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

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Abstract

We use financial intraday data to identify monetary policy surprises in the euro area. We find that monetary policy statements and press conferences after Governing Council meetings convey information that moves the yield curve far out. Moreover, the nature of information revealed in a narrow window around this statement and press conference evolved over time. Until 2013, unexpected variations in future interest rates were positively correlated with changes in market-based measure of inflation expectations consistent with news on future macroeconomic conditions. That negative correlation disappeared roughly when forward guidance on future rates started to be given by the Governing Council. We use conditions on the joint reaction of expected interest rates and inflation rates to disentangle the two types of monetary policy shocks. A surprise that lowers future interest rates does not engineer a boom. A surprise that lowers future interest rates because it signals future accommodation does.

Keywords: Signaling, Forward guidance, High frequency data, VAR with instrumented proxy, Euro area

JEL Classification: C10, E52, E32.

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1 Introduction

The impact of monetary policy decisions on the yield curve is not limited to its short-end: an interest rate hike today is often perceived as signalling future increases to come (see Gürkaynak, Sack and Swanson (2005b)). Since economic decisions depend on the whole path of expected interest rates such evidence is viewed as proof that the information central banks reveal about future rates is an important channel through which monetary policy can impact the macro-economy (see e.g. Bernanke (2013)). Such evidence also gives support to the idea that monetary authorities can sustain aggregate demand by communicating that short-term interest rates will remain low for long when the policy rate can no longer be lowered because of the Effective Lower Bound (ELB).

Yet, this view neglects the fact that two very different surprises can have an observationally equivalent impact on the yield curve. A drop in future rates can result from bad news on the future macroeconomic state to which the central bank will adjust following its reaction function. Alternatively, a drop in future rates can derive from a commitment to future stimulative deviations from the normal time policy rule.

In this paper, we introduce a methodology to disentangle these two types of surprise and to assess their impact on financial and macroeconomic variables. We use the terminology introduced by Campbell, Evans, Fisher and Justiniano (2012) in their analysis of the US forward guidance policy and call the first type of surprise a "Delphic" shock as it corresponds to a situation where the central bank gives an oracle on the macroeconomic outlook. We call the second type of surprise an "Odyssean" shock as it corresponds to a situation where the central bank ties its hands to the mast. We show that central banks' announcements can convey both Delphic and Odyssean information even when forward guidance policies are implemented. Finally, we provide evidence that only accommodative Odyssean surprises lead to a boom in aggregate activity.

More precisely, we use intra-day data and assume that monetary policy shocks can be recovered from variations in interest rate swaps of up to 2-year maturity observed in a narrow window around monetary policy announcements as in Kuttner (2001) or Piazzesi (2002). Following Gürkaynak, Sack and Swanson (2005a), we decompose such variations into a component reflecting information about the current rate (the *target factor*) and a component reflecting information on future rates (the *path factor*). We apply this methodology to the Euro Area where monetary authorities announce policy decisions by a policy statement followed by a press conference at the end of every Governing Council's meeting. We find that a positive shock to the path factor has a positive impact on the yield curve for horizons greater than 2 years. It also leads to an increase in expected inflation but has no impact on stock prices.

We then disentangle the Delphic and Odyssean components of monetary policy announcements assuming different sign impacts on inflation expectations. In particular, we assume that an announcement of future monetary policy tightening 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). When the opposite occurs, we define it as Odyssean. Since the latter generates an identified set, we consider the average impact to construct observable proxies of the Odyssean shocks.

We find that our observable proxy of monetary policy news shocks (Odyssean shock) displays desirable properties relative the Gürkaynak et al. (2005a)'s *path factor*. First, it is consistent with a narrative description of the latest episodes of the ECB monetary policy announcements. Second, it impacts daily financial instruments in accordance with our priors about the effect of an announcement of future monetary policy tightening (or accommodation). In particular, we find that an Odyssean announcements of monetary policy tightening moves the expected nominal interest rates up and inflation expectations down. Hence, by construction, expected real interest rates increase. While stock market prices do not react to the path factor, they decline in response to Odyssean announcements of monetary policy tightening. Moreover, these responses display some form of persistence and the impact of monetary policy announcements extends behind the immediate business days following the monetary policy press conference.

