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# DELPHIC AND ODYSSEAN MONETARY POLICY SHOCKS: EVIDENCE FROM THE EURO-AREA

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# Delphic and Odyssean monetary policy shocks: Evidence from the euro-area*

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**Abstract**

In this paper, we study the impact of the ECB announcements on the market-based expectations of interest rates and of inflation rates. We find that the impact of the ECB announcements on inflation expectations has changed over the last fifteen years. In particular, while in the central part of our sample the ECB announcements were read as a signal about the economic conditions (i.e. *Delphic* component), in latest episodes they have been interpreted as a commitment device on future monetary policy accommodation (i.e. *Odyssean* component). We propose an approach to separately identify the Delphic and Odyssean component of the ECB monetary policy announcements and we measure their dynamic impact on the economy.

**Keywords**: Forward guidance, High Frequency data, VAR with instrumented proxy

**JEL Classification**: C10, E52, E32.

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# 1 Introduction

Central banks around the world have been steadily placing more attention on the communication of their current and perspective monetary policy stance to the public. In particular, explicit guidance about the likely future path of the short term interest rate has been increasingly used as monetary policy instrument. The main justification behind the use of monetary policy announcements is grounded on the idea that individuals base their decisions conditional on their expectations about the future. So, by manipulating the expectations of future interest rates the central bank can affect the decisions of the agents today.

Using high frequency data on US market based interest rate expectations, Gurkaynak, Sack and Swanson (2005) showed that the Federal Reserve monetary policy announcements have significant impact on market traded assets, e.g. interest rates futures. While markets react to these announcements, it is not clear what type of information is conveyed, as pointed out by Campbell, Evans, Fisher and Justiniano (2012). For example, in the case of the announcement of - say - a future monetary accommodation, do the market participants read the signals as conveying negative information about the future state for the economy (”Delphic” forward guidance) or as commitments to future stimulative deviations from the historical policy rule (”Odyssean” forward guidance)? In other words, have the recent forward guidance policies made private agents more optimistic or pessimistic about the future? Using data from surveys and interest-rate futures, Campbell et al. (2012) found that the FED forward guidance were mostly ”Delphic”, since announcements of monetary accommodation typically generated downward revisions of inflation expectations, consistent with a pessimistic review of expectations.

In this paper, we offer two contributions. First, we show that the ECB announcements on the perspective monetary policy stance had a time-varying impact on the marked-based inflation expectations, displaying a Delphic nature in early samples and an Odyssean one towards the end. The second contribution is to propose an approach that allows to separately identify the Delphic and Odyssean component of monetary policy announcements. The approach works as follows. We assume that monetary policy shocks can be isolated from the interest rates variations in a narrow window around the ECB interest rate decision and monetary policy press conference (as in Kuttner (2001) or Piazzesi (2002)). Following Gurkaynak et al. (2005), we assume that forward guidance shocks only affects future interest rates and do not affect the current rate. However, when looking only at interest rate variations it might be difficult to assess how agents interpreted the central bank announcement, i.e. as a bad or a good signal. To avoid this impasse, we add in the information set the variations in the market-based inflation expectations and isolate the Delphic and Odyssean component of forward guidance shocks by assuming different sign impacts on inflation expectations. In particular, we assume that a forward guidance shock has a Delphic nature if it raises the *slope* of the term structure of interest rates and generates a positive variation in inflation expectations (contemporaneously). A forward guidance shock is Odyssean when the opposite occurs. Since the latter generates an identified set, we consider the average impact to construct observable proxies of the Delphic and Odyssean forward guidance shocks. One interesting result is that the ECB forward guidance policies were not an important driver of the fluctuations in inflation expectations if we identify forward guidance as the unexpected movements in future interest rates, as in Gurkaynak et al. (2005). The contrary is true if we distinguish between Delphic and Odyssean forward guidance shocks and we find that they account for a non-negligible portion of volatility of inflation expectations. In particular, Delphic forward guidance shocks explain roughly more than 50% of the variations in inflation expectations at short horizons around the monetary policy press conference. The Odyssean forward guidance explain very little of the variations of inflation expectations at short horizons but it gets more important at medium/long term. The figures suggest that Delphic and Odyssean forward guidance shocks coexisted and they accounted for a large portion of fluctuations in inflation expectations.

We then offer a quantitative estimate of their dynamic propagation on output and prices using a Vector of Autoregression (VAR) model. We identify the transmission mechanism by instrumenting the reduced form VAR residuals with our observable measures of Delphic and Odyssean forward guidance shocks as in Mertens and Ravn (2013) and Stock and Watson (2012). In particular, the ECB announcements of the Odyssean type did have a statistically significant impact on prices and the dynamic transmission to the economy is substantially different to one obtained with an announcement that does not distinguish between the Delphic and Odyssean component. An Odyssean announcement of monetary policy accommodation (generating a decrease in the one year Euribor) depresses the harmonized consumer price level and the core price level, generates a depreciation of the euro. The impact on the economic activity is not statistically significant.

The paper is organized as follow. Section 2 presents a simple theoretical framework to characterize Odyssean and Delphic forward guidance shocks and their implication in terms of observable quantities. Section 3 reports the estimated impact of monetary policy announcements on market based inflation expectations and stock prices. Section 4 presents the identification strategy to tease Odyssean and Delphic forward guidance shocks apart. In section 5 we estimate their dynamic impact on macroeconomic aggregates. Section 6 concludes.

### 1.1 Related Literature

As mentioned, it is important to understand if forward guidance policies made private agents more optimistic or pessimistic about the future. However, the empirical evidence on the effect of Delphic and Odyssean forward guidance is limited. Moreover, the existence of these two types of shocks creates an identification problem for those studies that analyze how economic and financial variables respond to shifts in monetary-policy expectations without making this distinction, e.g. Gertler and Karadi (2015). However, teasing these two shocks apart is difficult. Campbell, Fisher, Justiniano and Melosi (Forthcoming) use the difference between the blue chip forecasts and the Greenbook forecasts as an observable proxy of information asymmetry. They interpret the latter as the amount of Delphic forward guidance contained in the monetary policy announcements. Similarly, Miranda-Agrippino (2015) propose to extract dynamic factors from a dataset including public and central bank (Greenbook forecasts) information set and to remove the predictability of the factors from the variation of rates around a narrow window of the monetary policy announcements. In either cases, their empirical approach is unable to extract an observable measure of Odyssean shocks. D'Amico and King (2015) consider a VAR with slow moving (quarterly) variables and survey data on expectations on interest rate, inflation and output. To identify Odyssean and Delphic shocks they impose different sign restrictions on the pattern of the expected short term rate on the one hand and the expected inflation and expected GDP on the other. This identification strategy is attractive because it isolates shocks in which Odyssean dominates Delphic guidance. Our approach is similar; we impose zero and sign restrictions to isolate these shocks. The main difference rests on the frequency of the observations. While they condsider slow moving variables, we focus on variations of expectations of interest and inflation rates in a narrow window around the monetary policy announcement.

## 2 Theoretical Background

To build intuitions about the effect of monetary policy announcements, it is instructive to consider the three equations textbook New Keynesian model, as presented in Woodford (2003) or in Nakamura and Steinsson (2013). The first equation of the NK model is the IS curve (derived from linearizing the Euler equation), which relates the current output gap with the expected output gap and the gap between the real rate and the natural interest rate, i.e.

$$x_t = x_{t+1,t} - 1/\sigma(i_t - \pi_{t+1,t} - r_t^n)$$

where $x_t$ is the output gap, $x_{t+1,t}$ is the expected output gap and $r_t^n$ is the real interest rate, i.e. the rate that would prevail if prices were fully flexible. Solving forward, we obtain an expression where the output gap is the sum of future deviation of the real interest rate from the natural rate of interest, i.e.

$$x_t = -1/\sigma \sum_{j=0}^{\infty}(i_{t+j,t} - \pi_{t+1+j,t} - r_{t+j,t}^n)$$

The second equation of the NK model is the Phillips Curve, linking current inflation with the future expected inflation and the output gap, i.e.

$$\pi_t = \beta\pi_{t+1,t} + \kappa x_t$$

where $\pi_t$ and $\pi_{t+1,t}$ are current and expected inflation rates. Solving this equation forward we obtain that current inflation can be expressed as the discounted sum of current and expected output gaps, i.e.

$$\pi_t = \kappa \sum_{j=0}^{\infty} \beta^j x_{t+j,t}$$

We assume that the central bank follows a very simple rule such that the real interest rate tracks the natural real rate with some error:

$$r_t = i_t - \pi_{t+1,t} = r_t^n + e_{t,t-j}$$

Absent any monetary shocks, the real interest rate will perfectly track the natural real rate and both the output gap and inflation will be zero.

A monetary policy announcement at time $t$ of - say - a monetary policy accommodation at time $t+N$ takes the form of a future decline in the real interest rate, i.e. the real interest rate will be lower for a single quarter $N$ quarters in the future, but maintained at $r_t^n$ elsewhere. That is

$$e_{t+N,t} < 0 \rightarrow r_{t+N,t+N} - r_{t+N,t+N}^n < 0$$

Given the IS curve dynamics, such announcement generates an increase in the current output gap, $x_t = -1/\sigma \ e_{t+N,t} > 0$, and by moving the IS curve forward, also the expected output gaps increase, $x_{t+j|t} = -1/\sigma \ e_{t+N,t} > 0$. Since inflation is purely forward looking, we have that inflation today and tomorrow increase. In particular, the current and expected inflation is a decreasing function in the horizon, i.e.

$$\pi_{t+j|t} = -\kappa/\sigma \frac{1-\beta^{N+1-j}}{1-\beta} \ e_{t+N,t}$$

for $j \leq N$ and expected inflation is zero behind the announcement horizon since agents expect the central bank to revert to the optimal rule, i.e. $\pi_{t+j|t} = 0$ for $j > N$. Accordingly, the nominal interest rates at various maturities are given by

$$\begin{aligned} i_{t+j,t} &= r_{t+j,t}^n - \kappa/\sigma \frac{1-\beta^{N-j}}{1-\beta} \ e_{t+N,t} \quad for \quad j < N \\ i_{t+N,t} &= r_{t+N,t}^n + e_{t+N,t} \end{aligned}$$

since $\pi_{t+N+1,t} = 0$, that is inflations expectations are zero behind the announcement horizon (i.e. agents expect the central bank to revert to the optimal zero inflation rule after $t+N$ periods). In the standard New Kenynesian model, the natural rate of interest is a linear combination of the structural exogenous shocks that describe technology and preferences. The expectations about the future exogenous shocks are typically linear projections of the current fundamentals of the economy, i.e. the current realization of the shocks. Therefore, one can express the $t+j$ step ahead forecast of the natural rate of interest, i.e. $r_{t+j,t}^n$, as a linear projection of the current value of the fundamentals, i.e.

$$r_{t+j,t}^n = \phi_j' \ \Omega_t$$

where $\Omega_t$ is the column vector collecting the current realizations of the fundamentals and $\phi_j$ is a column vector of convoluted parameters that project the fundamentals out-of-sample. Therefore, the $t+j$ step ahead expected nominal rates is given by

$$i_{t+j,t} = \phi_j' \; \Omega_t - \psi_j \; e_{t+N,t}$$

where $\psi_j = \kappa/\sigma \frac{1-\beta^{N-j}}{1-\beta} > 0$ for $j = 1, .., N-1$ and $\psi_N = -1$. The slope of the term structure of rates can be expressed as the difference between long and short rates, i.e.

$$i_{t+N,t} - i_{t+j,t} = (\phi_N - \phi_j)'\Omega_t + (1+\psi_j)e_{t+N,t}$$

Therefore, in this simple three equation NK model we can derive analytically the sign of the correlation between the slope of the term structure of interest rates and inflation expectations conditional on a monetary policy shocks, that is

$$corr\left((i_{t+N,t} - i_{t+j,t}), \pi_{t+j,t} \mid e_{t+N,t}\right) = -\kappa/\sigma \frac{1-\beta^{N+1-j}}{1-\beta}(1+\psi_j)\sigma_e^2 < 0$$

where we assume that shocks to the monetary policy and to the fundamentals are independent. Models with more shocks and more nominal and/or real frictions behave very similarly. Magnitudes are different, but the sign implications are unaffected (see the Appendix A.2 for details). In a narrow window around the monetary policy announcement, it is reasonable to assume that there are no major variations in the values of the fundamentals. This is our working assumption

**Assumption 1** *In a narrow window around the monetary policy press conference and interest rate decision, there is no variation in the value of the fundamentals, i.e.* $\Delta_\varepsilon \Omega_t = 0$*, where* $\varepsilon$ *denotes the window around the monetary policy announcement.*

In a model with perfect information all the variation in slope of the term structure of nominal interest rates is attributable to the monetary policy announcements, i.e.

$$\Delta_\varepsilon(i_{t+N,t} - i_{t+j,t}) = (1+\psi_j)e_{t+N,t}$$

In a model where the fundamentals are imperfectly or asymmetrically observed, agents needs to form estimates of the current state of the economy. Therefore, the change in the slope of expected nominal rates is given by

$$\Delta_\varepsilon(i_{t+N,t} - i_{t+j,t}) = \Delta_\varepsilon(\phi_{t+N} - \phi_{t+j})' \; \widehat{\Omega}_{t|t} + (1+\psi_j) \; e_{t+N,t}$$

where $\widehat{\Omega}_{t|t}$ is the nowcast of the fundamentals. Revisions in left hand side of the previous equation can be the result of the monetary policy announcement, but also the results of the agents' revision of their estimate of the current values of the fundamentals or the revision of their out-of-sample projections.

