneity after 2012 as pre-2008.

There is suggestive evidence that personal experiences determine the dynamics of inflation expectations. The literature provides two major explanations. First, there are studies addressing inflation expectations based on inflation individuals have observed throughout their lifetime. Second, literature looks at media coverage as the source of imperfect inflation expectation updating. However, existing literature has not been able to distinguish between the two. Media coverage statistics: Lamla and Lein (2014) show, empirically, that the amount and tone of media coverage affect inflation expectations. Badarinza and Buchmann (2009) assess the degree of heterogeneity of consumers inflation perceptions and expectations in the Euro Area. Coibion, Gorodnichenko and Kamdar (2017) present evidence that firms update their inflation expectations in a Bayesian manner. However, inflation was reported not to be the main concern. Malmendier and Nagel (2015) argue that personal experiences play an important role.

III. Empirical results

A. Aggregate responses to a monetary policy shock

Before moving to the inflation expectations by demographic groups, it is informative to examine the aggregate responses of EA macroeconomic variables to a monetary policy shock. Responses of GDP, inflation and unemployment received the most attention in previous studies and are useful to compare the performance of the model. Figure 1 displays the estimated impulse responses of the level of aggregate real activity measures, consumer prices, number of unemployed and inflation expectations to a monetary policy contraction. The left panels of the figure show the median responses in each quarter over the 2000Q1 - 2017Q4 period. The two middle panels compare the responses at the beginning and end of the sample, as representative dates. The last column considers the relative importance of time variation in impulse responses following the approach by Cogley, Primiceri and Sargent (2010); Baumeister, Liu and Mumtaz (2013) and Baumeister, Liu and Mumtaz (2013). The last panel plots the joint posterior distribution of the accumulated responses at the 1-year horizon with values for 2000Q1 plotted on the x-axis and those for 2017Q4 on the y-axis. Shifts of the distribution relative to the horizontal line indicate a systematic change across time Baumeister, Liu and Mumtaz (2013). For IRFs with no accumulation over time see Figures A4 and A3.

Figure 1 shows that a 1% increase in the EA shadow rate reduces the level of GDP at market prices by around 2% at a horizon of 2 years in more recent times, which is about half the magnitude relative to the first half of the sample. The second row of Fig. 3 displays the responses of consumer prices. After an unexpected positive monetary policy shock, the price level fell by around 2% in the long run during the 2000s, while it currently levels off at 1% below baseline.

Evolution of the employment responses exhibits amplified time variation. The last column of Figure 1 provides some indication that the milder reaction of real GDP, unemployment and inflation expectations in more recent times is a non-

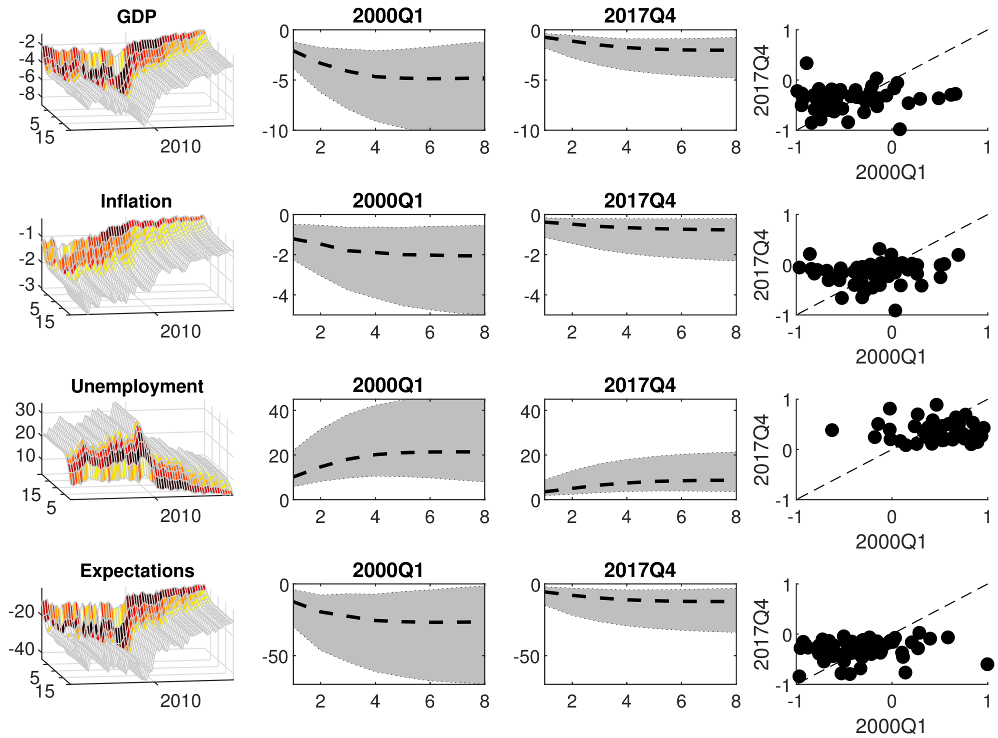

FIGURE 1. ACCUMMULATED IMPULSE RESPONSES.