We then offer a quantitative estimate of the dynamic propagation of Odyssean shocks on output and prices (measured as industrial production and HICP respectively) and on survey expectations (Consensus Economics) on output growth and inflation and compare it with the one implied by the path factor. We identify the transmission mechanism by instrumenting the reduced form VAR residuals with our observable measures of Odyssean monetary policy shocks as in Mertens and Ravn (2013) and Stock and Watson (2012). Our findings read as follow. A 'generic' announcement of future rates hikes (i.e. an increase in the path factor) generates a boom in expectations about inflation and output growth prospects and an increase in prices. The latter result is difficult to rationalize as a standard transmission mechanism of a future monetary policy tightening unless we acknowledge a strong signaling effect of monetary policy. The dynamic transmission of the Odyssean shock does not lead to this interpretation. In response to an announcement of a future monetary policy tightening, we find that both actual prices and quantities as well as their expectations decline.

The paper is organized as follow. Section 2 presents the data on market-based expectations of interest and of inflation rates. Section 3 presents the identification strategy. In section 4 we estimate their dynamic impact on macroeconomic aggregates. Section 5 concludes.

1.1 Related Literature

Gürkaynak et al. (2005a) show that FOMC announcements have strong effects on asset prices and in particular expected future policy rates, and Jardet and Monks (2014) offer similar evidence for the euro area. Romer and Romer (2000) provide evidence that FOMC decisions convey Fed-specific information about the macroeconomic outlook so that private agents update their forecasts accordingly. Nakamura and Steinsson (2017) also emphasize such signalling effect using intraday data but do not identify the two shocks. Campbell et al. (2012) confirm such results in a sample that includes the Great Recession. Their results are consistent with market participants interpreting FOMC's announcements as being Delphic rather than Odyssean. For the euro area, we show that the two interpretations of announcements of future monetary policy stance coexisted. Besides the fact that it is important to understand if these announcements made private agents more optimistic or pessimistic about the future, 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 (2017) 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 for the US experience. 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. We argue that for the euro area experience we lack appropriate measures of information asymmetry and hence these approaches are not suitable. 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 consider slow moving variables, we focus on variations of expectations of interest and inflation rates in a narrow window around the monetary policy announcement. The paper most closely related to our approach is Karadi and Jarocinsky (2018), where they combine low and high frequency variables in a VAR and study the transmission of monetary policy in the US and in the EA. Similarly to us, they introduce sign and zero restrictions to identify monetary policy (Odyssean) and information (Delphic) surprises. Unlike us, they impose opposite signs restrictions on interest rates and stock market prices variations. While an interest rate hike accompanied by a decline in stock market price is interpret as an Odyssean monetary policy surprise, the latter can be the result of the endogenous response to a supply side information shocks. Imposing sign restrictions on market based inflation expectations does not lead to this ambiguity. Moreover, while they focus on unexpected monetary policy shocks, we study the effects of forward guidance or, in general, announcement of future monetary policy. Miranda-Agrippino and Ricco (2017) propose to remove the predictable component of the US high frequency interest rate variations from the Greenbook's forecasts and forecast revisions and use the residual as a proxy for monetary policy shock. For the Euro Area, we do not find evidence that announcements of future monetary policy surprises respond to ECB and Euro system staff macroeconomic projections and forecast revisions.

An alternative avenue is to consider a structural model (e.g. DSGE) and study the transmission of the monetary policy announcements (or news) of the estimated version of the model. However, several authors expressed concerns that *quantitatively* standard DSGE models predict incredibly high positive impacts of forward guidance policies on future inflation and activity, see Carlstrom, Fuerst and Paustian (2015) and Del Negro, Giannoni and Patterson (2012). Bringing discounting to the linearized inter-temporal consumption Euler equation reduces the impact of these policies, as discussed by Kiley (2016), McKay, Nakamura and Steinsson (2015). Moreover, information imperfections and heterogeneous believes can generate macroeconomic outcomes that are at the opposite end to the ones of the standard full information rational expectation benchmark. However, the quantitative assessments depend crucially on the model specification. In this paper, we impose only a minimal amount of theory, which is based on the sign of co-movement between the slope of the term structure of nominal interest rates and the expectation of inflations.

2 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 Gürkaynak et al. (2005a) for the US experience[1]. 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 in central samples an unanticipated increase in the path factor triggered an upward revision in the forecast of inflation. Towards the end of our sample, 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.

[1]In Jardet and Monks (2014) the sample spans from 2002 until 2013. Here we extend the sample until 2016m1.