Two remarks are of order. First, if there are no major revisions in estimates of the current state of the economy or in their out-of-sample projections, $\Delta_\varepsilon(\phi_{t+N} - \phi_{t+j})' \; \widehat{\Omega}_{t|t} = 0$, then an observed decline in the slope of the term structure of future expected interest rates should lift expectations about inflation and output gap. This is the first testable implication that we wish to verify with the intra-day observations on interests rates, market based inflation expectations and stock market prices. In the following sections, we will also try to quantify the magnitude of the first term, i.e. $\Delta_{\varepsilon}(\phi_{t+N} - \phi_{t+j})' \ \widehat{\Omega}_{t|t}$. Second, if there are large asymmetries between the central bank's and the private agents' information sets, this might give rise to major revisions in the now-casts or in the projections. As a consequence, variations in interest rates are not uniquely mapped into the monetary policy surprise.

If, however, the response of the monetary policy rule to inflation is sufficiently strong, meaning that the central bank dislikes inflations, then optimistic or pessimistic revisions of the fundamentals should generate co-movements between expected inflation and interest rates. For the sake of the argument, assume first that there is an optimistic (pessimistic) revision in the demand component of the the economy, meaning that inflation and output gap are expected to be higher (lower) in the near future. If agents believe the central bank responds strongly to inflation, then expected future interest rates should raise as well and move in the same direction of the expected inflation rates. Assume that the revision has a supply component. An optimistic (pessimistic) revision would generate an decline (increase) in inflation expectations and an increase (decline) in the output expectations. If the central bank is more concerned of inflation than of output and agents know that, then we should observe an increase (decline) in expected interest rates and expected inflation. This means that an Odyssean monetary policy announcements can be identified when imposing restriction on the co-movement between inflation expectations and expected future rates. We can use this insight to separately identify Delphic and Odyssean monetary policy shocks.

## 3 Market-based Expectations on Interest Rates and Inflation

In this section, we assess empirically the ability of the ECB to communicate future policy intentions to the private sector. By using high frequency data on market interest rates we measure the changes in interest rate futures associated with ECB statements from January 2002 until January 2016. The construction of interest rate variations follows closely the works of Jardet and Monks (2014) for the Euro Area who draw insights from the analysis of Gurkaynak et al. (2005) for the US experience. The key idea is to isolate the variations in the current and future market interest rates at different maturities (up to two years) in a narrow window around the monetary policy decision and press conference. We estimate two factors that explain most of these variations, a target (intercept) factor that moves the current and expected policy rates and a path (slope) factor that only moves expected future rates and measure their impact on market based inflation expectations and stock market prices.

Various results emerge, all pointing at a substantial instability over time of the impact of the path factor on market based inflation expectations and stock price variations. In particular, we find that during the Trichet presidency an unanticipated increase in the path factor triggered an upward revision in the forecast of inflation. During Draghi presidency, we find that most of these impacts change signs and the monetary policy announcements had an Odyssean component, meaning that a decline in the expected rates triggered an increase in market-based inflation expectations and generated positive returns on stock prices. These time variations in the response of inflation expectation and stock market returns are unchanged when instead of considering arbitrary subsamples we use rolling estimates or local kernel estimators.

### 3.1 The impact of the ECB announcements on interest rates

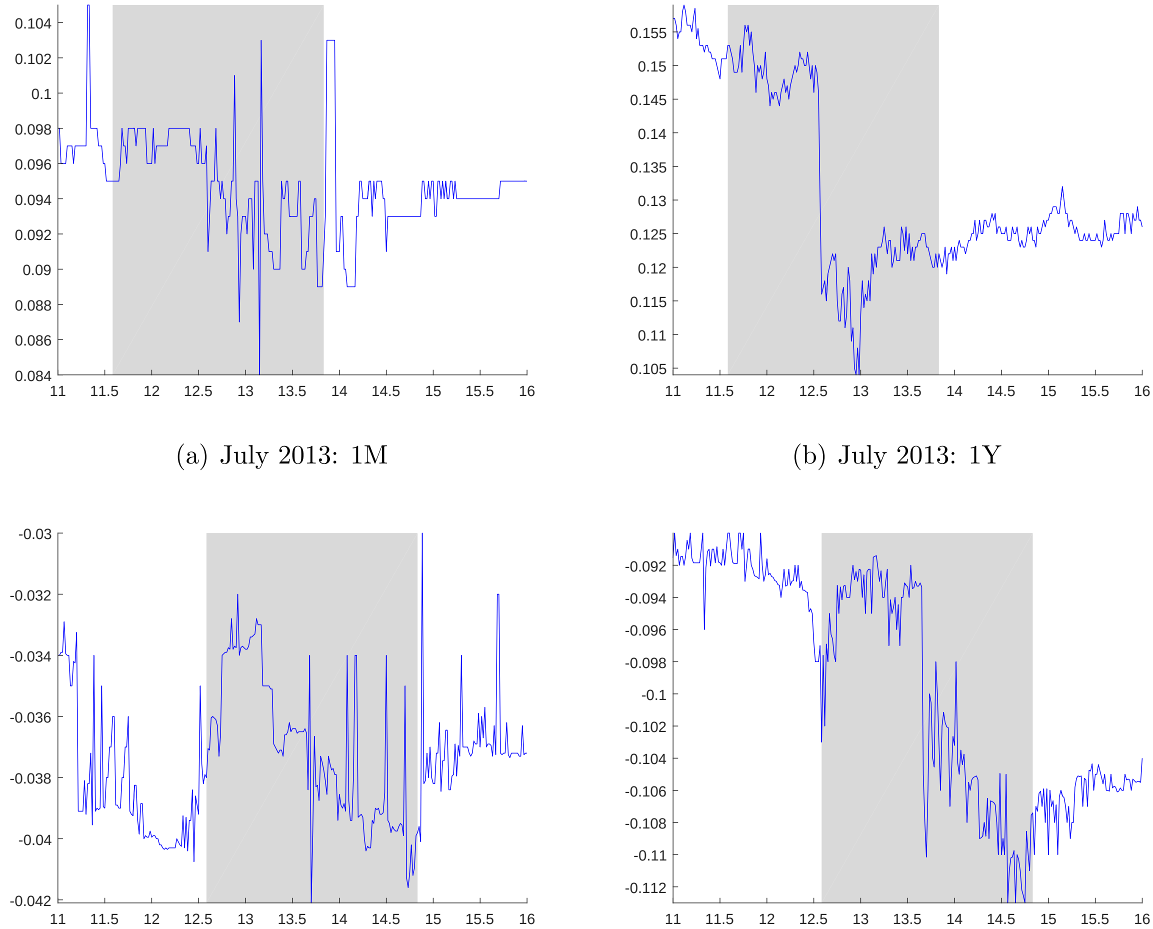
We consider the changes in the forward Overnight Index Swaps (OIS)[1] in a 30 minute window around the ECB's monthly interest rate announcements and conference press from January 2002 until January 2016. Forward OIS are commonly used to measure expectation of future path of EONIA and by having as a counterpart payment only the accrued interest rate payments they are less sensitive to fluctuations in the credit risk premia. The data are extracted from the Thomson Reuters Tick History application. The database consists of minute by minute mid-quote rates for OIS contracts of different maturities up to two years during the days of the ECB monetary policy announcements. We consider 8 maturities from the current month until 2 years ahead[2]. We calculate the difference of each OIS forward rate using 5-minute averages before the start and after the end of a window around the ECB interest rate announcement and press conference. In particular, the ECB interest rate announcement and monetary policy decision is posted on the ECB webpage at 13:45 and the press conference begins around 14:30 and lasts one hour. The conference usually starts with the reading of the introductory statements by the ECB President which contains the motivation of the monetary policy decisions and is followed by a Questions and Answers part. The length of the former ranges between 10 to 15 minutes and the rest of the time is allocated for the questions of journalists and participants. We thus define the identification window as beginning at 13:35 and ending at 15:50.

Figure 1 reports the fluctuations in the one month and the one year OIS fluctuations on the day of the ECB monetary policy decision and press conference in July 2013 and in January 2015. These dates are selected because are associated with key decisions taken by the ECB Governing Council. During the July 2013 press conference, President Draghi announced for the first time forward guidance, i.e. in the introductory statement we can

[1]The overnight indexed swap (OIS) is an interest rate swap where the periodic floating payment is generally based on a return calculated from a daily compound interest investment. The reference for a daily compounded rate is an overnight rate (or overnight index rate) and for the euro area is the EONIA rate.

[2]For each maturity, mid-quotes figures are transformed into forwards using the following formula

$$r_{t_1,t_2} = \left(\frac{(1+r_2)^{d_2}}{(1+r_1)^{d_1}}\right)^{\frac{1}{d_2-d_1}} - 1$$




(a) July 2013: 1M

(b) July 2013: 1Y

(c) January 2016: 1M

(d) January 2016: 1Y

Figure 1: One month (left) and one year (right) OIS fluctuations on day of the ECB press conference. Top panel, reports the July 2013 press conference day where forward guidance is announced, i.e. '[The GC] expects the key ECB interest rate to remain at present or lower levels for an extended period of time.' The bottom panel corresponds to the announcement of the full blown QE package. Gray shaded areas report the identification window.

read '[The GC] expects the key ECB interest rate to remain at present or lower levels for an extended period of time.' At 13:45 of the 22nd of January of 2015 the Governing Council announces the intention to implement a full blown QE with details on the duration and on the amount of asset to be bought. In both events, market reacted sharply.

The short term rate (1M OIS) did not display any particular patters and looks pretty erratic. Given the binding lower bound since 2012, this is not surprising. The one year OIS does present interesting variations. In July 2013, the Governing Council did not change the monetary policy stance, i.e. the monetary policy decision was to keep the monetary stance unchanged. However, during the introductory statement at the beginning of the press conference at 14:30 (12.5 in x-axis scale of the Figure 1)[3], the long term interest rate felt significantly, i.e. from 15 basis points to 10. On the 22nd of January 2015, we can notice

[3]Conversions of the CET GMT and the legal hour

a series of declines in the one year OIS, i.e. two sharp declines at 13:45 and at the beginning of the press conference and a steady and gradual one during the Questions and Answers part. This seems to suggest that not only the announcement of QE moved markets prices and expectations but also the motivations behind this choice. The time series cumulative variations of OIS futures are plotted in figure 9 top panel. A few comments are of order. OIS futures cumulative variations with short maturities, i.e. current month (0-30), next month (30-30) and next quarter (90-90), tend to be fairly stable along the full sample; particularly so towards the end of the sample where the zero lower bound was clearly binding. OIS futures cumulative variations with longer maturities, display downward sloping trends, with two large episodes of sudden decline at the end of 2008 and in the middle of 2011.

From the term structure of variations in OIS forward rates we extract the first two principal components that explain the largest portion of variation in the standardized dataset. The identification of the factors is performed by rotating the factors in such a way that the second factor (path) explains the variation in all OIS future contracts but the current month interest rate variation[4]. Both estimated and rotated factors have zero mean and zero autocorrelation and partial autocorrelation functions, and by construction they are orthogonal to each other (see figure 5). Figure 6 reports the cumulative path factor along with two observable measures that turned out to be correlated with the future monetary policy stance, i.e. the spread between the current month and the one-year hence OIS future and the leading excess liquidity. Gray areas represent periods of a sequence of negative shocks, interpretable as periods of monetary policy easing. The top panel reports the estimated path factor and the spread between the OIS futures with one month and one-year hence maturities, which could serve as a rough proxy for the slope of the term structure of expected interest rates. The cumulated series tend to comove and the correlation coefficient between the path factor and the spread is significant of the order of 0.42.

One interesting exercise is to assess the relative contribution of each identified factor in explaining the volatility of the OIS futures at various maturities. The first two columns of table 4 reports the fractions of innovation variance of each interest rate futures contract rate that are due to the identified target factor and to the identified path factor over the sample period of January 2002 until January 2016. The variance is computed as the $R^2$ of the regression of each future contract on the target or path factor respectively. The path factor accounts for no changes in the current month interest rate and it accounts for only 17 % of the variance in the interest rate expected for the next month. The target factor accounts for nearly all of the remaining variance from these two contracts. The path and the target factors each explain about 40-50 % of the variance in interest rates expected for the next quarter. Finally, the path factor dominates in explaining the volatility of OIS futures contract expected at maturities longer two quarters. The remaining columns of table 4 carry

[4]We normalize the target factor loadings on the current OIS rates and the path factor loading the one-year-ahead future to unity. GSS and JM use a slightly different normalization. This normalization has no impact on the variance decomposition and statistical significance.

the same information using two different sub-sample periods. In particular, we consider the ECB announcements during the Trichet presidency, i.e. from January 2002 until October 2011, and the ECB announcements during the Draghi presidency, i.e. from November 2011 until January 2016. The two subsamples are chosen because characterized by very different economic episodes. The large swings in oil prices preceding the Great Recession, the global financial turmoil of 2009, the Euro Area sovereign debt crisis, and the short term rates hitting the zero lower bound and a novel set of unconventional monetary policy tools implemented by the ECB. Moreover, one could also argue that the communication strategy of the ECB has adapted to this changing environment, moving form a 'no pre-commitment' attitude as it was the case during the Trichet presidency towards more forward looking statements and commitments. This is somehow reflected in column 4 and 6 of table 4 where the portion of variance explained by the path factor for OIS future contracts at long horizons larger during Draghi presidency. For example, the path factor explains 55 % of the volatility the one year and half ahead OIS future contracts during Trichet and 78% during Draghi.