Note: Time-varying median impulse response functions of selected aggregate variables at each point in time (first column) and in 2000Q1 and 2017Q4 (second and third columns) with 16th and 84th percentiles (shaded areas) to a 100 basis points shock to a shadow rate and joint distribution of the cumulated responses 2 year after the monetary policy shock in 2000Q1 and 2017Q4 (fourth column). Colormap in the first column corresponds to 68% credible set, with blank region capturing values not significantly different from zero.

negligible feature at the 4-quarter horizon since for both measures at least 75% of the joint distribution lies above the 45-degree line. Due to large uncertainty around median estimates, the evidence of time variation is less clear-cut at the longer horizon.

Alternative specification with Cholesky identification of the shocks supports the analysis of Castelnuovo and Surico (2010) who argue that the price puzzle in structural VARs may be a symptom of omitted-variable bias that may arise when the Taylor principle is violated. In particular, they show that when the economy is operating under indeterminacy, an additional unobserved variable characterizes the dynamics of the economy. The factors included in our model summarize a large amount of information that may proxy this latent variable. The fact that the price puzzle is absent from alternative Cholesky identification throughout the sample lends support to this idea Bernanke, Boivin and Eliasz (2005).

B. Disaggregate responses to a monetary policy shock

Figure 2 demonstrates the accumulating responses of inflation expectations disaggregated by demographic groups. The first row depicts the responses of 4 age group regarding their inflation expectations. Note that the responses are not restricted by the identification strategy. The specification with disaggregate age groups exhibits similar behaviour to a price puzzle, with an initial increase in the level of consumers which expect prices to rise, levelling off after the 1-year horizon. The median responses retain the same order as corresponding age groups, with younger demographics showing the weakest response.

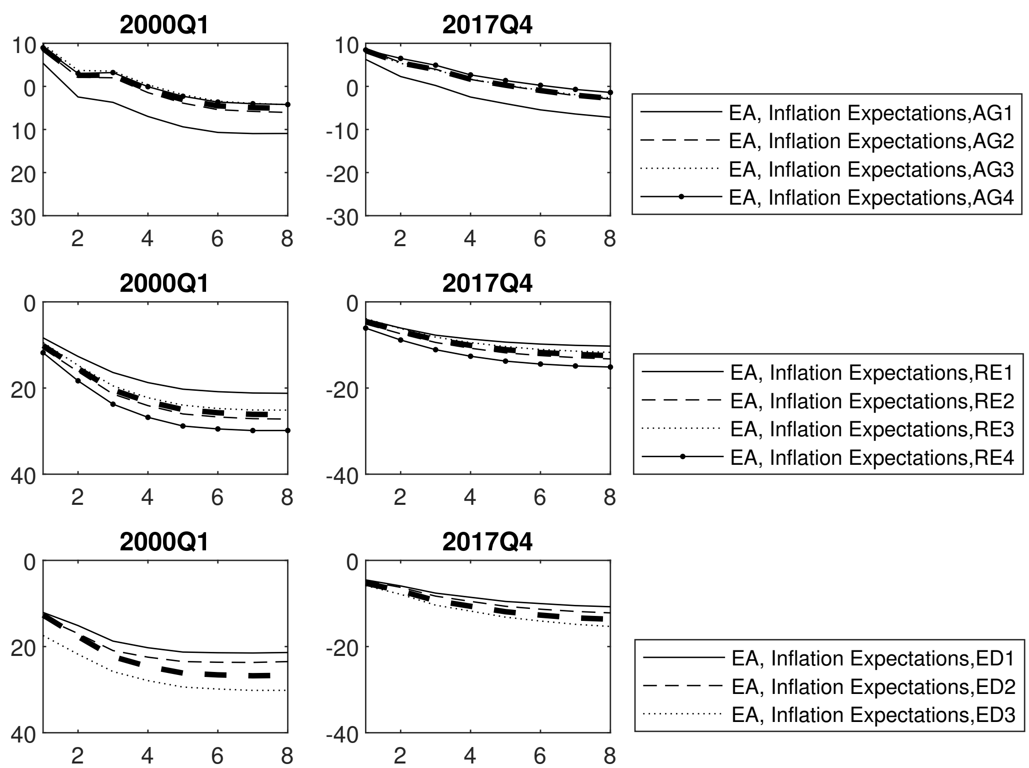

Figure 2. Accummulated Impulse Responses of Inflation Expectations.