2.1 The impact of the ECB announcements on interest rates

We consider the changes in the forward Overnight Index Swaps (OIS)[2] 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[3]. 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 is approximately 10/15 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 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 further monetary monetary measures and at 14:30 Presisdent Draghi describe the intention to expand the Asset Purchases Program to government bonds with details on the duration and on the amount of asset to be bought. In both events, market reacted sharply.

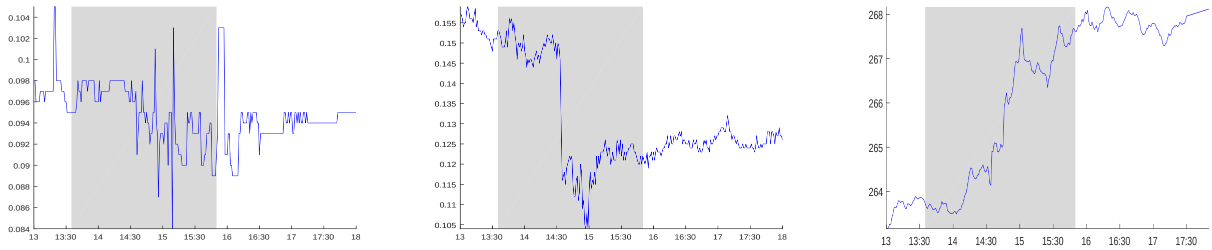
The short term rate (1M OIS) did not display any particular patters and looks pretty

[2]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.

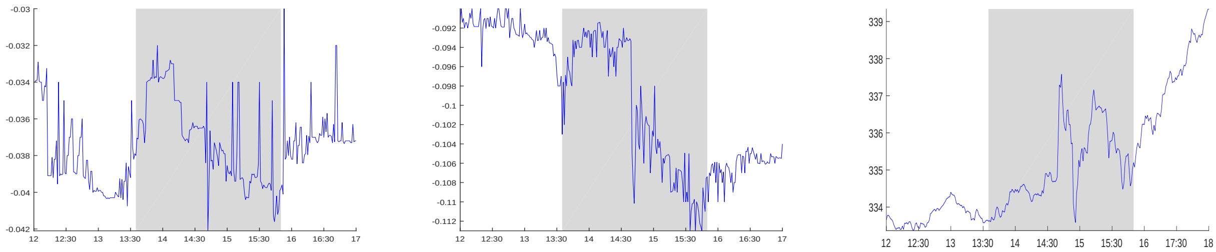
[3]For each maturity, mid-quotes figures are transformed into forwards using the following formula

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

where t_1 refers to the start of the forward rate, t_2 to the end of the forward rate and $d1$ and d_2 to the respective day counts.



(a) July 2013: OIS 1M (b) OIS 1Y (c) STOXXE



(d) January 2015: OIS 1M (e) OIS 1Y (f) STOXXE

Figure 1: One month (left) and one year (center) OIS fluctuations, and Euro STOXX index 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.

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, the long term interest rate felt significantly, i.e. from 15 basis points to 10. On the 22nd of January 2015, we can notice 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.

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 7). The target factor is usually interpreted as a conventional monetary

[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.

policy shocks, and the path factor as a forward guidance shock or as a large asset purchases shock that affects the slope of the term structure of the interest rates, i.e. the correlation between the path factor and the spread between the one year and one month OIS is 0.94 (see Figure 8).

	Variance Decomposition					
	2002m1-2016m1.		2002m1-2011m12		2012m1-2016m1.	
OIS futures	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
Seven quarter hence 630-90	2	64	2	62	0	84

Table 1: Decomposition of the Variance in Changes in OIS futures, full sample and subsamples, i.e. 2002m1-2011m12 and 2012m1-2016m1.

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 1 reports the fractions of 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 1 carry the same information using two different sub-sample periods. In particular, we consider the ECB announcements from January 2002 until January 2012 and from then to 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. All this is somehow reflected in column 4 and 6 of table 1 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.

While explaining a large portions of volatility in intraday OIS futures, one may wonder how much these surprises contribute to the variation of interest rates at lower frequencies - say monthly variations. Table 2 shows the regression of the monthly variations in (Spot) Eonia Swaps at various maturities on target and path factors (and a constant not shown).

$$\Delta^{monthly} OIS_t = \alpha_0 + \alpha_1 f_t^{target} + \alpha_2 f_t^{path} + e_t$$

The path factor loads significantly in the monthly variation of (Spot) Eonia Swaps at various maturities. The share of variance of monthly variations in Eonia explained by the two factor is between 10% to 20% for one year to three years maturities for the full sample. This share increases up to 40% in the second part of the sample. Similar patterns can be found for the average EA government bond rates and Euribor interest rates.