### 3.2 The predictability of ECB monetary policy

Before treating these observed measures as proxy of the exogenous shits in the current and future stance of monetary policy, it is important to assess if they are indeed exogenous and cannot be predicted using the available information set immediately before the conference. In other words, can the variations in the target and path factors be explained by the information available the month before the press conference ? If so, then the monetary policy shocks we are trying to measure cannot be treated as 'surprise' or exogenous. The predictability of target and path factors would invalidate our identification procedure since part of their variations would come from variations in the systematic part of the monetary policy reaction functions and not from an exogenous shift in the monetary policy stance, see Ramey (2016) and Miranda-Agrippino (2015) for critical reviews.

One simple way to test the predictability is to project the the path and target factors onto a set of variables intended to capture the information set common to the central bank and the agents. Let $\eta_t$ be the vector containing the path and path factor and let $X_t$ a vector collecting a number of macroeconomic and financial variables. We define the following system

$$X_t = \Lambda \mathbf{f}_t + u_t$$
$$\eta_{t+1} = \mathbf{f}_t' B + e_{t+1}$$

where $e_t$ and $u_t$ are i.i.d. uncorrelated shocks, and $B$ is the matrix that loads the factors onto the monetary policy surprises. If $B$ is statistically significant, then monetary policy surprises can be predicted by using past common information.

The test is run in various steps. We first extract the first principal components that explains about 70 percent of the volatility of the entire data set. Factors are extracted on a rolling basis in order to avoid including the information available after the announcement.

In a second step, we regress the path and target factors on the lagged factors and look at the $F$ and $t$ statistics to test for statistical significance. $X_t$ contains the set of observables whose realizations are known before the announcement. About 40 variables are considered, ranging from macro data, financial variables and to surveys. The variables selection is pretty standard for the Euro Area and mimics the choices in Banbura and Modugno (2014). More details on variables selection and transformation is reported in the appendix, see table 5.

| | P values | | | |
|---|---|---|---|---|
| | Full | | Only Financial | |
| | Target | Path | Target | Path |
| $c$ | 0.3911 | 0.3613 | 0.3131 | 0.396 |
| $f_1$ | 0.2805 | 0.398 | 0.3706 | 0.3981 |
| $f_2$ | 0.1394 | 0.3393 | 0.1847 | 0.2651 |
| $f_3$ | 0.0933 | 0.3937 | 0.2361 | 0.3725 |
| $f_4$ | 0.3048 | 0.3859 | 0.3485 | 0.3918 |
| $f_5$ | 0.0174 | 0.2858 | | |
| $f_6$ | 0.2748 | 0.384 | | |
| $f_7$ | 0.2245 | 0.2066 | | |
| $f_8$ | 0.3882 | 0.3122 | | |
| F test | 1.4981 | 0.3927 | 0.8504 | 0.2496 |

Table 1: Predictability of monetary policy announcements. P-values of the regression of the paths and target factors on macroeconomic and financial lagged factors. Last raw reports the F statistics.

Table 1 reports the individual p-values of the coefficients of the regression of the paths and target factors on lagged macroeconomic and financial factors or only lagged financial factors. Last row reports the the F test of the joint statistical significance. Overall, the public available information seems to explain very little of the the interest rates variations in a narrow window around the monetary policy press conference. If anything, one macro factor appears to be statistical influential in explaining the target factor. However, monetary policy announcements about future monetary policy actions (path factor) are not predictable using past information. This ensures that only unsystematic policy changes are used, and that, to the extent that monetary policy typically moves in response to changes in macroeconomic and financial conditions, past target rates are a sufficient measure of the state of the economy.

### 3.3 Information Asymmetries

While factors are not predictable using the information available to the private sector and to the central bank, Campbell et al. (Forthcoming) raised the concern that private and central banks information set might not be the same before the conference press. Some authors argue that the central bank can process more information relative to the private sectors. Agents might then close the information asymmetry gap during the conference press and

| | R2 | P-values | | | | | F test |
|---|---|---|---|---|---|---|---|
| | | Const | HICP | HICP(+1) | RGDP | RGDP(+1) | |
| target | 0.05 | 0.38 | 0.40 | 0.38 | 0.36 | 0.27 | 0.70 |
| path | 0.02 | 0.20 | 0.39 | 0.31 | 0.39 | 0.40 | 0.22 |

Table 2: Monetary policy surprises and Information gaps. Information gaps are derived by taking the difference between the SFP and the ECB current or next year forecast of Real GDP and HICP.

revise their expectations about the future. If this is the case, then variations in interest rate do not reflect exogenous monetary policy shocks and they are rather the result of information sets adjustments. If we had an empirical measure of information asymmetry, then we could clean the monetary policy surprises extracted from interest rate futures variations from the adjustments in private and central bank information sets.

The problem is that it is not easy to measure information sets. Focusing on the UK and the US interest rate markets, Miranda-Agrippino (2015) proposes to extract a number of factors from a database that includes also variables only available to the central bank, i.e. Greenbook forecasts and Bank of England projections. Campbell et al. (Forthcoming) use the difference between the blue chip forecasts and the Greenbook forecasts as an observable proxy of information asymmetry. They interpret the latter as the amount of Delphic forward guidance contained in the monetary policy announcements. We follow the Campbell et al. (Forthcoming) and construct an observable proxy for the Euro Area. We consider inflation and real GDP forecasts obtained from the the Survey of Professional Forecasters as a measure of private sector forecasts and from the Eurosystem staff projections for the euro area as a measure of central bank forecasts[5]. Tables 8 and 9 report the available figures at quarterly frequency. We define the difference between the ECB and SPF forecasts for the current year and the next year as a measures of information discrepancy. We have in total four times series. We then regress the target and path factor on these (lagged) gaps and report the results in Table 2. Regression results are poor. $R^2$ are low and either singularly or jointly we fail to reject the singularity of coefficients.

Even if we do not find evidence of statistical significance, we are a bit reluctant in ruling out the hypothesis that the Delphic forward guidance is negligible. It might well be the case that our measure is a poor proxy of the information gaps and we lack good measure of Delphic forward guidance. However, as we will show next, an alternative approach is available to extract the Dephic and Odyssean component of the ECB forward guidance.

[5]Tables can be downloaded from the ECB webpage. See
https://www.ecb.europa.eu/mopo/strategy/ecana/html/table.en.html and
http://www.ecb.europa.eu/stats/prices/indic/forecast/html/table_hist_hicp.en.html

### 3.4 The impact of ECB announcements on inflation expectations

Have the ECB forward guidance made market participants more optimistic or pessimistic ? To answer this question, we gather the daily average figures on Inflation Linked Swaps (ILS) at various maturities as proxies for market-based inflation expectations. Inflation-linked swaps are an outstanding source of information about private sector inflation expectations, particularly for short-term horizons. An ILS is a contract, which involves an exchange of a fixed payment (the so-called 'fixed leg' of the swap) for realised inflation over a predetermined horizon. Thus, through the construction of the contract, the fixed swap rate provides a direct reading of the market's expected inflation rate. They are available daily over a wide range of horizons. An alternative financial market indicator is the break-even inflation rate, which is calculated as the yield spread between nominal and inflation-linked bonds. In contrast, inflation-linked swaps: (i) do not require the estimation of nominal and real term structures, thereby avoiding problems related to the limited number of bonds at short maturities; (ii) are less prone to liquidity distortions resulting from turbulence in financial markets than break-even inflation rates; (iii) are less affected by HICP seasonality than than break-even inflation rates, and are therefore more suitable for monitoring inflation expectations at short horizons. ILS, as with all market-based indicators of inflation expectations, may include an inflation risk premium component to compensate investors for the risks surrounding inflation expectations over the forecast horizon. Available euro area evidence suggests that such a premium increases with maturity, but remains very limited in size and variability at the horizons considered, see Garcia and Werner (2010). In the specific case of the euro area, the ILS market has grown rapidly since 2003, reflecting the increasing demand for inflation-linked instruments and the relatively limited supply of index-linked bonds. We consider the variation in a one- and two-day window around the ECB monetary policy press conference and decision. Figure 9 reports the cumulative changes of the ILS from June 2004 until January 2016. Except for the one year ILS which looks clearly an outlier, they share common features; they are aligned until the 2009, and since then they decoupled showing different behavior. In particular, short term maturities (2-5 years) display an inverse U-shaped patterns and long term maturities (8 to 12 years) have an increasing pattern (see figure 10).

How much of these variations are due to changes in the target and path factor? Table 6 reports the coefficient estimates of the regression of the one- or two-day variations of the inflation linked swaps on the path and the target factors for the full sample and for different subsamples. A number of interesting results are worth highlighting. First, only few coefficients loading the target factor are statistically significant, typically at short horizons. When significant, they have negative signs, meaning that an increase in the target factor generates a decline in the the 2 and 3 years ILS for the two-day window and from the two-to the five-year ILS for the one-day window, which is consistent with the announcement of a monetary policy tightening. Interestingly, these results hold for the full sample and the Trichet period, but not for the Draghi presidency. Second, the path factor which captures the announcements of future monetary policy is significant at any horizon. Third, the path factor has a positive impact on the Trichet period and negative during the Draghi subsample. This suggests that, while for the first subsample the ECB announcements are characterized by a strong Delphic attitude, our estimates for the second subsample indicate that response of market-based inflation expectations to monetary policy becomes negative and therefore the Delphic component found for the previous episodes vanishes. The sign found for the second subsample is consistent with an Odyssean form of forward guidance and in line with a number of public statements characterized by future commitments on the monetary policy stance. As mentioned, in July 2013 the Governing Council of the ECB provided forward guidance on the future path of the ECB policy interest rate conditional on the outlook for price stability. Since then, the Governing Council 'firmly reiterated' its forward guidance in January and February 2014. On 6 March 2014 the Governing Council reinforced the guidance formulation by spelling out more precisely the conditions for a low interest rate policy. Announcements about the stance of monetary policy also includes the communication of large asset purchases programs and various form of Quantitative Easing (QE). For example, the announcement of public sector purchase program (PSPP) was disclosed during the January 2015 conference press and it was coupled with the announcement of the indicative duration, i.e. 'until September 2016, and in any case until the Governing Council of the ECB sees a sustained adjustment in the path of inflation which is consistent with our aim of achieving inflation rates below, but close to, 2% over the medium term'. All these statements were interpreted by market participant as a commitment device on future monetary policy accommodations.

More precisely, our estimates indicate that since November 2011 the ECB announcements generating a 1 percent reduction in the one-year OIS future were able to generate an increase in inflation swaps of roughly 60 basis points if we consider the two-days window variation. On a similar ground, the impact of the path factor on stock market prices has been relatively unstable in the two subsamples. Table 7 reports the impact of the path and target factors on the percentage variation in the Euro Stoxx 50 during the ECB conference press. We clearly see significant differences among the two sub periods. In the full sample and during the Trichet presidency announcements about the likely course of the key policy interest rates did not generate statistical significant variation in the stock market prices. If wee focus our analysis on the Draghi presidency we observe that a one percent decline in the one year OIS future triggers a statistically significant 10% increase in the Euro stoxx 50.

To gauge more evidence on the possible time variation in the impact of the path factor on ILS and stock market prices we have conducted two complementary exercises where we do not arbitrarily select the subsamples. The first exercise is based on rolling window regression and the second on local kernel regression which has the advantage of smoothing the abrupt time variation of the rolling window estimates. The local kernel regression is a form of rolling regression with a different data weighting scheme. More formally, for each $\tau = 1, .., T$ we minimize the following residual sum squares

$$\sum_{t=1}^{T} K_f(\frac{t-\tau}{h})(ILS_{j,t} - \eta_t' B_\tau)$$

where $K_f(.)$ is the Gaussian kernel function and $h$ is the bandwidth, where $\eta_t$ collect the path and target factors. Data points far form $\tau$ will have small weights, yet non zero as in the rolling window[6].

Figures 7 and 8 reports the rolling sample estimates of the impact of the path factor on the stock market prices and on market-based inflation expectations. In particular, the blue solid and dashed lines reports the mean estimates along with the 90% confidence bands of the impact of the path factor on the ILS in a 24 month window. The gray areas report the same information using a local linear kernel estimator. Both approaches offer the similar reading of the impact of ECB announcements. While in the central part of our sample the ECB communication had a Delphic component, last part of the sample is dominated by the Odyssean forward guidance.