Note: Cumulative IRFs at a disaggregated level. The first row contains specifications with expectations by age groups 16-29, 30-49, 50-64, and 65+ respectively. The second row contains specifications with expectations by income groups 1st, 2nd, 3rd and 4th quartiles respectively. The third row contains specifications with expectations by education groups for primary, secondary, and further education respectively.

The median impulse responses in the second row of Figure 2 captures of the individual components of the inflation expectations by income groups after a contractionary monetary policy shock of 100 basis points at our two representative points in time: 2000Q1 and 2017Q4. The behaviour of these responses is in line with the aggregate measure of inflation expectations from Figure 1. The long-run response is lower in 2017q4, and the order of income quartile is maintained in the level of responses: the lowest quartile income group exhibiting the lowest updating of inflation expectations. The last row in Figure 2 captures a similar dynamic within different education groups, with the lowest education group having the lowest levels of updating inflation expectations.

While the disaggregated series for inflation expectations do not exhibit clear-cut heterogeneity within demographic groups, the time variation of IRFs shows a consolidating trend among all specifications. There is a general trend among the sampled countries, of increasing persistence of inflation expectations responses starting from 2012. This outcome is in line with Coibion and Gorodnichenkos (2015) earlier findings, who argue that it is relative stability of inflation expectations which has kept the inflation stable post-2012.

C. VAR perfomance

The literature on the Monetary Policy Transmission channel often relies on VAR methodology. Therefore, it is instructive to demonstrate the performance of VAR with the EA sample with popular identifications. Figure 3 presents the results for VAR estimation with $[Y_t, {}_t, I_t]$ identified with the recursive scheme, augmented recursive scheme with inflation expectations variable, following the order Castelnuovo and Surico (2009) with $[\mathbb{E}[\pi_{t+1}], Y_t, \pi_t, I_t]$ and finally sign restrictions in the third column.

Contemporaneous zero restriction presented in the first column exhibit a prize puzzle, similarly to the literature. The second column presents similar results to the first column, and forward-looking inflation expectations variable doesnt change responses as in Castelnuovo and Surico (2009). Finally, the last column shows the IRFs with sign restrictions exhibit correct responses, yet them being exogenously imposed.

D. TVP FAVAR SV perfomance

One of the concerns in estimating highly parameterised models is the availability of data. To provide the robustness check on the performance of TVP FAVAR with stochastic volatility in small samples consider a DSGE model of Smets and Wouters (2007). The monetary policy rule is specified as follows:

$$
\begin{aligned}
r_t = \rho * r_{t-1} + (1-\rho)(r_\pi * \pi_t r_Y(y_t - y_t^p))+ \\
+\delta y[(y_t - y_t^p) - (y_{t-1} - y_{t-1}^p)]) + \varepsilon
\end{aligned}
$$