	Sample 2002-2016			Sample 2002-2012			Sample 2012-2016		
Eonia Maturity	Target	Path	Adj R^2	Target	Path	Adj R^2	Target	Path	Adj R^2
One month	0.44	0.31	0.01	0.27	0.34	0.00	1.40***	0.09	0.43
Three months	0.34	0.48**	0.02	0.19	0.49*	0.01	1.28***	0.39***	0.41
Six months	0.36	0.75***	0.06	0.20	0.77***	0.05	1.33***	0.65***	0.43
One year	0.42	1.17***	0.11	0.27	1.20***	0.10	1.28***	1.02***	0.43
Two years	0.62	1.48***	0.15	0.46	1.49***	0.14	1.63***	1.49***	0.41
Three years	-0.18	1.69***	0.21	-0.55	1.72***	0.20	1.70**	1.85***	0.34
Five years	-0.44	1.44***	0.16	-0.91	1.40***	0.16	2.08*	2.14***	0.27
Ten years	-1.09*	0.92***	0.07	-1.33*	0.95***	0.10	0.15	1.08	0.00

Table 2: Regression Estimating the monthly variation of Eonia swaps at the different maturities explained by the (intraday) target and the path factor. One (two, three) star indicates the statistical significance at 1% (5%, 10%) computed with robust standard errors.

2.2 The predictability of ECB monetary policy

Before treating these observed measures as proxy of the exogenous shifts 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 information set available before the conference. In other words, can the variations in the target and path factors be explained by the data of 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.

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 η_t be the vector containing the target and path factor at time t 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[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 3: 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 3 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

[5]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 10

factor appears to be statistical influential in explaining the target factor[6]. However, monetary policy announcements about future monetary policy actions (path factor) are not predictable using past information[7].

While factors are not predictable using the information available to the private sector and to the central bank, Campbell et al. (2017) raised the concern that private and central banks information set might not be the same before the conference press and constructed a measure of information discrepancy. Unfortunately, for the euro area we lack a sensible measure of asymmetry in the private sector and central bank information set. Moreover, the empirical measures of private sector and central banks expectations are little informative for our scopes (see Appendix A.3).

2.3 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 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 realized 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.

[6] Factor 5 can be associated to measures of inflation. Table 17 in the appendix reports the regression estimating f_5 on each observable variable in the factor model, $f_{5,t} = \alpha_0 + \alpha_0 X_{j,t} + e_t$. Individual regressions are ranked with respect to the R^2. Core and headline HICP inflation explain one fourth of the variation in the $f_{5,t}$.

[7] If interested in studying the properties of the target factor, one could take the residuals of the regression of the target factor on f_5 and treat the latter as measure of monetary policy shock, e.g. Miranda-Agrippino (2015).

		ILS 2Y	ILS 5Y	ILS 10Y	ILS 15Y	STOXX
	Target	-0.41*	-0.08	0.12	0.05	-5.06**
2002-2016	Path	0.34***	0.24***	0.17***	0.13**	-0.19
	Adj R^2	0.07	0.09	0.06	0.04	0.02
	Target	-0.37	-0.02	0.18	0.11	-7.19***
2002-2012	Path	0.38***	0.28***	0.20***	0.17***	0.23
	Adj R^2	0.09	0.14	0.12	0.09	0.08
	Target	-0.64	-0.73**	-0.83***	-0.58**	-2.47
2012-2016	Path	-0.64***	-0.69***	-0.63***	-0.81***	-1.42
	Adj R^2	0.24	0.27	0.51	0.55	-0.01

Table 4: Regression Estimating Responses of the revision of ILS to Target and Path factors, full sample and subsamples. The target (path) factor is normalized so that it generates a 1% increase in the 1 month (year) OIS futures. One, two and three asterisks indicate statistical significance at 10%, 5% and 1% respectively.