## 4 Identifying the Delphic and Odyssean component of ECB announcements

The results of the previous sections highlighted the fact that the path factor (i.e. variations in the slope of the interest rates term structure) had varying impact on the Euro Area inflation expectations and stock market prices. When using only the information of the variations in the OIS future contracts, we are unable to tease Delphic and Odyssean forward guidance shocks apart. However, if we introduce in the dataset also the measures of inflation expectations, we can exploit the opposite signaling implications that Delphic and Odyssean shocks have as a device to separately identify them.

To this aim, we pool together variations in the OIS futures and in the ILS, and extract three factors. We rotate the factors so that the second and the third factor do not influence the current month OIS. Moreover, we assume that the second factor has a positive impact on the one year OIS future and on the five year ILS, and the third factor has a positive impact on the one year OIS future and negative on the five year ILS[7]. The second factor can be interpreted as a Delphic forward guidance shock and the third factor as an Odyssean forward guidance shock.

More precisely, let $Y$ be a $T \times k$ matrix containing the OIS and ILS variations. We assume that the data are generated by the following factor structure,

$$Y = F\Lambda' + e = \eta(\Lambda H)' + e$$

[6] We use the optimal bandwidth as suggested by Bowman and Azzalini (1997). Since the weighting scheme is known, standard weighted least square methods can be used to estimate the parameters, $B_\tau$.

[7] Details on the identification with zero and sign restrictions can be found in the appendix A.1.

Without loss of generality, assume that the ordering of the variables in the $Y$ matrix is the following: current month OIS, one year ahead OIS, 5 year ILS and then all the remaining variables. Our identification is achieved assuming that $\Lambda H$ has the following structure

$$\begin{pmatrix} OIS_{1M,t} \\ OIS_{1Y,t} \\ ILS_{5Y,t} \\ \vdots \\ * \end{pmatrix} = \begin{pmatrix} * & 0 & 0 \\ * & + & + \\ * & + & - \\ \vdots & \vdots & \vdots \\ * & * & * \end{pmatrix} \begin{pmatrix} \eta_t^t \\ \eta_t^d \\ \eta_t^o \end{pmatrix} + e$$

Table 4 reports the decomposition of the variance of the changes in the OIS and ILS contracts in terms of target shocks, forward guidance shocks and when we distinguish between Delphic and Odyssean forward guidance.

| | Target | Path | Delphic | Odyssean |
|---|---|---|---|---|
| OIS 0-30 | 84 | 1 | 0 | 0 |
| OIS 30-30 | 72 | 22 | 9 | 5 |
| OIS 90-90 | 50 | 53 | 25 | 9 |
| OIS 180-90 | 34 | 70 | 38 | 10 |
| OIS 270-90 | 21 | 82 | 44 | 13 |
| OIS 360-90 | 23 | 79 | 33 | 14 |
| OIS 450-90 | 16 | 80 | 35 | 17 |
| OIS 540-90 | 15 | 58 | 22 | 13 |
| OIS 630-90 | 6 | 61 | 25 | 16 |
| ILS 1Y | 1 | 8 | 46 | 1 |
| ILS 2Y | 2 | 6 | 68 | 5 |
| ILS 3Y | 4 | 8 | 72 | 7 |
| ILS 4Y | 1 | 4 | 64 | 18 |
| ILS 5Y | 0 | 10 | 62 | 24 |
| ILS 6Y | 0 | 12 | 67 | 19 |
| ILS 7Y | 0 | 6 | 61 | 28 |
| ILS 8Y | 0 | 7 | 57 | 30 |
| ILS 9Y | 0 | 6 | 52 | 37 |
| ILS 10Y | 1 | 7 | 41 | 43 |
| ILS 12Y | 1 | 12 | 41 | 33 |
| ILS 15Y | 0 | 5 | 34 | 48 |

Table 3: Decomposition of the Variance of Changes in OIS futures and ILS in terms of path, target, Delphic and Odyssean factors.

Table 4 contains interesting results. First, the path factor seems to explain very little of the variation in ILS, typically less then 10%. This means that if one considers only the path factor she would conclude that the ECB forward guidance policies were not an important driver of the fluctuations in inflation expectations. This is not the case if we distinguish between Delphic and Odyssean forward guidance shocks. In fact, they had a non-negligible impact on inflation expectations. In particular, Delphic forward guidance shocks explain roughly more than 50% of the variations in ILS around the monetary policy press conference. While Odyssean forward guidance explain less than the Delphic one, its contribution is not negligible. Interestingly, it is small at short horizons and gets more important at medium/long term. These figures suggest that Delphic and Odyssean forward guidance shocks coexisted and they canceled out over the full sample if one focuses on a specific linear combination of them (e.g. the path factor).

Figure 11 reports the cumulated Delphic (red) and Odyssean (blue) forward guidance shocks in the top panel and in the bottom panel cumulative variation in the five year ILS. Periods of downward sloping trend correspond to period where OIS futures at long maturity decline, which can be interpreted as periods of monetary policy accommodation. For the Delphic shock, we observe a period of tightening from the end of 2006 up until middle of 2008. Then, a sequence of sharp accommodating episodes resulting in a decline form the end of 2008 until the end of 2012. Since then, a gradual tightening again. The Odyssean forward guidance shock has displayed less clear-cut trends. Given our identification strategy, periods

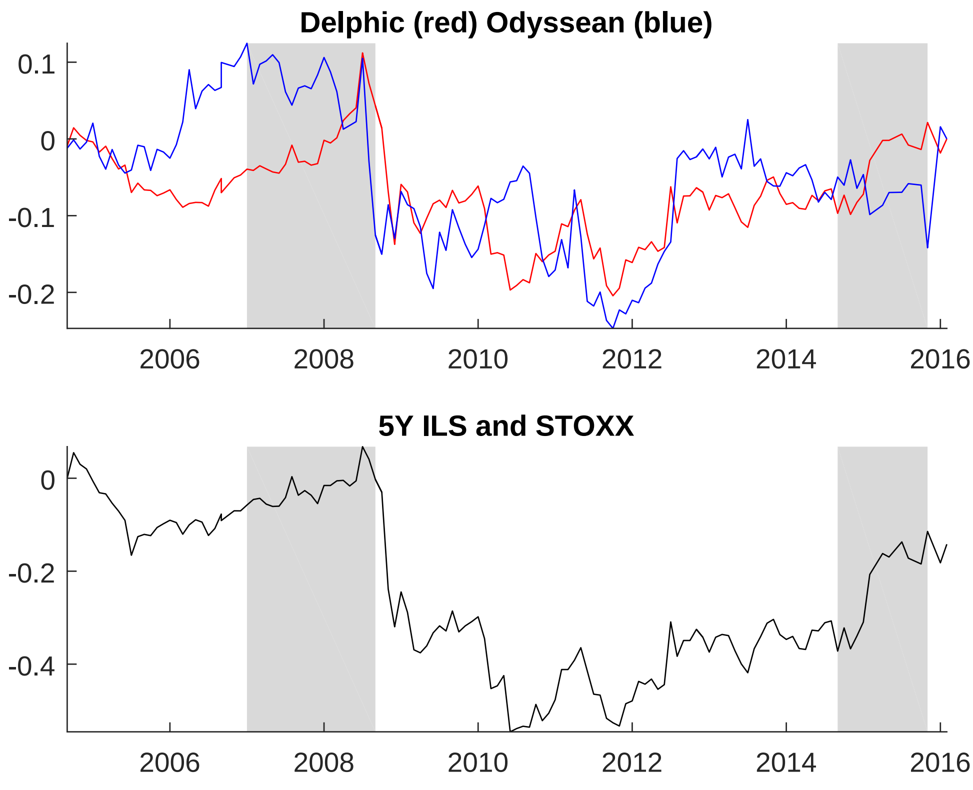



Figure 2: Delphic and Odyssean FG shocks and the 5 year ILS

characterized by diverging paths of Delphic and Odyssean shocks generate either an increase or a decrease of ILS, whereas periods of comovement between Delphic and Odyssean shocks have an ambiguous effect on ILS. There are two episodes of diverging paths identified as the shaded areas in figure 2: (1) from middle of 2007 until the middle of 2008 (Delphic increasing and Odyssean decreasing), (2) from the middle of 2014 until end of 2015 (Delphic increasing and Odyssean mildly decreasing). Given the sign restrictions that we have imposed, both episodes generate an increase in ILS, which is what we observe in the the five-year ILS.

## 5 The macroeconomic impact of Odyssean monetary policy surprises

What are the dynamics impacts of the identified measures of monetary policy announcements on macroeconomic variables ? A popular way to measure the dynamic transmission of macroeconomic shock in general and monetary policy shock in particular is by means of Vector of Autoregression models, see Ramey (2016) for an overview. VAR models assume that the joint co-movements of the macroeconomic variables can be described by linear lag structure order $p$ which take the following form

$$y_t = \Phi_0 + \Phi_1 y_{t-1} + ...\Phi_p y_{t-1} + e_t \quad e_t \sim N(0, \Sigma)$$

where $y_t$ is a vector that contains the observable variables and $\epsilon_t$ is a vector of normal zero mean i.i.d. shock with $\Sigma = E(\epsilon_t \epsilon_t')$. $\Phi_0, \Phi_1, ..., \Phi_p$ are matrices of appropriate dimensions describing the dynamics of the system. We can rewrite the VAR in a companion form, i.e. $y_t = x_t'\Phi + e_t$, where $x_t = [y_{t-1}', ..., y_{t-p}', 1]'$ and $\Phi$ is the companion form matrix, and estimate the parameters of interests either with classical estimators or using a Bayesian approach. Under the assumption of normal distribution of the residuals, the reduced form VAR is compatible with several structural representations where reduced form shocks can be expressed as linear combination of structural uncorrelated innovation, i.e.

$$e_t = \Omega \nu_t$$

where $\Omega\Omega' = \Sigma$, $E(\nu_t \nu_t') = I_n$. Since the likelihood of the data is flat along the $\Omega$ matrix dimension, additional restrictions are need to identify the structural shocks.

Following Mertens and Ravn (2013) and Stock and Watson (2012), we map the reduced form VAR residuals with the structural shock of interest by *instrumenting* the VAR residuals (observable) with a measurable proxy of the structural shock (unobservable). In our context the proxy of monetary policy shock is given by the Delphic and Odyssean forward guidance shocks extracted from the high frequency data as discussed in previous sections. Gertler and Karadi (2015) applied this methodology to study the transmission of FOMC announcements on prices, output and the credit spread using an small scale VAR estimated with classical inference. Similarly, Miranda-Agrippino (2015) used this framework to measure the transmission of orthogonal monetary policy surprises in the United Kingdom. None of them however tried to isolate the Odyssean component of monetary policy announcements and measure its impact.

The basic idea of the structural VAR with external instrument is that the monetary policy shock in the structural VAR is identified as the predicted value in the population regression of the instrument on the reduced form VAR residuals. For this result to hold, the instrument needs to be valid; that is it needs to be relevant (correlated with the unobserved monetary policy shock of the VAR) and exogenous (uncorrelated with the other shocks). This approach allows to recover the the first column of the rotation matrix $\Omega$, and thus to recover impulse responses and transmission mechanism. More formally, let $m_t$ be the time series proxy for the unobserved structural shock. Assume without loss of generality that the proxy is linked to the first shock as follows

$$E(\nu_t m_t) = [\rho, 0, ..., 0]'$$
$$E(\Omega\nu_t m_t) = \Omega[\rho, 0, ..., 0]'$$
$$E(e_t m_t) = \rho[\Omega_{11}, \Omega'_{2:N,1}]'$$

Assuming that the first reduced form shock is related to the observed proxy, we can partitioning the two set of relationship and obtain

$$E(e_{2,t}m_t)E(e_{1,t}m_t)^{-1} = \Omega_{11}^{-1}\Omega_{2:N,1}$$

where the second equation is estimable using the sample analog since $m_t$ is observable, $e_t$ is observable conditional on $\Phi$ and $\Sigma$ and they are both stationary. This restriction coupled with the fact that $\Omega\Omega' = \Sigma$ give rise to a set of equations that up to a sign normalization uniquely pin down the first column of the rotation matrix. The econometric approach works as follows. We first run the VAR OLS regression to obtain $\Phi$ and $\Sigma$. We then isolate the variation in the reduced-form residual of the policy indicator that is attributable to the proxy. We then regress the remaining reduced-form residuals on the fitted value of the first regression. This two stage regression allows to recover the first column of the rotation matrix, and thus to recover impulse responses and transmission mechanism of the monetary policy surprises. To obtain the confidence bands around the impulse response we follow Mertens and Ravn (2013) and run a wild bootstrap of the VAR residuals.