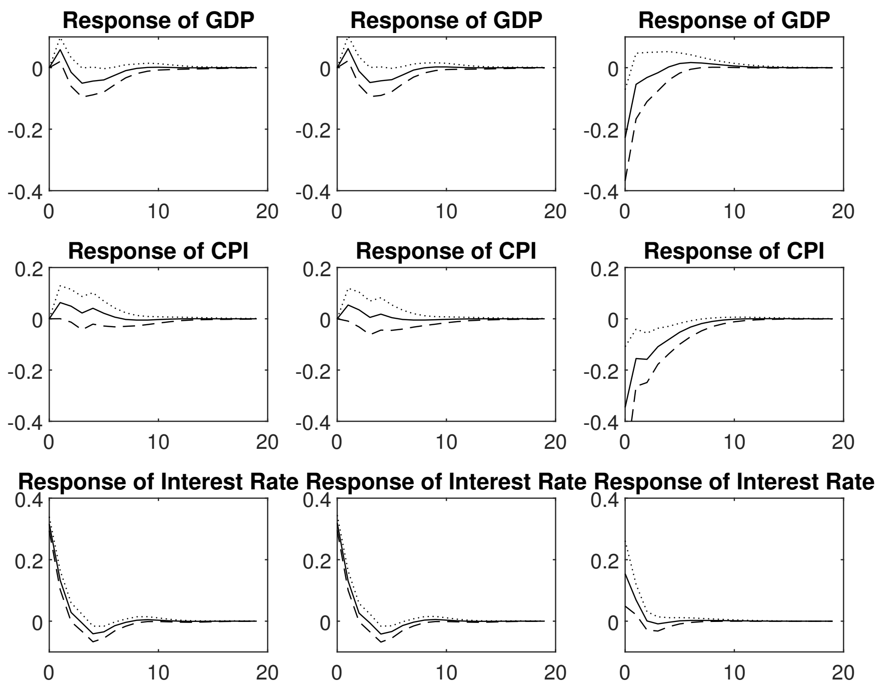

FIGURE 3. IRFs FROM VAR WITH ZERO AND SIGN RESTRICTIONS.

Note: The first column contains IRF from VAR with 4 lags and 3 variables with Cholesky identification, ordered GDP, CPI, and Interest Rate; the second column contains IRF from VAR with 4 lags and 4 variables with Cholesky identification, ordered Inflation Expectations, GDP, CPI, Interest Rate; the third column contains IRF from VAR with 4 lags and 3 variables with contemporaneous Sign Restrictions, GDP (-), CPI (-), Interest Rate (+).

Following a procedure in Justiniano and Primiceri (2008), lets further consider a structural change of the following form: $r_\pi^1 = 1.5$ and $r_\pi^2 = 2.5$, Sample size $t = 70$, regime change at $t = 35$.

Figure 4 compares the estimated response of inflation at the eighth horizon to a monetary policy shock identified with sign restrictions following the same procedure presented in Section 2 to a true response obtained from the theoretical model. TVP FAVAR SV captures time variation at t=35, and true inflation response remains within the credible set. Another finding, consistent with robustness checks using other DGP is a wider credible sets for the part of the ample with is used as a training sample for priors.

Following Ellis, Mumtaz and Zabczyk (2014), I also consider an open economy DSGE model of Justiniano and Preston (2010) as a DGP and results are presented in the Appendix.

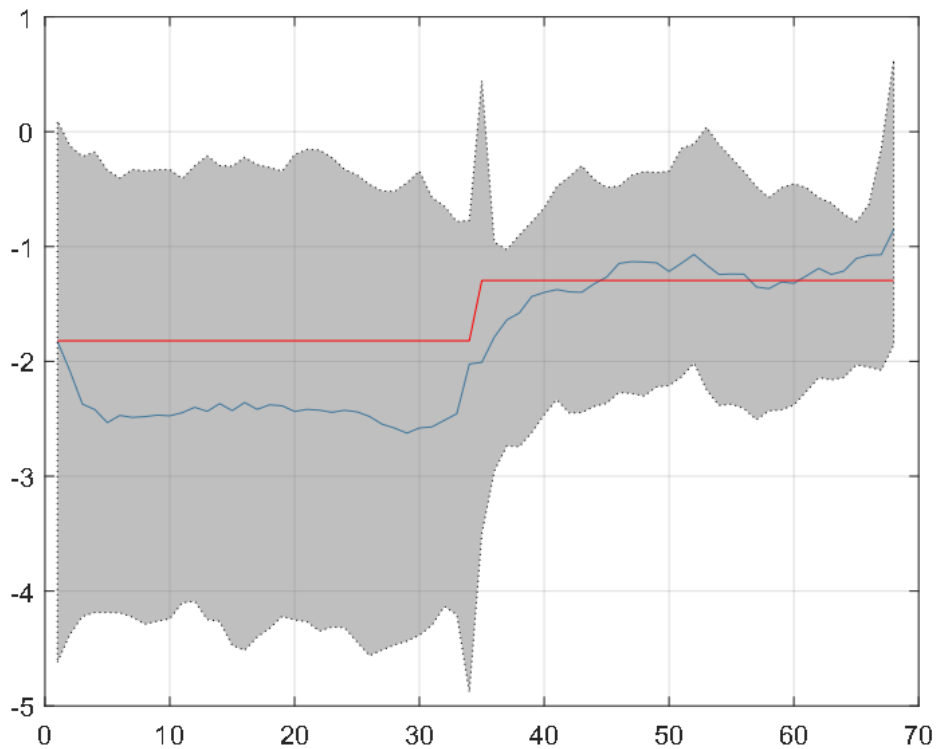

Figure 4. Time-varying median responses of inflation at 8 quarter horizon.

Note: Time-varying cumulative impulse responses at an impulse horizon h = 8 obtained by the 100 pseudo-experiments: The estimated responses are from TVP FAVAR SV with 16/84th percentiles. Blue solid line and shaded area represent the median, 16/84-percentiles, respectively. The red solid line indicates the true response in the DSGE Smets and Wouters (2007).