In particular, we run the following regression

$$\Delta ILS_{t+1,t-1} = \alpha_0 + \alpha_1 \eta_t^{target} + \alpha_2 \eta_t^{path} + u_t$$

where η^j denotes the monetary policy surprise for $j = target,\ path$. Table 4 reports the coefficient estimates for α_1 and α_2 and the adjusted R^2 for the full sample and for different subsamples[8]. The target (path) factor is normalized so that it generates a 1% increase in the 1 month (year) OIS futures. The last column of table 4 reports the impact of the path and target factors on the (intraday) variation in the Euro Stoxx 50 during the ECB conference press. A number of interesting results are worth highlighting. First, when significant, coefficients loading the target factor have negative signs, meaning that an increase in the target factor generates a decline in the inflation expectations, which is consistent with the announcement of a monetary policy tightening. Second, the path factor which captures the announcements of future monetary policy is significant and positive at any horizon. Third, the path factor has a positive impact on the first subsample period and negative during the second one. This indicates that, while for the first subsample the ECB announcements are characterized by a strong Delphic attitude, our estimates for the second subsample suggests a vanishing importance of Delphic component. More precisely, our estimates indicate that since January 2012 the ECB announcements generating a 1 percent reduction in the one-year OIS future were able to generate an increase in inflation swaps at 2 years horizon of roughly 30 basis points. On a similar ground, the impact of the path factor on stock market prices

[8]Tables 13-16 in the appendix reports the regression of the 1 day or 2 days variations in (Spot and Forwards) ILS on target and path factors. We considered as baseline the 2 days variations because the adjusted R^2 is larger. However, the signs on the coefficients are *qualitative* similar to the exact specification used, i.e. using forward or spot rates within a one- or two-day variation.

has been relatively unstable in the two subsamples. These time variations in the response of inflation expectation is still visible when instead of considering arbitrary subsamples we use rolling estimates or local kernel estimators (see A.4).

3 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. Standard macroeconomic models have something to say about the co-movements between the slope of interest rates and expected inflation conditional on monetary policy news. And we can use these insights to discipline the properties of monetary policy announcements. We take as an example of transmission mechanism of monetary policy announcements the one present in 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 π_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

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

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

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

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. $r^n_{t+j,t}$, as a linear projection of the current value of the fundamentals, i.e.

$$r^n_{t+j,t} = \phi'_j \; \Omega_t$$

where Ω_t is the column vector collecting the current realizations of the fundamentals and ϕ_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. Therefore, in a model with perfect information the unconditional correlation between the slope of the term structure of rates and inflation expectations coincides with correlation conditional on monetary policy announcements. Moreover, all the variation in slope of the term structure of nominal interest rates is attributable to the monetary policy announcements. With imperfect or dispersed information this is not longer true. During the conference press, the private sector might revise their estimates of the fundamentals based on the monetary authority communication. However, a credible announcement of a (Odyssean) commitment to future accommodation (i.e. a future positive demand shock), that is understood by the public as such, should reduce the slope of the interest rate term structure and should lead to an increase of inflation expectations. The latter can be seen as a necessary condition. If this does not happen, then the shock is not an Odyssean forward guidance shock. While one could impose more restrictions and narrow the identification set down, this restriction is relatively uncontroversial and common to a wide variety of structural models with different types of frictions.

3.1 Econometric Identification

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 sign of the conditional correlation as a device to identify the Odyssean shocks. 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[9]. 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

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

assume that the data are generated by the following factor structure,

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

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 ΛH has the following structure

$$\begin{pmatrix} \Delta_{30m} OIS_{1M,t} \\ \Delta_{30m} OIS_{1Y,t} \\ \Delta_{2d} ILS_{5Y,t} \\ \vdots \\ * \end{pmatrix} = \begin{pmatrix} * & 0 & 0 \\ * & + & + \\ * & + & - \\ \vdots & \vdots & \vdots \\ * & * & * \end{pmatrix} \begin{pmatrix} \eta_t^t \\ \eta_t^d \\ \eta_t^o \end{pmatrix} + e_t$$

Figure 2 reports the target (top panel black) and path factor (central panel in black) using only OIS information and the target, Delphic and Odyssean factors using OIS and ILS. The target (path, Delphic and Odyssean) factor is normalized so that it generates a 1% increase in the 1 month (year) OIS futures. The target factors are similar when using only OIS or OIS and ILS. The central panel reports the path factor and the Delphic component of monetary policy announcements and shows the degree of comovement between the two series[10]. The bottom plot reports the estimated Odyssean shocks and highlights a number of episodes where the realized shocks was larger than its standard deviations (in absolute values). In particular, we focus our attention on the following press conference days

07/2013 Odyssean factor -4.8 basis points. President Draghi announced for the first time forward guidance, i.e. in the introductory statement we can read '[The GC] expects the key ECB interest rate to remain at present or lower levels for an extended period of time.'