The VAR dataset includes the 1 year Euribor, HICP, HICP excluding oil and commodity prices, Industrial Production Index (without the construction sector), total outstanding loans, M3, and the real effective exchange rate from January 2002 to January 2006. Figures 3 report the estimated impulse responses of the Odyssean monetary policy announcement and a generic monetary policy announcement. They are dramatically different. We find that an announcement of future monetary policy tightening interpreted as Odyssean decreases the price level, increases the real effective exchange rate, but has not effect on industrial production. The impact on the price level is delayed reaching the maximum impact after 15 months. In terms of magnitude, an announcement that triggers an increase in the one year Euribor of 4 basis points generates a decline in the price level whose trough is located after 15 months at - 6 basis points. A generic monetary policy announcements have a dynamic impact which is counterintuitive. An announcement of tightening generates a boom on impact, i.e. prices and output increases on impact and become negative only after 20 months. Impulse responses to a monetary policy shock identified using the orthogonal proxies are shown to be in line with economic theory and less reliant on the composition of the VAR information set and the sample considered even in small, potentially informationally insufficient VARs.

## 6 Conclusions

We study the Delphic and Odyssean component of forward guidance shocks. We propose an approach to separately identify them and we measure their dynamic impact on the euro area macroeconomic aggregates. Two findings emerge. First, the ECB announcements were read as a signal about the economic conditions in the central part of our sample and in latest episodes they have been interpreted as a commitment device on future monetary policy accommodation. Second, we showed that euro area macroeconomic aggregates responded very differently from a generic forward guidance impulse and from an Odyssean monetary policy impulse. In particular, in the former case an announcement of tightening generates a boom on impact, i.e. prices and output increases on impact. In the latter, an announcement of future monetary policy tightening interpreted as Odyssean decreases the price level, increases the real effective exchange rate, but has not effect on industrial production. The impact on the price level is delayed reaching the maximum impact after 15 months.

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# A Appendix

## A.1 Identification with zero and sign restrictions

Let $X$ be a $T \times k$ matrix containing the OIS and ILS variations. We assume that the data are generated by the following factor structure,

$$X = F\Lambda' + e$$

where $F$ is a $T \times 3$ matrix containing the unobserved factors, $\Lambda$ is a $k \times 3$ matrix of factor loadings, $e$ is a matrix of iid normal shocks of appropriate dimension. We extract factors and loadings using PCA. We rotate the factor using an orthonormal matrix $H$ (i.e. $HH' = H'H = I$) so that

$$Z = FH$$

Substituting the latter equation into the factor model we obtain

$$X = Z(\Lambda H)' + e$$

Without loss of generality, assume that the ordering of the variables in the X matrix is the following: current month OIS, one year ahead OIS, 5 year ILS and then all the remaining variables. Our identification is achieved assuming that $\Lambda H$ has the following structure

$$\Lambda H = \begin{pmatrix} * & 0 & 0 \\ * & + & + \\ * & + & - \\ \vdots & \vdots & \vdots \\ * & * & * \end{pmatrix}$$

where asterisk indicate a number. Imposing the zero and sign restrictions on $\Lambda H$ is equivalent to imposing the zero and sign restrictions on $\Lambda_{3:3}H$ which is the top $3 \times 3$ submatrix of $\Lambda H$. In order to obtain the desired rotation, we proceed in two steps. We first obtain the Cholseky decomposition of $\Lambda_{3:3}\widetilde{H}$, i.e.

$$\Lambda_{3:3}\widetilde{H} = \begin{pmatrix} * & 0 & 0 \\ * & * & 0 \\ * & * & * \end{pmatrix}$$

and recover $\widetilde{H}$ by

$$\widetilde{H} = \Lambda_{3:3}^{-1} chol(\Lambda_{3:3}\Lambda_{3:3}')$$

since $\Lambda_{3:3}\Lambda_{3:3}' = \Lambda_{3:3}\widetilde{H}\widetilde{H}'\Lambda_{3:3}'$. We then rotate the $\widetilde{H}$ matrix using the Givens rotation such that the structure of $\Lambda H$ is preserved. More formally,

$$\widetilde{H}Q(\theta) = H$$

where

$$Q = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{pmatrix}$$

This rotation will leave unchanged the first row and column of $\Lambda_{3:3}\widetilde{H}$, thus preserving the zero restrictions. We consider a grid of values for $\theta$ ranging from 0 to $\pi$ with a 0.05 step. For each of these values we keep the rotation if the sign in $\Lambda\widetilde{H}Q(\theta)$ are satisfied. We then consider the average of the accepted rotations, $H_m = \Lambda_{3:3}^{-1} 1/J \sum_j^J \Lambda_{3:3}\widetilde{H}Q(\theta^{(j)})$.

### A.2 Extension: Smets and Wouters (2007) model

This section provides a quantitative exploration of the correlation between the slope of the term structure of interest rates and inflation expectations conditional on monetary policy announcements in a medium scale DSGE model. We consider the baseline version of the Smets and Wouters (2007) model (henceforth SW). This model is selected because of its widespread use for policy analysis among academics and policymakers, and because it is frequently adopted to study cyclical dynamics and their sources of fluctuations in developed economies. We retain all the nominal and real frictions originally present in the model.

Since we cannot solve the model analytically, we need to rely on specific exercises. We assume that the monetary policy authority announces that in one year time the policy (nominal) interest rate $r_t$ will be higher. More precisely, since the SW model is quarterly, we postulate that the nominal short term interest rate will be increased by five basis points in four periods time. We compute the trajectories of inflation expectations, $E_t\pi_{t+j}$, and of the slope term structure of interest rates, $E_t r_{t+j} - r_t$ (where $r_t$ is the short run nominal interest rate), in response to this monetary policy tightening. In order to show that these results are not driven by a specific parameter value combination, we draw random numbers from the priors indicated in SW.

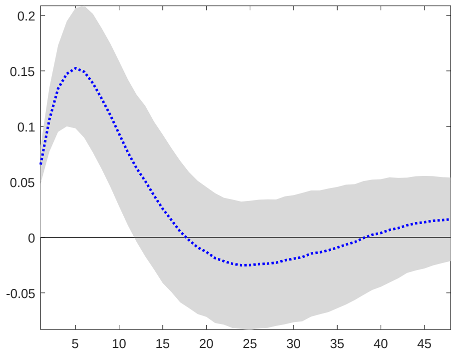
In Figure 4 the gray ares reports all the possible trajectories for the slope of the the term structure of rates, $E_t r_{t+4} - r_t$, and the inflation expectations $E_t\pi_{t+j}$ for $j+1, ..., 4$ of such announcements. Following the announcement of tightening, the slope of the interest rate term structure increases and inflation expectations rise. Hence, the correlation conditional on monetary policy announcement is negative.

| | Variance Decomposition | | | | | |
|---|---|---|---|---|---|---|
| | Full | | Trichet | | Draghi | |
| | Target | Path | Target | Path | Target | Path |
| Current month (0-30) | 85 | 0 | 84 | 0 | 93 | 0 |
| Next month (30-30) | 66 | 17 | 66 | 17 | 67 | 19 |
| Next Quarter (90-90) | 42 | 49 | 44 | 49 | 27 | 59 |
| Two Quarter hence (180-90) | 25 | 67 | 26 | 67 | 15 | 73 |
| Three Quarter hence (270-90) | 16 | 76 | 16 | 76 | 7 | 83 |
| One year hence (360-90) | 15 | 78 | 15 | 78 | 9 | 81 |
| Five quarter hence (450-90) | 8 | 80 | 8 | 79 | 5 | 88 |
| One year and half hence (540-90) | 11 | 57 | 12 | 55 | 7 | 75 |
| 630-90 | 2 | 64 | 2 | 62 | 0 | 84 |

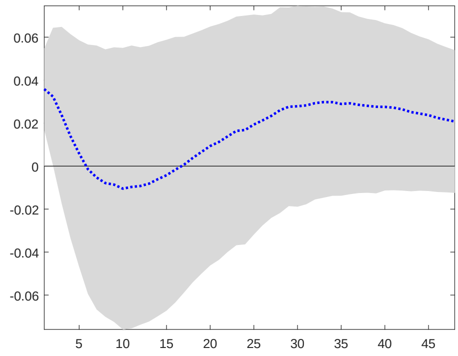
Table 4: Decomposition of the Variance in Changes in OIS futures, full sample and Trichet and Draghi presidency.

| Variables | Transf |
|---|---|
| ECB Nominal effective exch. Rate | 1 |
| UK pound sterling/Euro, 2:15 pm (C.E.T.) | 1 |
| Japanese yen/Euro, 2:15 pm (C.E.T.) | 1 |
| US dollar/Euro, 2:15 pm (C.E.T.) | 1 |
| Total Turnover Index, Manifacturing | 2 |
| ECB Commodity Price index Euro denominated | 2 |
| Standardised unemployment, Rate, | 1 |
| Car registration, New passenger car; | 2 |
| Total Turnover Index, Retail trade including fuel | 2 |
| New orders, total, MANUFACTURING, FOR NEW ORDERS | 2 |
| Industrial Production Index, Total Industry (excluding construction) | 2 |
| Industrial Production Index, Total Industry excluding construction and MIG Energy | 2 |
| Brent crude oil 1-month Forward | 2 |
| Equity index - Dow Jones Eurostoxx 50 index - Index | 2 |
| Rate - Eonia rate - Euro | 1 |
| Rate - 1-year Euribor (Euro interbank offered rate) - Euro | 1 |
| Rate - 3-month Euribor (Euro interbank offered rate) - Euro | 1 |
| Equity index - Standard and Poor 500 - Index | 2 |
| Exchange rate, ECB real effective exchange rate CPI deflated | 2 |
| Loans, total maturity, all currencies combined | 2 |
| Monetary aggregate M3, all currencies combined | 2 |
| HICP - Overall index - Index | 2 |
| HICP - All-items excluding energy and unprocessed food - Index | 2 |
| Standardised unemployment, Total (all ages), Male - Percentage | 1 |
| Consumer Survey - Consumer Confidence Indicator - Percentage | 2 |
| Economic Sentiment Indicator - Percentage | 2 |
| Industrial Production Index, Consumer goods industry - Index | 2 |
| Industrial Production Index, MIG Durable Consumer Goods Industry - Index | 2 |
| Industrial Production Index, MIG Energy - Index | 2 |
| Industrial Production Index, Total Industry - Index | 2 |
| Industrial Production Index, MIG Intermediate Goods Industry - Index | 2 |
| United States - CONSUMER PRICES, ALL ITEMS | 2 |
| United States - Employment | 1 |
| United States - 10-Year Treasury Constant Maturity Rate | 1 |
| United States - Manufacturing ISM Report on Business | 2 |
| United States - Real Retail and Food Services Sales | 2 |
| United States - Three months treasury bill | 1 |
| United States - Unemployment rate | 1 |

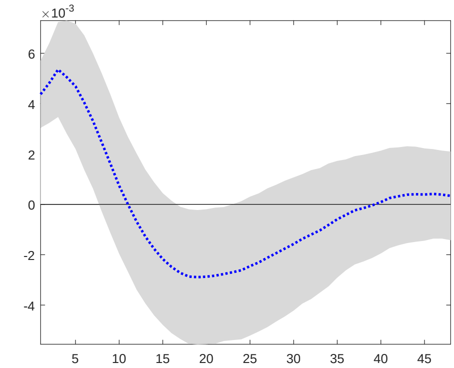
Table 5: List of variables included in $X_t$ to test the predictability of monetary policy surprises. Transformations: 1 = first difference, 2= growth rate