IV. Conclusions

This paper investigates the Monetary Policy transmission channel through consumer inflation expectations and how it varies across four demographics (16-29, 30-49, 50-64, and 65+ age groups) and the 10 Euro Area (EA) countries. This paper addresses a gap in the literature by exploring how the formation of inflation expectations has evolved over time at the aggregate level and by demographic groups.

One of the questions economists are concerned with, is the particularly subdued behaviour of inflation in the recent decade in the EA Miles et al. (2017*b*). There have been a few explanations proposed as to why inflation remains anchored in a post-2010 period. One of the explanations is proposed by Blanchard, Cerutti and Summers (2015). They explore two issues with regards to the financial crisis. Firstly, they observe that the output in advanced countries is below pre-crisis levels, which they explain with the hysteresis hypothesis. Secondly, they capture a flatter Phillips curve in the post-2008 period. These two facts suggest that the economies of advanced countries are not in a recovery regime yet.

Coibion and Gorodnichenko (2015*a*) argue that it is the relative stability of inflation expectations which has kept the inflation stable post-2010. This paper expands on the point of inflation expectations playing a key role in inflation dynamics in the recent decade. For monetary authorities, it is crucial to know the effects of their interventions on inflation expectations. Coibion, Gorodnichenko and Kamdar (2017) further highlight the importance of expectations by stating that first and most practically, we lack direct empirical evidence on the real-time beliefs of firms, those agents whose expectations play a central role in price-setting, hiring, and investment decisions.

I find heterogeneity in responses of disaggregate consumer inflation expectations in the Euro Area, based on time-varying factor-augmented vector autoregression. The results indicate some heterogeneity in responses of different age groups to an EA-wide monetary policy shock, although not significant for most of the countries. Younger demographics (16-29) exhibit a higher level of updating inflation expectations compared to older groups.

The key finding is that the responses of expectations have become weaker over time. The responses of inflation expectations after 2010 take more time to react, weaker, on average than responses before 2008. The dynamics of inflation expectations could be one of the possible causes of inflation persistence in the EA.

There is a number of dimensions upon which further research can improve. Firstly, there are a number of novel identification strategies, which could help pin down MP shock more precisely. Secondly, there is concern over the rather small sample for the EU to estimate a model with a large number of parameters. Thirdly, introducing a panel structure, for instance through estimating dynamic factor models with restricted factor loadings for countries, is an interesting possibility. Fourthly, estimating individual countries with a smaller VAR to analyse historical decomposition of inflation expectations, which might reveal what the variables contributing to the formation of inflation expectations are.

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1. Estimation Procedure

1) Set the priors and starting values.
2) Conditional on factors and observed variable sample factor loadings.
3) Conditional on factors and factor loadings sample variance of error terms of the observation equation from the IG distribution.
4) Conditional on the factors and error covariance, obtain VAR coefficients in the transition equation with Carter and Kohn.
5) Conditional on factors and VAR coefficients, sample error covariance from IW distribution.
6) Given factor loadings, error covariance matrix observation equation, VAR coefficients in transition equation, error covariance matrix in transition equation, obtain factors via Carter and Kohn algorithm.

Similarly, the above could be expressed with following notation:

- Γ (Factors loadings)
- R (Covariance matrix X)
- $\{\beta_t\}_{t=1}^{T}$ (VAR coefficients in the transition equation)
- Q (Covariance matrix for $_t$)
- $\{a_{ij,t}\}_{t-1}^{T}$ Off diagonal elements of A_t
- D covariance matrix for A
- Diagonal elements of H_t
- Variance of $ln(h_{i,t})$
- $\{F_t^j\}_{t-1}^{T}$ Factors

Steps:

1) Set priors and initial values for model parameters. Parameters in the transition equation. Parameters in the RW process for $\{a_{ij,t}\}$. Parameters in the observation equation. Parameters in the RW process for $ln(h_{i,t})$.
2) Given R draw Γ.
3) Given Γ and Z_t, draw R.
4) Given Z_t ,Q, $\{a_{ij,t}\}$, and $h_{i,t}$, draw β_t.
5) Given β_t, draw Q.

6) Given Z_t, β_t, $h_{i,t}$ and D, draw $a_{ij,t}$.

7) Given $a_{ij,t}$, draw D.

8) Given Z_t, β_t and g_i, draw $h_(i,t)$.

9) Given $h_{i,t}$, draw g_i.

10) Given Γ, R, β_t, $a_{ij,t}$ and $h_{i,t}$, draw F_t.