01/2015 Odyssean factor -4.9 basis points. President Draghi announced the QE package. 'First, [the GC] decided to launch an expanded asset purchase programme, encompassing the existing purchase programmes for asset-backed securities and covered bonds. Under this expanded programme, the combined monthly purchases of public and private sector securities will amount to Euro 60 billion. They are intended to be carried out until end-September 2016 and will in any case be conducted until we see 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'.

10/2015 Odyssean factor -6.3 basis points. President Draghi anticipated that the QE package might be adjusted. 'In this context, the degree of monetary policy accommodation will need to be re-examined at our December monetary policy meeting, when the new Eurosystem staff macroeconomic projections will be available. The Governing Council is willing and able to act by using all the instruments available within its mandate if warranted in order to maintain an appropriate degree of monetary accommodation. In

[10] The correlation between the path factor and the Delphic FG is 0.70 and the correlation between the path factor and the Odyssean is 0.46.

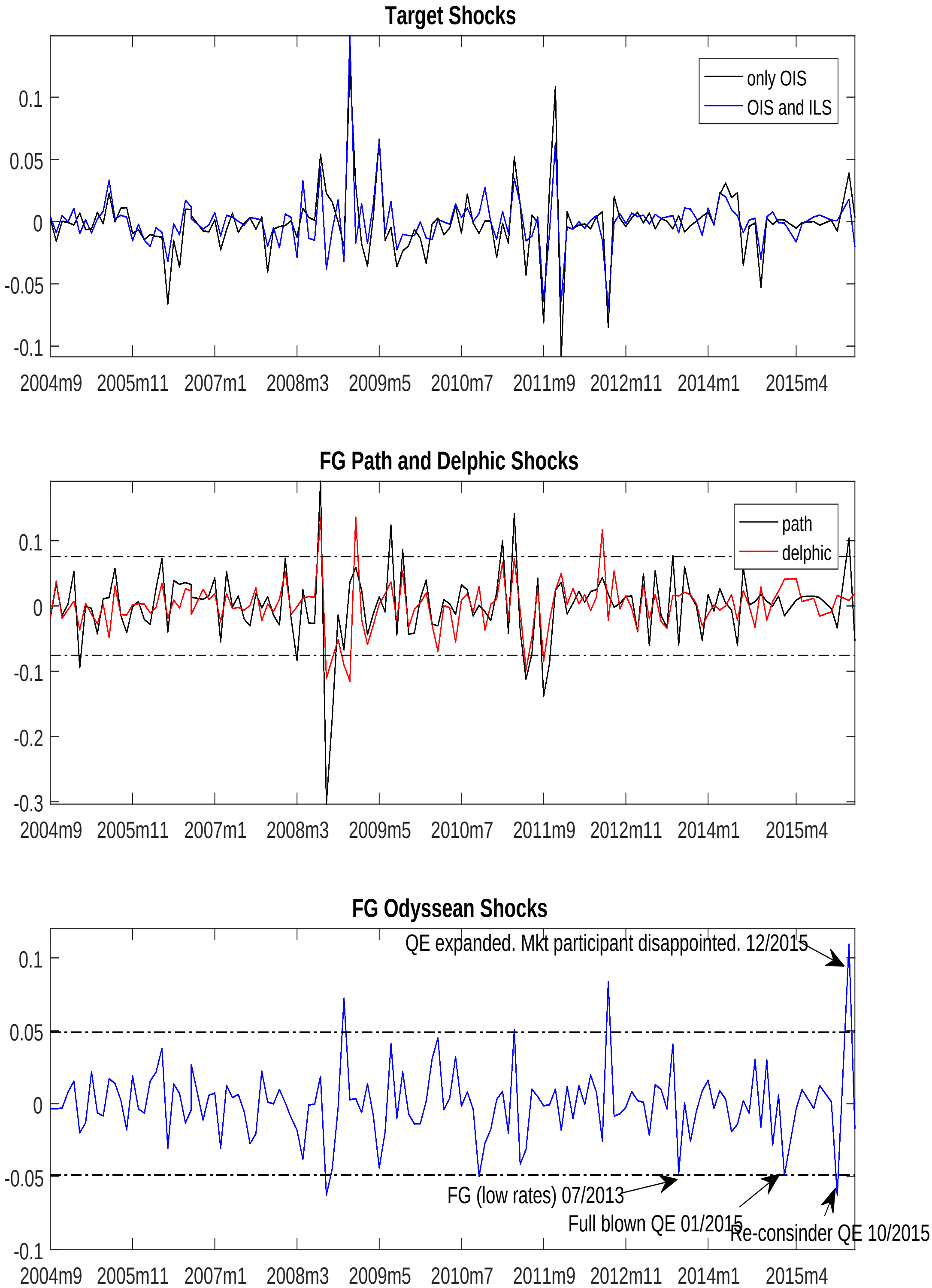


Figure 2: Target, Path and Delphic and Odyssean FG shocks in percentage units.

particular, the Governing Council recalls that the asset purchase programme provides sufficient flexibility in terms of adjusting its size, composition and duration.'