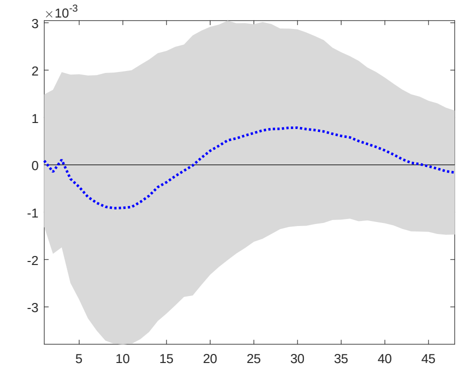
(a) Path to 1Y Euribor



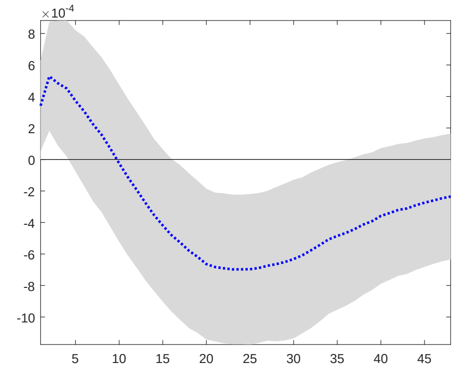
(b) Odyssean to Euribor



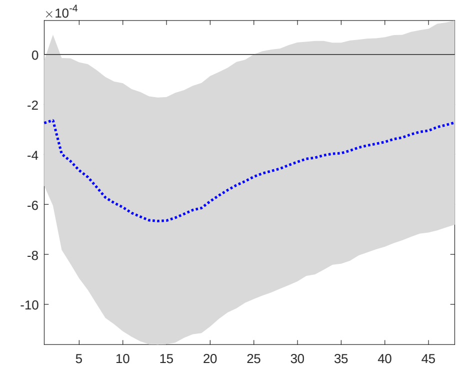
(c) Path to IPI



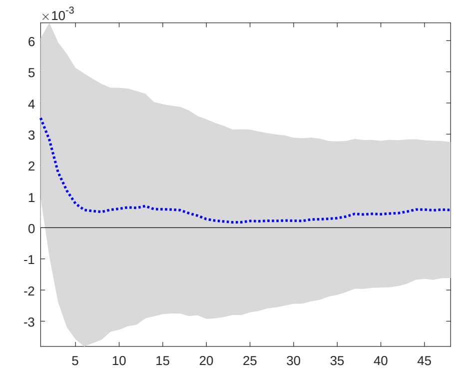
(d) Odyssean to IPI



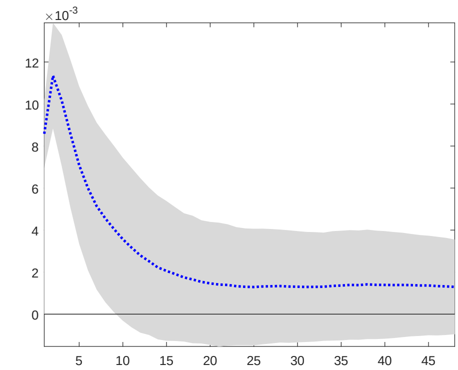
(e) Path to HICP



(f) Odyssean to HICP

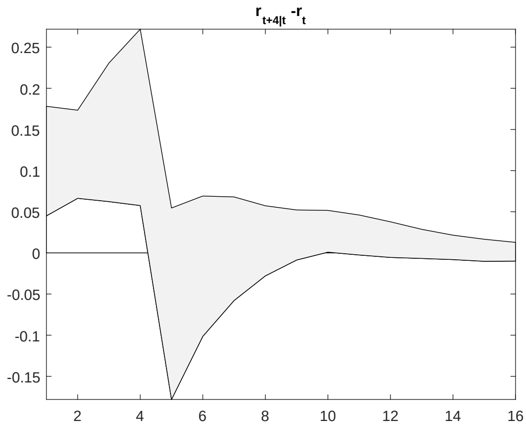


(g) Path to EXRATE

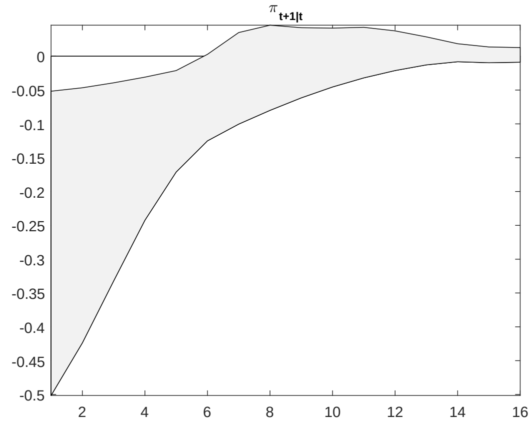


(h) Odyssean to EXRATE

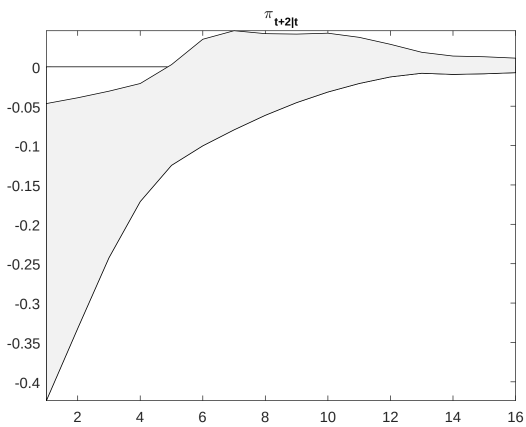
Figure 3: Impulse responses of the Odyssean monetary policy announcement, and a generic monetary policy announcement on one year Euribor, industrial production (IPI), consume price index (HICP) and the real effective exchange rate.



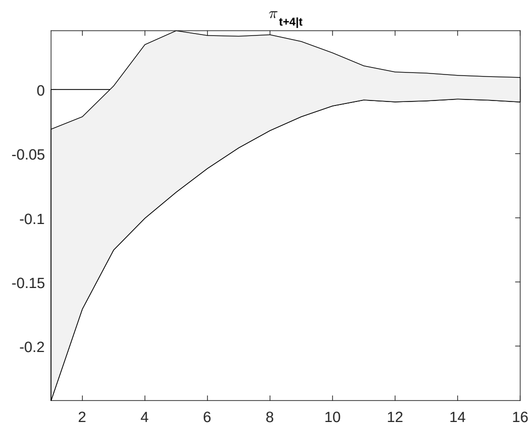

(a) Slope, $E_t r_{t+4} - r_t$




(b) $E_t \pi_{t+1}$




(c) $E_t \pi_{t+2}$




(d) $E_t \pi_{t+4}$

Figure 4: Responses to an announcement of a 5 basis points increase in interest rate (tightening) in one year time. Gray shaded areas contains all the possible IRFs drawing independently from the parameters priors.

| | | 1Y | 2Y | 3Y | 4Y | 5Y | 6Y | 7Y | 8Y | 9Y | 10Y | 12Y | 15Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Full Sample | Target | 0.23 | -0.41* | -0.53*** | -0.24 | -0.08 | 0.04 | -0.14 | -0.06 | -0.01 | 0.12 | 0.07 | 0.05 |
| | Path | 0.43*** | 0.34*** | 0.33*** | 0.19** | 0.24*** | 0.26*** | 0.18*** | 0.18*** | 0.16*** | 0.17*** | 0.23*** | 0.13** |
| | Adj $R^2$ | 0.07 | 0.07 | 0.12 | 0.05 | 0.09 | 0.11 | 0.06 | 0.06 | 0.05 | 0.06 | 0.11 | 0.04 |
| Trichet | Target | 0.29 | -0.38 | -0.49** | -0.19 | -0.02 | 0.11 | -0.08 | 0.00 | 0.05 | 0.19 | 0.13 | 0.11 |
| | Path | 0.49*** | 0.38*** | 0.37*** | 0.23*** | 0.27*** | 0.30*** | 0.22*** | 0.21*** | 0.20*** | 0.20*** | 0.27*** | 0.17*** |
| | Adj $R^2$ | 0.09 | 0.09 | 0.14 | 0.07 | 0.14 | 0.17 | 0.09 | 0.10 | 0.09 | 0.12 | 0.18 | 0.09 |
| Draghi | Target | -0.64 | -0.69 | -0.85 | -0.88 | -0.85 | -0.92* | -0.96* | -0.95** | -0.87** | -0.95** | -0.82** | -0.83** |
| | Path | -0.86** | -0.61* | -0.65* | -0.69** | -0.63* | -0.66** | -0.63** | -0.58** | -0.57** | -0.57** | -0.62*** | -0.69*** |
| | Adj $R^2$ | 0.30 | 0.24 | 0.27 | 0.29 | 0.27 | 0.37 | 0.40 | 0.44 | 0.46 | 0.51 | 0.51 | 0.52 |
| Full Sample | Target | 0.39 | -0.38** | -0.56*** | -0.39*** | -0.22** | -0.08 | -0.15 | -0.11 | -0.13 | -0.04 | -0.17 | -0.11 |
| | Path | -0.43*** | 0.15* | 0.18** | 0.11* | 0.11** | 0.13** | 0.09* | 0.12** | 0.10* | 0.11** | 0.10* | 0.06 |
| | Adj $R^2$ | 0.07 | 0.04 | 0.11 | 0.06 | 0.05 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.03 | 0.00 |
| Trichet | Target | 0.43 | -0.37* | -0.56*** | -0.37** | -0.20* | -0.04 | -0.12 | -0.09 | -0.11 | 0.00 | -0.14 | -0.09 |
| | Path | -0.43*** | 0.16* | 0.20** | 0.13* | 0.13** | 0.16*** | 0.11** | 0.14*** | 0.12** | 0.13*** | 0.12** | 0.08 |
| | Adj $R^2$ | 0.07 | 0.04 | 0.12 | 0.06 | 0.06 | 0.05 | 0.03 | 0.05 | 0.03 | 0.05 | 0.03 | 0.01 |
| Draghi | Target | -0.36 | -0.34 | -0.38 | -0.50 | -0.47 | -0.50 | -0.50 | -0.45 | -0.47 | -0.56 | -0.52 | -0.37 |
| | Path | -0.42 | -0.26 | -0.30 | -0.27 | -0.31 | -0.37 | -0.36* | -0.34 | -0.30 | -0.28 | -0.33* | -0.35* |
| | Adj $R^2$ | 0.08 | 0.02 | 0.07 | 0.09 | 0.08 | 0.17 | 0.20 | 0.14 | 0.13 | 0.16 | 0.21 | 0.15 |

Table 6: Regression Estimating Responses of the revision of ILS to Target and Path factors, full sample and subsamples. Two (one) day window upper (bottom) part.

| | | STOXX |
|---|---|---|
| Full Sample | Target | -5.06** |
| | Path | -0.19 |
| | Adj $R^2$ | 0.02 |
| Trichet | Target | -5.23** |
| | Path | 1.06 |
| | Adj $R^2$ | 0.05 |
| Draghi | Target | -7.17 |
| | Path | -10.78*** |
| | Adj $R^2$ | 0.14 |

Table 7: Regression Estimating the STOXX % change to Target and Path factors, full sample and subsamples.

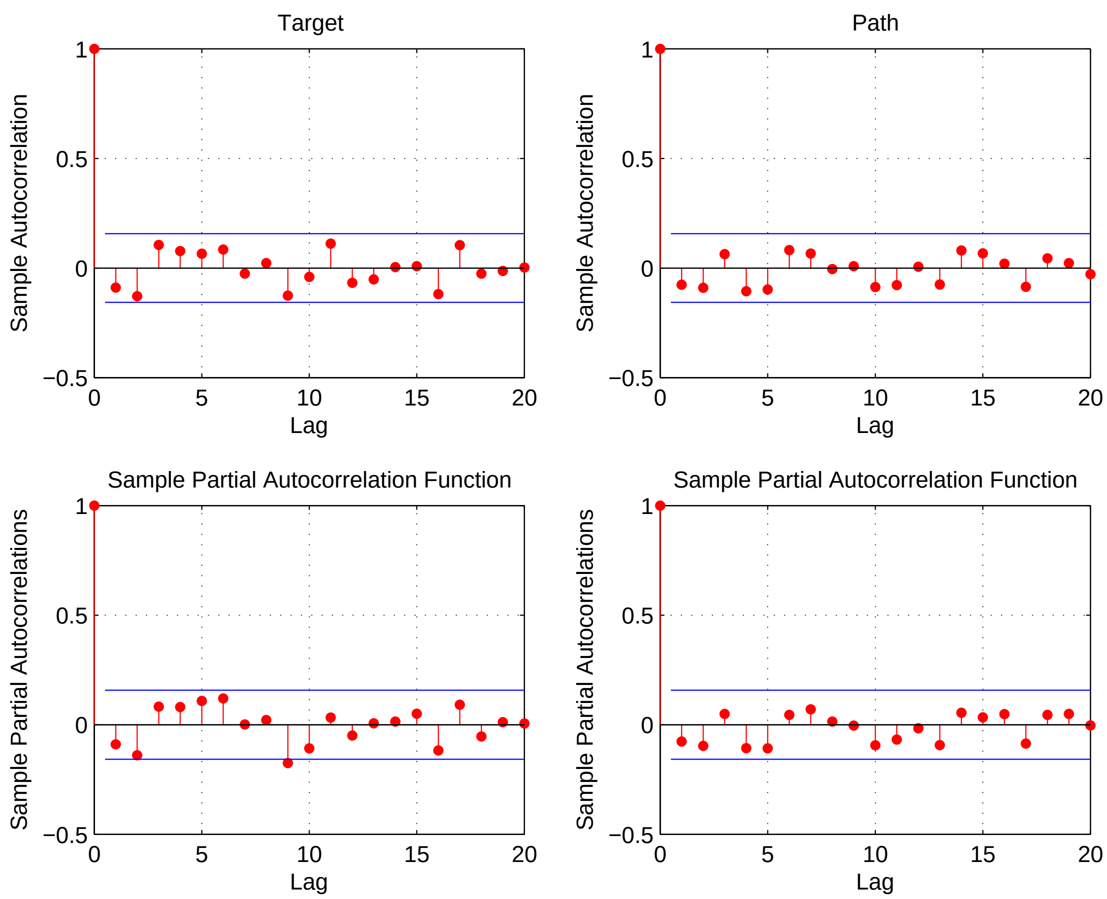


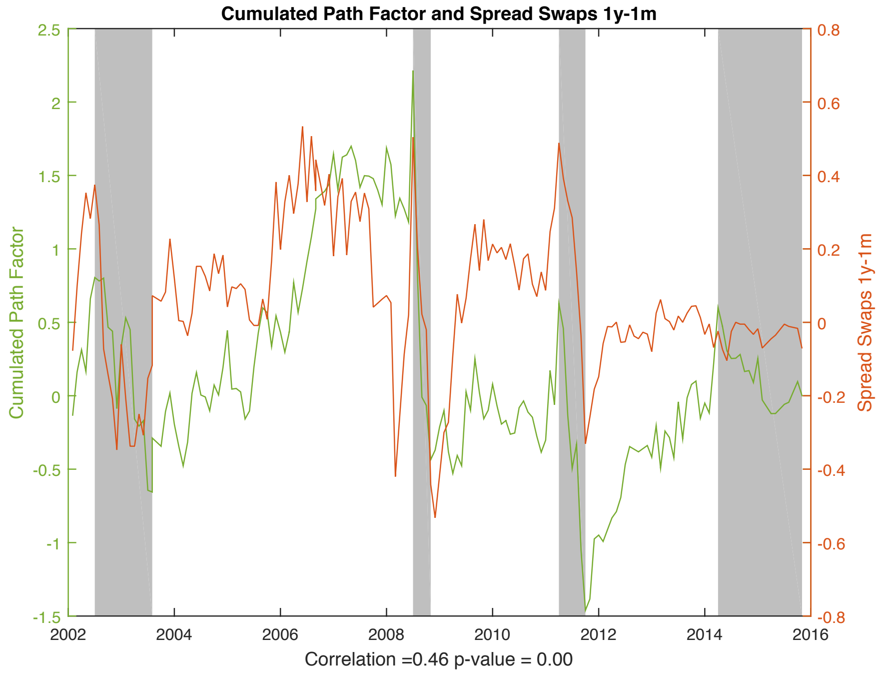

Figure 5: Autocorrelation and Partial Autocorrelation function for the path and the target factor. Blue bands indicate statistical significance.