11) Iterate steps 2 to 10 M times. When M and M_0 are sufficient large but $M > M_0$ the marginal posterior distribution of each parameter can be approximately obtained from the last $(M - M_0)$ iterations.

2. Details of survey data

The Joint Harmonised EU Programme of Business and Consumer Surveys (BCS) was introduced in 1961 and extended to the consumer sector in 1972. The survey is conducted each month. As of May 2016, the program includes 28 member states, out of which 10 are of interest in this paper: Belgium, Germany, Greece, Spain, France, Italy, the Netherlands, Austria, Portugal and Finland. The questions of interest from the consumer survey include: Q5. How do you think consumer prices have developed over the last 12 months? They have

- ++ risen a lot
- + risen moderately
- = risen slightly
- − stayed about the same
- −− fallen
- N don't know.

Q6 By comparison with the past 12 months, how do you expect consumer prices to develop in the next 12 months? They will

- ++ increase more rapidly
- + increase at the same rate
- = increase at a slower rate
- − stay about the same
- −− fall
- N don't know.

Table 1—AWM. List of variables.

Variable	**AWM index**	**T**	**F**
Gross Domestic Product (GDP) at market prices	YER	6	0
Individual Consumption Expenditure	PCR	6	0
General Government Final Consumption Expenditure	GCR	6	0
Gross Fixed Capital Formation	ITR	6	0
Exports of Goods and Services	XTR	6	0
Imports of Goods and Services	MTR	6	0
GDP, Income Side	YIN	6	0
Net Factor Income from Abroad as a Share of GDP	NFN_YEN	4	0
Number of Unemployed	UNN	6	0
Nominal Short-Term Interest Rate 3	STN	4	1
Nominal Long-Term Interest Rate 10	LTN	4	1
Commodity Prices	COMPR	6	1
Non-oil Commodity Prices	PCOMU	6	1
World GDP	YWR	6	0
Nominal Effective Exchange Rate	EEN	4	1
EURUSD	EXR	4	1

Note: Column T denotes transformation:6 $= log - difference$,4 $- difference$; Column F denotes fast moving varialbes (BBE):1 $= fast$,0 $= slow$.

Figures

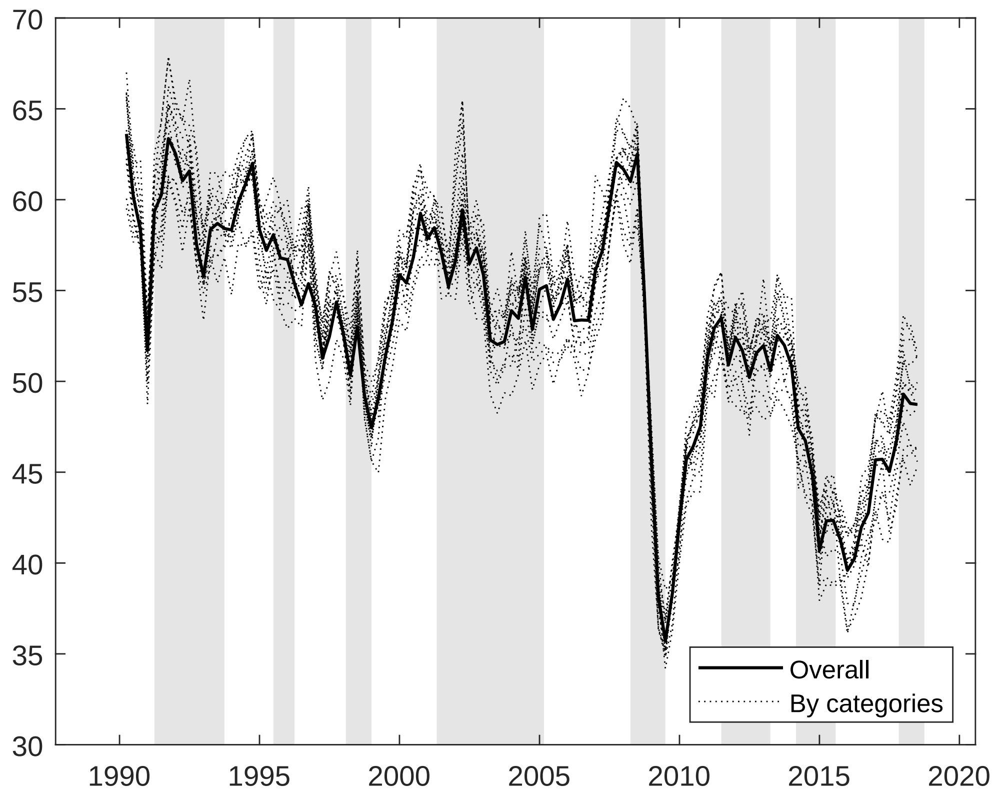

Figure A1. Dissaggregated inflation expectations by categories.