12/2015 Odyssean factor +10 basis points. President Draghi announced two MP measures, i.e. cut of interest rates on deposit facilities and to extend the duration of the asset purchase program until March 2017. The Odyssean figure seems inconsistent with the announcement of MP accommodation. However, markets participant were expecting a more aggressive move. As it appears in the transcripts of the monetary policy press conference, questions about the weakness of MP actions were raised by the press conference participants. For example, 'And my second question is, it seems like what you've done is a little bit on the low end of the range of what the financial markets had expected, in terms of your stimulus package today. It seems like the initial reaction in the financial markets bears this point. Why didn't you do more, given how much you've warned about the risks of low inflation? Why didn't you raise the monthly purchase amount? Why didn't you cut the deposit rate more?' or similarly 'You've just explained your reasoning, but nevertheless, financial markets appear to be disappointed. So what is the reason there? Do you think that something went wrong in your communication in the run-up to the decision? Did you perhaps overestimate your ability to convince fellow policy-makers to decide something even more aggressive? Or do financial markets not understand yet how powerful these measures actually are?'

Contrary to the path factor, our measure of Odyssean shocks is able to identify a number of recent key events that appear relevant from a narrative viewpoint. Moreover, it seems that the Delphic shocks are more important in the central part of our sample and less so in the recent episodes. As mentioned, we are studying an eventful sample span, e.g. 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 ... To this list we would add the change in the ECB communication at the monetary policy press conference, moving form a 'no pre-commitment' attitude towards more forward looking statements and commitments.

What are the impacts of the monetary policy announcements on financial instruments ? Are they different when considering a generic announcement (path factor) or an Odyssean one ? We considered various depended variables and regressed them on the different measures of monetary policy shocks. We considered nominal interest rates and inflation rates at various horizons and the real rates by taking the difference between the nominal spot rates and the inflation spot rates. We considered daily figures for the borrowing rates for non financial corporations and for banks from Gilchrist and Mojon (2017). These rates correspond to the effective yields on the zero-coupon euro-denominated bonds issued by banks and by non-financial corporations in the euro area. We also included in our analysis the log of euro area (overall and only banks) stock market prices. We considered the two days variations on the

		t	p	Adj R^2	t	d	o	Adj R^2
Nominal Rates	1m	0.78***	-0.03	0.34	0.58***	0.10	-0.08	0.13
	2y	0.87***	1.16***	0.44	1.57***	1.60***	0.49**	0.59
	3y	0.58**	1.13***	0.48	1.45***	1.54***	0.51**	0.54
	5y	0.37	0.93***	0.38	0.90***	1.42***	0.49**	0.46
	10y	-0.09	0.50***	0.11	0.18	0.88***	0.01	0.17
Inflation	2y	-0.41*	0.34***	0.07	-1.08***	1.52***	-0.66***	0.85
	3y	-0.53***	0.33***	0.12	-0.99***	1.32***	-0.63***	0.92
	5y	-0.08	0.24***	0.09	-0.08	0.87***	-0.83***	0.86
	10y	0.12	0.17***	0.06	0.33***	0.61***	-0.96***	0.88
	1y1y	-1.05***	0.26	0.06	-1.85***	1.46***	-0.96***	0.42
	2y2y	-0.06	0.04	-0.01	-0.02	0.47***	-0.98***	0.37
	5y5y	0.31**	0.09	0.04	0.75***	0.35***	-1.09***	0.60
Real Rate	2y	1.20***	0.76***	0.37	2.65***	0.08	1.14***	0.52
	3y	1.08***	0.79***	0.36	2.44***	0.21	1.13***	0.45
	5y	0.42*	0.69***	0.27	0.97***	0.56***	1.32***	0.31
	10y	-0.23	0.33***	0.05	-0.17	0.28*	0.97***	0.11
Borrowing rates	NFC	0.22	0.77***	0.25	0.51**	0.85***	0.75***	0.31
	Banks	0.13	0.70***	0.30	0.54**	0.68***	0.94***	0.31
(log) STOXX	All	-0.02	0.05	0.00	0.01	0.14***	-0.29***	0.15
	Banks	-0.01	0.07	0.00	0.01	0.21***	-0.33***	0.11