| | HICP | | Real GDP | |
|---|---|---|---|---|
| | Current Y | Next Y | Current Y | Next Y |
| March 2002 | 1.8 | 1.6 | 1.0 | 2.5 |
| June 2002 | 2.3 | 1.9 | 1.2 | 2.6 |
| September 2002 | 2.2 | 1.8 | 0.8 | 2.1 |
| December 2002 | 2.2 | 1.8 | 0.8 | 1.6 |
| March 2003 | 2.0 | 1.5 | 1.0 | 2.0 |
| June 2003 | 2.0 | 1.3 | 0.7 | 1.6 |
| September 2003 | 2.1 | 1.5 | 0.4 | 1.5 |
| December 2003 | 2.1 | 1.8 | 0.4 | 1.6 |
| March 2004 | 1.7 | 1.5 | 1.5 | 2.4 |
| June 2004 | 2.1 | 1.7 | 1.7 | 2.2 |
| September 2004 | 0.2 | 1.3 | 1.6 | 1.7 |
| December 2004 | 2.2 | 2.0 | 1.8 | 1.9 |
| March 2005 | 1.9 | 1.6 | 1.6 | 2.1 |
| June 2005 | 2.0 | 1.5 | 1.4 | 2.0 |
| September 2005 | 2.2 | 1.9 | 1.3 | 1.8 |
| December 2005 | 2.2 | 2.1 | 1.4 | 1.9 |
| March 2006 | 2.2 | 2.2 | 2.1 | 2.0 |
| June 2006 | 2.3 | 2.2 | 2.1 | 1.8 |
| September 2006 | 2.4 | 2.4 | 2.5 | 2.1 |
| December 2006 | 2.2 | 2.0 | 2.7 | 2.2 |
| March 2007 | 1.8 | 2.0 | 2.5 | 2.4 |
| June 2007 | 2.0 | 2.0 | 2.6 | 2.3 |
| September 2007 | 2.0 | 2.0 | 2.5 | 2.3 |
| December 2007 | 2.1 | 2.5 | 2.6 | 2.0 |
| March 2008 | 2.9 | 2.1 | 1.7 | 1.8 |
| June 2008 | 3.4 | 2.4 | 1.8 | 1.5 |
| September 2008 | 3.5 | 2.6 | 1.4 | 1.2 |
| December 2008 | 3.3 | 1.4 | 1.0 | -0.5 |
| March 2009 | 0.4 | 1.0 | -2.7 | 0.0 |
| June 2009 | 0.3 | 1.0 | -4.6 | -0.3 |
| September 2009 | 0.4 | 1.2 | -4.1 | 0.2 |
| December 2009 | 0.3 | 1.3 | -4.0 | 0.8 |
| March 2010 | 1.2 | 1.5 | 0.8 | 1.5 |
| June 2010 | 1.5 | 1.6 | 1.0 | 1.2 |
| September 2010 | 1.6 | 1.7 | 1.6 | 1.4 |
| December 2010 | 1.6 | 1.8 | 1.7 | 1.4 |
| March 2011 | 2.3 | 1.7 | 1.7 | 1.8 |
| June 2011 | 2.6 | 1.7 | 1.9 | 1.7 |
| September 2011 | 2.6 | 1.7 | 1.6 | 1.3 |
| December 2011 | 2.7 | 2.0 | 1.6 | 0.3 |
| March 2012 | 2.4 | 1.6 | -0.1 | 1.1 |
| June 2012 | 2.4 | 1.6 | -0.1 | 1.0 |
| September 2012 | 2.5 | 1.9 | -0.4 | 0.5 |
| December 2012 | 2.5 | 1.6 | -0.5 | -0.3 |
| March 2013 | 1.6 | 1.3 | -0.5 | 1.0 |
| June 2013 | 1.4 | 1.3 | -0.6 | 1.1 |
| September 2013 | 1.5 | 1.3 | -0.4 | 1.0 |
| December 2013 | 1.4 | 1.1 | -0.4 | 1.1 |
| March 2014 | 1.0 | 1.3 | 1.2 | 1.5 |
| June 2014 | 0.7 | 1.1 | 1.0 | 1.7 |
| September 2014 | 0.6 | 1.1 | 0.9 | 1.6 |
| December 2014 | 0.5 | 0.7 | 0.8 | 1.0 |
| March 2015 | 0.0 | 1.5 | 1.5 | 1.9 |
| June 2015 | 0.3 | 1.5 | 1.5 | 1.9 |
| September 2015 | 0.1 | 1.1 | 1.4 | 1.7 |
| December 2015 | 0.1 | 1.0 | 1.5 | 1.7 |
| March 2016 | 0.1 | 1.3 | 1.4 | 1.7 |
| June 2016 | 0.2 | 1.3 | 1.6 | 1.7 |

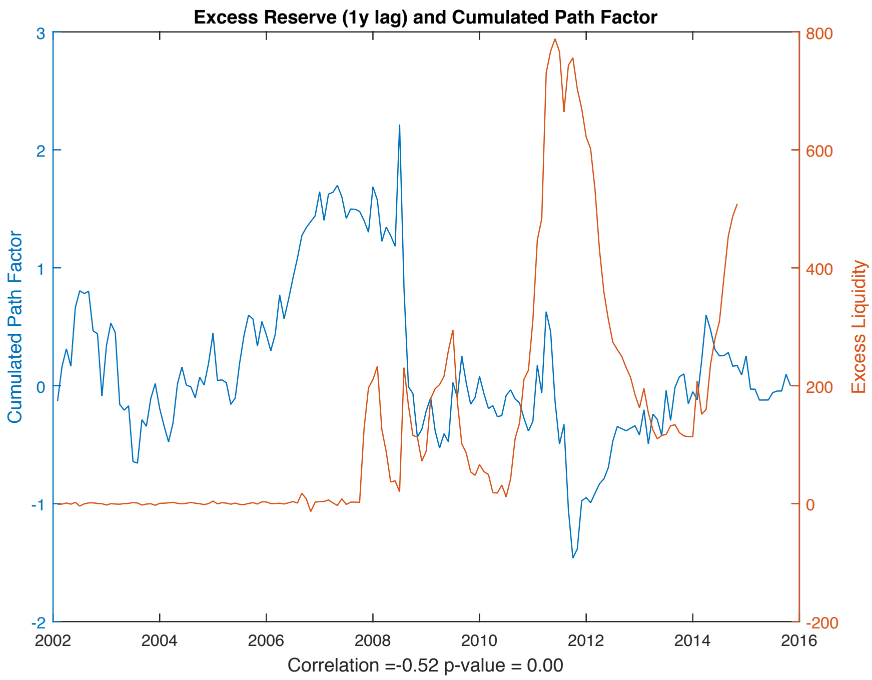
Table 8: Eurosystem staff inflation projections for the euro area, Inflation and Real GDP

| | HICP | | Real GDP | |
|---|---|---|---|---|
| | Current Y | Next Y | Current Y | Next Y |
| 2002 Q1 | 1.7 | 1.8 | 1.3 | 2.6 |
| 2002 Q2 | 2.1 | 1.9 | 1.4 | 2.7 |
| 2002 Q3 | 2.1 | 1.8 | 1.2 | 2.5 |
| 2002 Q4 | 2.2 | 1.8 | 0.8 | 1.8 |
| 2003 Q1 | 1.8 | 1.8 | 1.4 | 2.3 |
| 2003 Q2 | 2.0 | 1.7 | 1.0 | 2.1 |
| 2003 Q3 | 1.9 | 1.5 | 0.7 | 1.7 |
| 2003 Q4 | 2.0 | 1.6 | 0.5 | 1.7 |
| 2004 Q1 | 1.8 | 1.7 | 1.8 | 2.2 |
| 2004 Q2 | 1.8 | 1.8 | 1.6 | 2.1 |
| 2004 Q3 | 2.1 | 1.9 | 1.8 | 2.1 |
| 2004 Q4 | 2.1 | 1.9 | 1.9 | 2.0 |
| 2005 Q1 | 1.9 | 1.8 | 1.8 | 2.1 |
| 2005 Q2 | 1.9 | 1.8 | 1.6 | 2.0 |
| 2005 Q3 | 2.1 | 1.8 | 1.4 | 1.8 |
| 2005 Q4 | 2.2 | 2.0 | 1.3 | 1.7 |
| 2006 Q1 | 2.0 | 2.0 | 2.0 | 1.9 |
| 2006 Q2 | 2.1 | 2.1 | 2.1 | 1.9 |
| 2006 Q3 | 2.3 | 2.1 | 2.2 | 1.8 |
| 2006 Q4 | 2.2 | 2.1 | 2.6 | 2.0 |
| 2007 Q1 | 2.0 | 1.9 | 2.1 | 2.1 |
| 2007 Q2 | 1.9 | 1.9 | 2.5 | 2.3 |
| 2007 Q3 | 2.0 | 2.0 | 2.7 | 2.3 |
| 2007 Q4 | 2.0 | 2.0 | 2.6 | 2.1 |
| 2008 Q1 | 2.5 | 2.0 | 1.8 | 2.0 |
| 2008 Q2 | 3.0 | 2.2 | 1.6 | 1.6 |
| 2008 Q3 | 3.6 | 2.6 | 1.6 | 1.3 |
| 2008 Q4 | 3.4 | 2.2 | 1.2 | 0.3 |
| 2009 Q1 | 0.9 | 1.6 | -1.0 | 0.6 |
| 2009 Q2 | 0.5 | 1.3 | -3.0 | 0.2 |
| 2009 Q3 | 0.4 | 1.1 | -4.0 | 0.3 |
| 2009 Q4 | 0.3 | 1.2 | -3.0 | 1.0 |
| 2010 Q1 | 1.3 | 1.5 | 1.2 | 1.6 |
| 2010 Q2 | 1.4 | 1.5 | 1.1 | 1.5 |
| 2010 Q3 | 1.4 | 1.5 | 1.1 | 1.4 |
| 2010 Q4 | 1.5 | 1.5 | 1.6 | 1.5 |
| 2011 Q1 | 1.9 | 1.8 | 1.6 | 1.7 |
| 2011 Q2 | 2.5 | 1.9 | 1.7 | 1.7 |
| 2011 Q3 | 2.6 | 2.0 | 1.9 | 1.6 |
| 2011 Q4 | 2.6 | 1.8 | 1.6 | 0.8 |
| 2012 Q1 | 1.9 | 1.7 | -0.0 | 1.1 |
| 2012 Q2 | 2.3 | 1.8 | -0.0 | 1.0 |
| 2012 Q3 | 2.3 | 1.7 | -0.0 | 0.6 |
| 2012 Q4 | 2.5 | 1.9 | -0.0 | 0.3 |
| 2013 Q1 | 1.8 | 1.8 | -0.0 | 1.1 |
| 2013 Q2 | 1.7 | 1.6 | -0.0 | 1.0 |
| 2013 Q3 | 1.5 | 1.5 | -0.0 | 0.9 |
| 2013 Q4 | 1.4 | 1.5 | -0.0 | 1.0 |
| 2014 Q1 | 1.1 | 1.4 | 1.0 | 1.5 |
| 2014 Q2 | 0.9 | 1.3 | 1.1 | 1.5 |
| 2014 Q3 | 0.7 | 1.2 | 1.0 | 1.5 |
| 2014 Q4 | 0.5 | 1.0 | 0.8 | 1.2 |
| 2015 Q1 | 0.3 | 1.1 | 1.1 | 1.5 |
| 2015 Q2 | 0.1 | 1.2 | 1.4 | 1.7 |
| 2015 Q3 | 0.2 | 1.3 | 1.4 | 1.8 |
| 2015 Q4 | 0.1 | 1.0 | 1.5 | 1.7 |
| 2016 Q1 | 0.7 | 1.4 | 1.7 | 1.8 |
| 2016 Q2 | 0.3 | 1.3 | 1.5 | 1.6 |

Table 9: SPF projections for the euro area, Inflation and Real GDP




(a) Cumulated Path Factor and Spread Swaps 1y-1m




(b) Cumulated Path Factor and Excess Liquidity

Figure 6: Plot of the path factor against different observable variables, Spread 1y-1m OIS swaps and the Excess liquidity. Gray areas identify periods of downward trends which are interpretable as monetary policy tightening.