Note: Solid line denotes overall inflation expectations.Dotted lines denote inflation expectations by age, gender, education, income groups. Values are calculated as the sum of the proportions of the populations reporting price increase and price stability in the next 12 months.

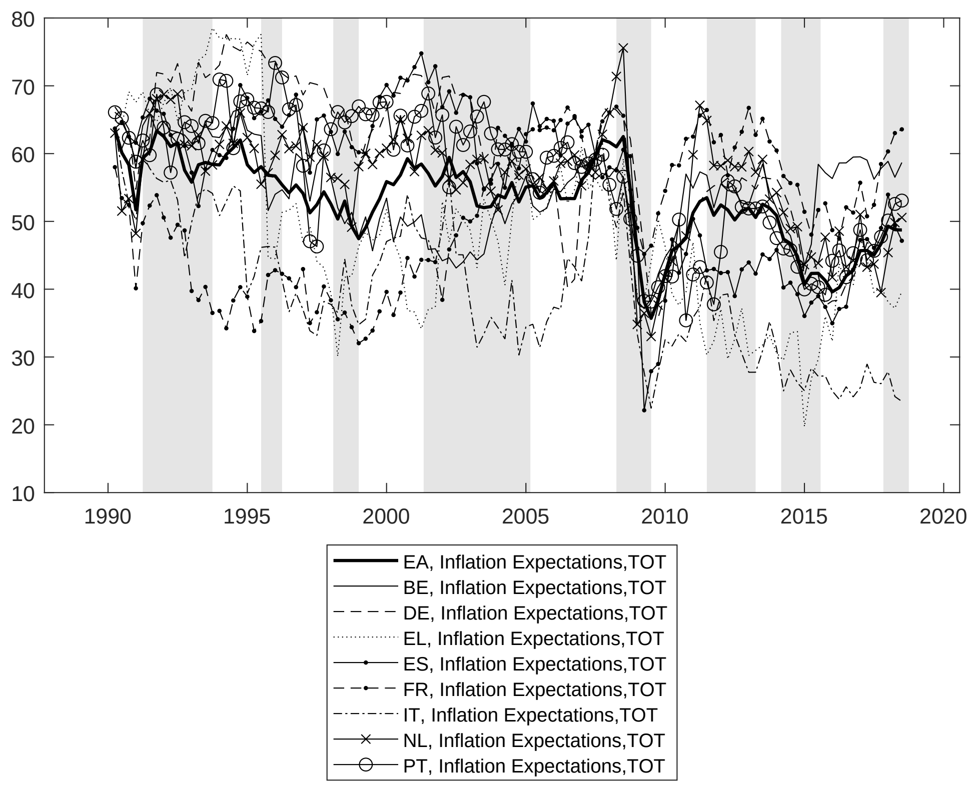

Figure A2. Dissaggregated inflation expectations by countries.

Note: Solid line denotes overall inflation expectations. Values are calculated as the sum of the proportions of the populations reporting price increase and price stability in the next 12 months.