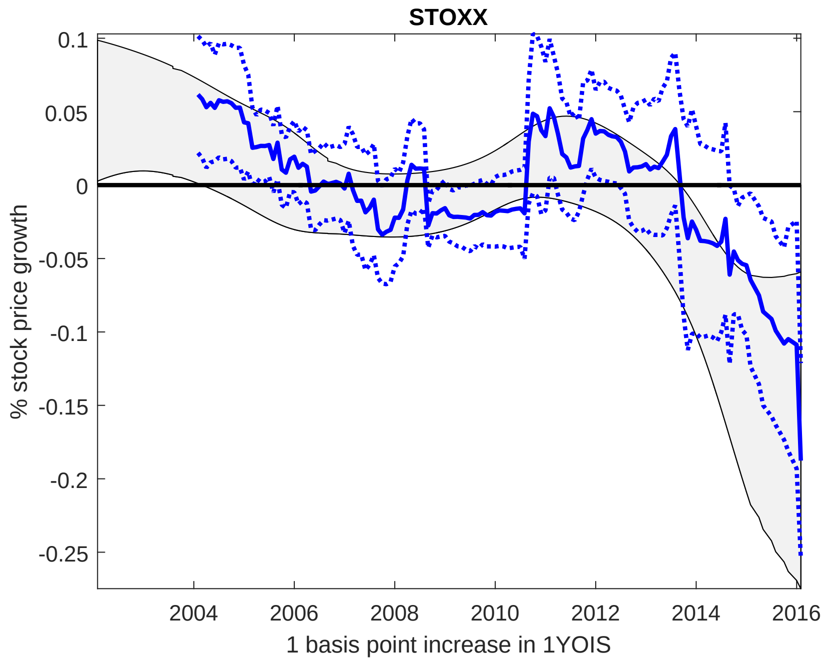
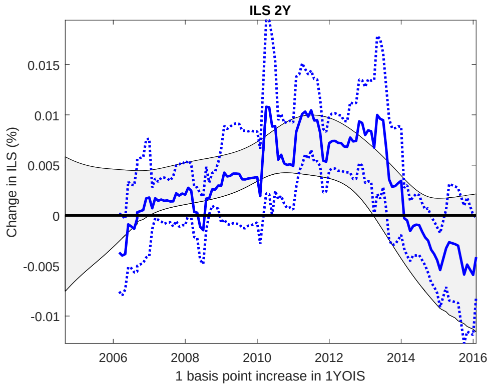
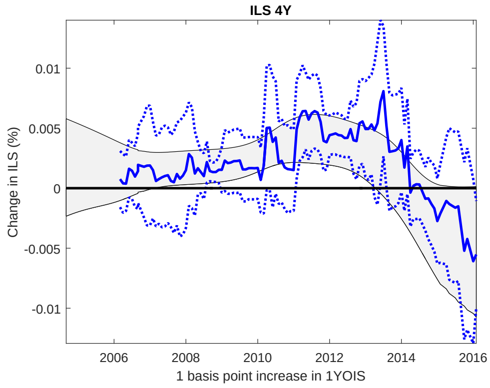


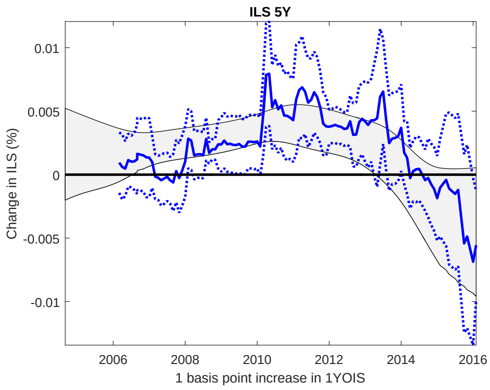

Figure 7: Impact of the path factor on the STOXX over rolling windows or with a local kernel estimator



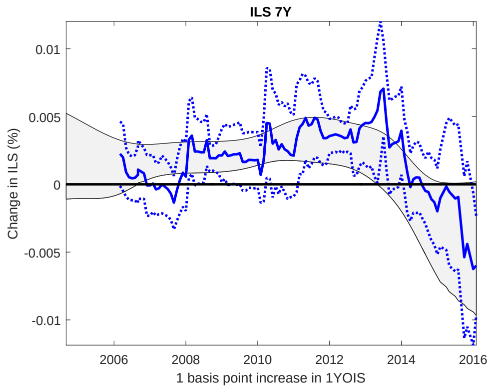

(a) 2 year



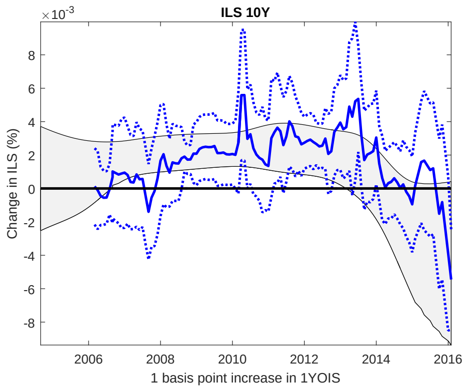

(b) 4 year



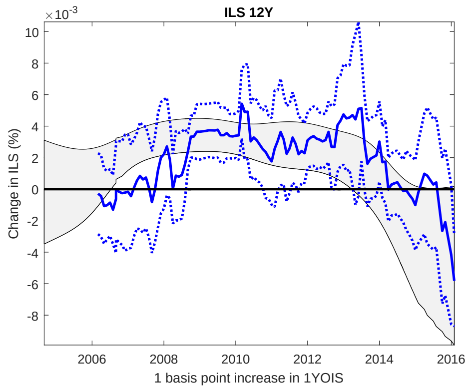

(c) 5 year




(d) 7 year

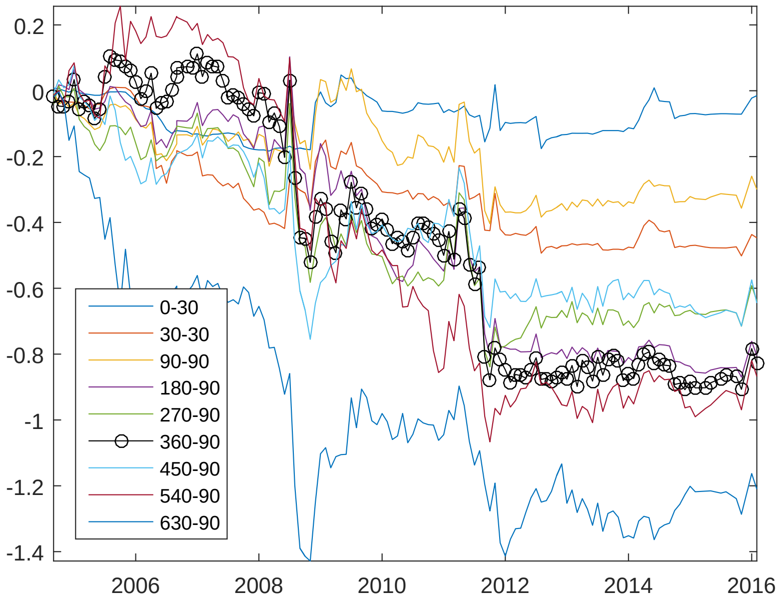



(e) 10 year

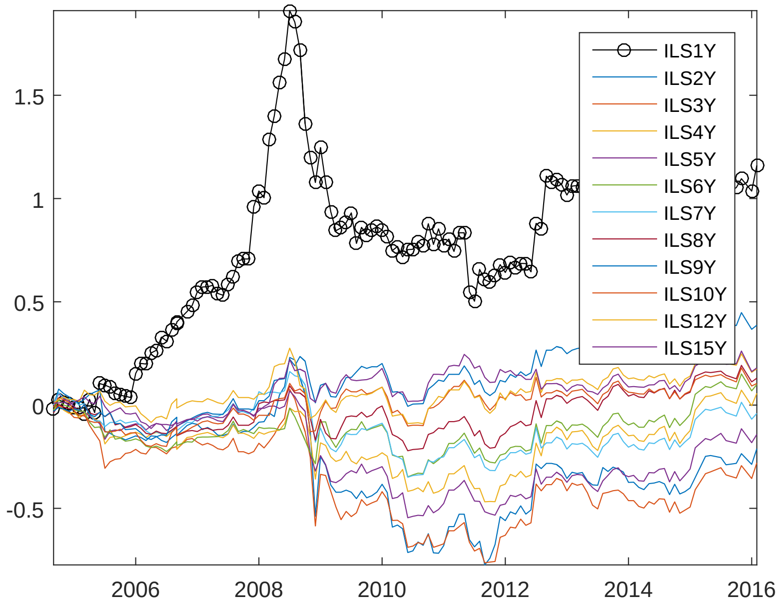



(f) 12 year

Figure 8: Impact of the path factor on the ILS over rolling windows or with a local kernel estimator



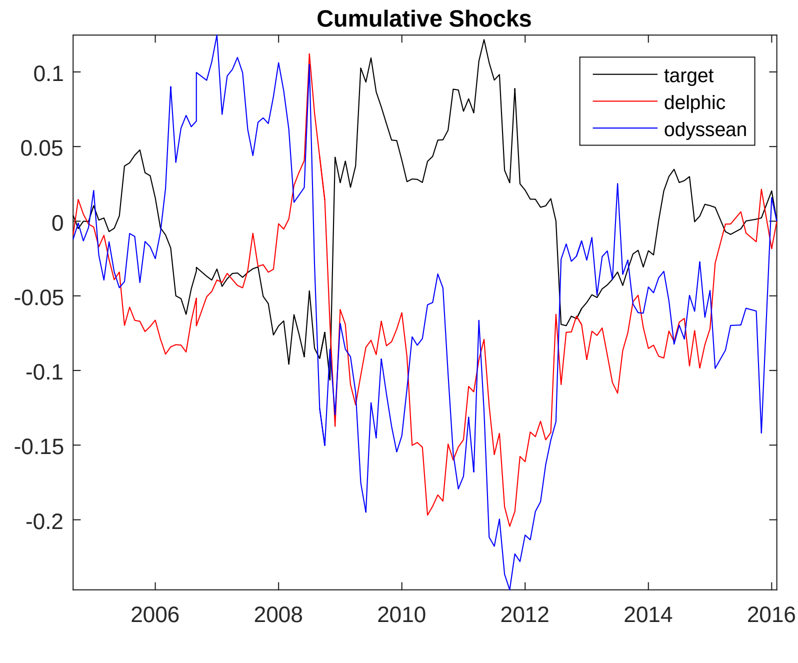

(a) Cumulated changes in OIS future during the ECB press conference



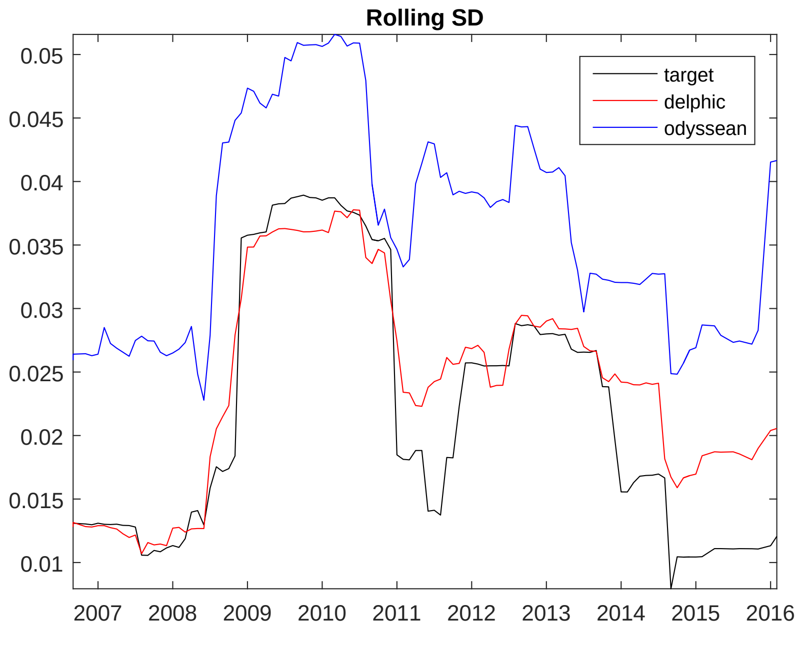

(b) Cumulated changes in Inflation Swaps during the ECB press conference

Figure 9: Plot of the cumulative changes in OIS and ILS around the ECB press conference.


Figure 10: Plot of the cumulative changes of ILS around the ECB press conference.




(a) Cumulated MP shocks




(b) Rolling SD of MP shocks

Figure 11: Plot of the cumulative Monetary Policy shocks (upper part) and the rolling standard deviation computed in a 2 years window (bottom). Black line represents the target factor, the red line the Delphic path factor and the blue line the Odyssean path factor. Dashed lines are obtained removing the 1 year inflation swaps from the database.