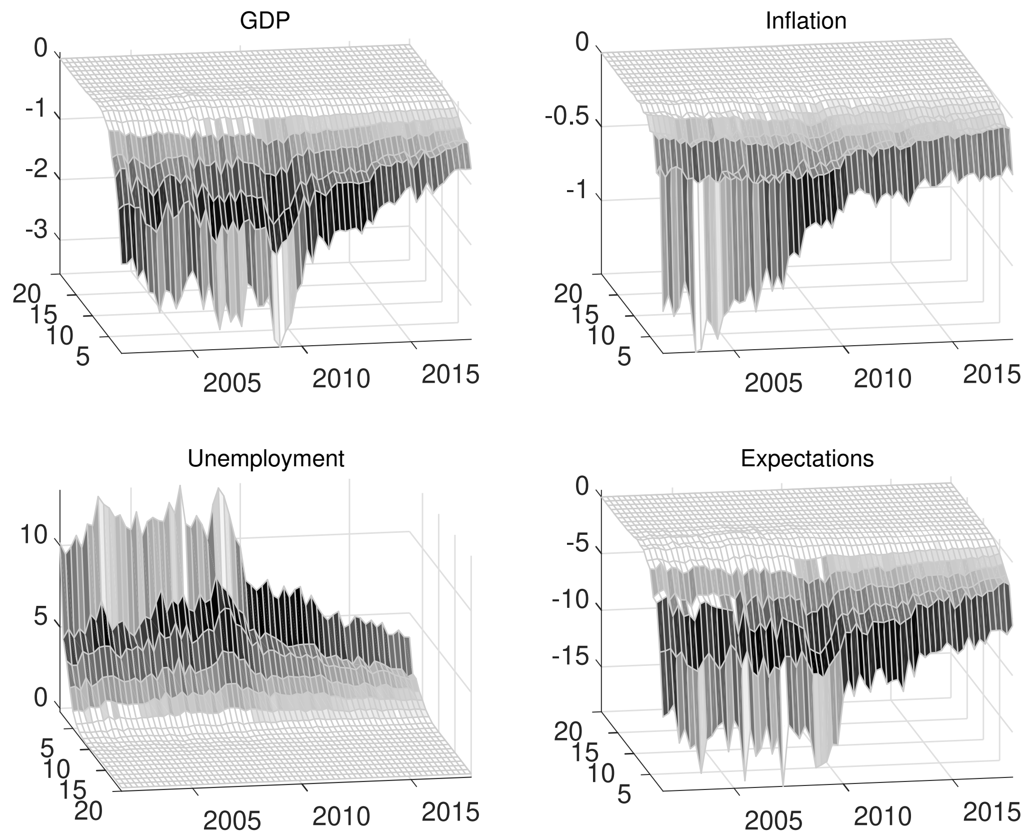

Figure A3. IRFs to a contractionary Monetary Policy shock.

Note: Time-varying median impulse response functions of selected aggregate variables at each point in time.

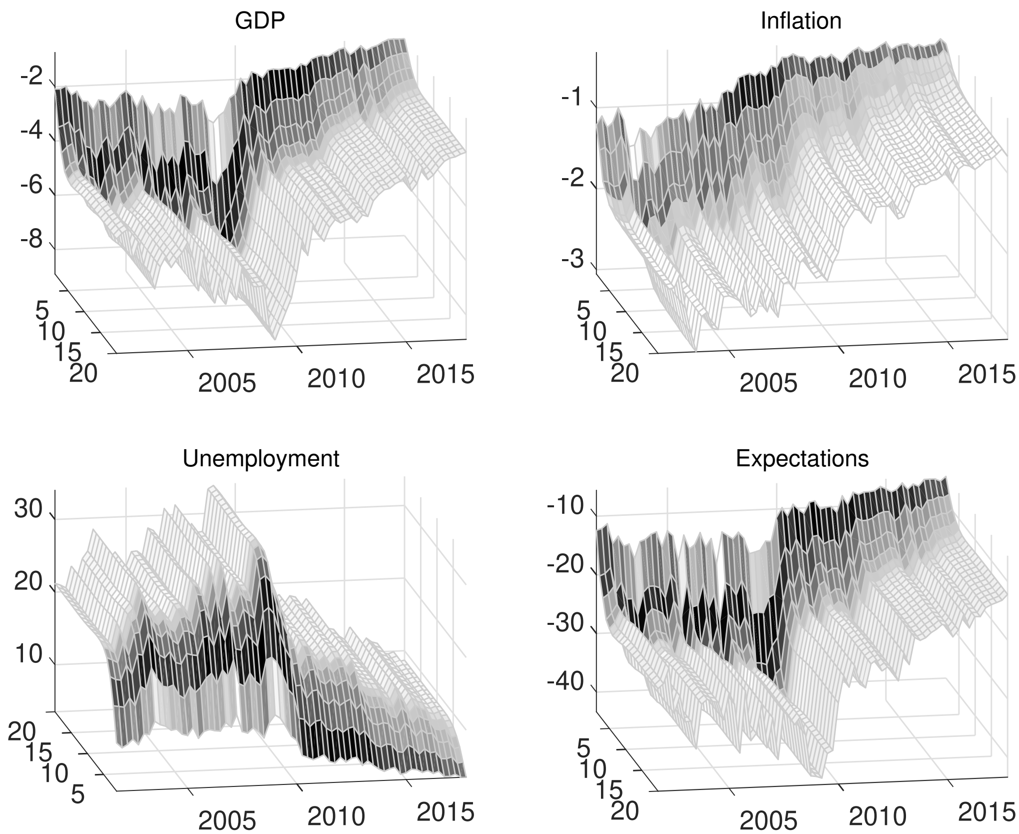

Figure A4. Accumulated IRFs to a contractionary Monetary Policy shock.

Note: Time-varying median impulse response functions of selected aggregate variables at each point in time.