Table 5: Regression Estimating Responses of the revisions to the target and path and to the target, Delphic and Odyssean factors. The real rates are computed as the difference between the nominal and inflation rates. t stands for target factor, p for path factor, d for Delphic factor and o for Odyssean. One, two and three asterisks indicate statistical significance at 10%, 5% and 1% respectively. The target (path, Delphic and Odyssean) factor is normalized so that it generates a 1% increase in the 1 month (year) OIS futures.

day of the press conference and regress them in turn on a constant, target and path factor and on a constant, target, Delphic and Odyssean factor. Table 5 reports the estimated coefficients on the first (columns 3-5) and second (columns 6-9) regression. There are a number of things worth highlighting. First, the fit improves using the target, Delphic and Odyssean shocks as opposed to using only the target and path factors. Second, the path factor moves the real forward rates up through an increase in the nominal rates which largely offsets the positive movement of expected inflation rates. The Odyssean factor moves the real rates in the same direction for a different reason, that is expected inflation rates decline and nominal rates increase. The impact of the Delphic shocks on the real rate is found to be muted, as the movements in expected nominal rates are offset by the increase in expected inflation. The impact of these factors on stock market prices is interesting. While the path factor does not have a significant impact on the movement of stock market prices, the Delphic and Odyssean shocks generate significant variations with the expected signs. Interestingly, regardless of the nature of the shocks, i.e. either an increase in the path, or in the Delphic or in the Odyssean factor, an announcement of future tightening exerts an upward pressure on the borrowing cost faced by non financial corporation and by banks. So, monetary policy shocks do not affect only financial markets instruments but translate into an increase in the borrowing costs faced by real side of the economy. Next section studies how long the impact of Delphic and Odyssean shocks last.

3.2 Persistence of Monetary Policy announcement

To get a sense of the persistence of the effects of the Delphic and Odyssean shocks, we run a series of daily regressions at multiple horizons of the form

$$y_{t-1+h} = \alpha_h + \beta_h(L)y_{t-1} + \gamma_h \eta_t^j + \epsilon_t^{(h)}$$

where each forecast horizon h is associated with a different regression, y denotes the variable of interest at given maturity, t indexes business days, η_t^j denotes the monetary policy surprises as estimated above (and is set equal to zero on non-ECB announcement days), $\epsilon_t^{(h)}$ is a residual, and $\alpha_h, \beta_h, \gamma_h$ are parameters that may vary across regressions h. This is essentially Jordá's (2005) 'direct projections' method of estimating impulse response functions, with a lag length of zero for the lagged endogenous variable y on the right-hand side. We estimate that the coefficients α_h and β_h are essentially always close to zero and one, respectively. Of course, for longer horizons, there will also be a greater amount of non-monetary-policy news that impacts swaps, so the residuals and standard errors surrounding the coefficient estimates will tend to be larger. Figure 3 plots the results of these regressions for the 2 years, the 2 years in 2 years and the 5 years in 5 years ILS, the NFC borrowing rates, and the (log of) stock market prices. The solid blue line in each panel plots the point estimates of γ_h as a function of horizon h, and gray area indicates the Newey-West (1987) $\pm$1.96-standard-error bands around those point estimates, allowing for $h - 1$ lags of autocorrelation.

The effects of the target shocks are transitory and disappear after few days. Delphic and Odyssean shocks have a persistent effect on the variables on interest, ranging from weeks to months. In particular, Delphic shocks have a long lasting effect on inflation expectations and stock market prices which do not disappear within a quarter. While Odyssean shocks are less persistent, their dynamic transmission is found to last for one/two months. While we impose signs restrictions only on the contemporaneous correlation between nominal and inflation rates, we find that the signs of the impact of Delphic and Odyssean shocks found with the two day variations hold also at different horizon.

In all, by imposing an additional restriction on the correlation between the expected nominal rates and expected inflation we constructed an observable proxy of monetary policy news shocks (Odyssean factor) with desirable properties. It is consistent with a narrative description of the latest episodes of the ECB monetary policy announcements. It impacts

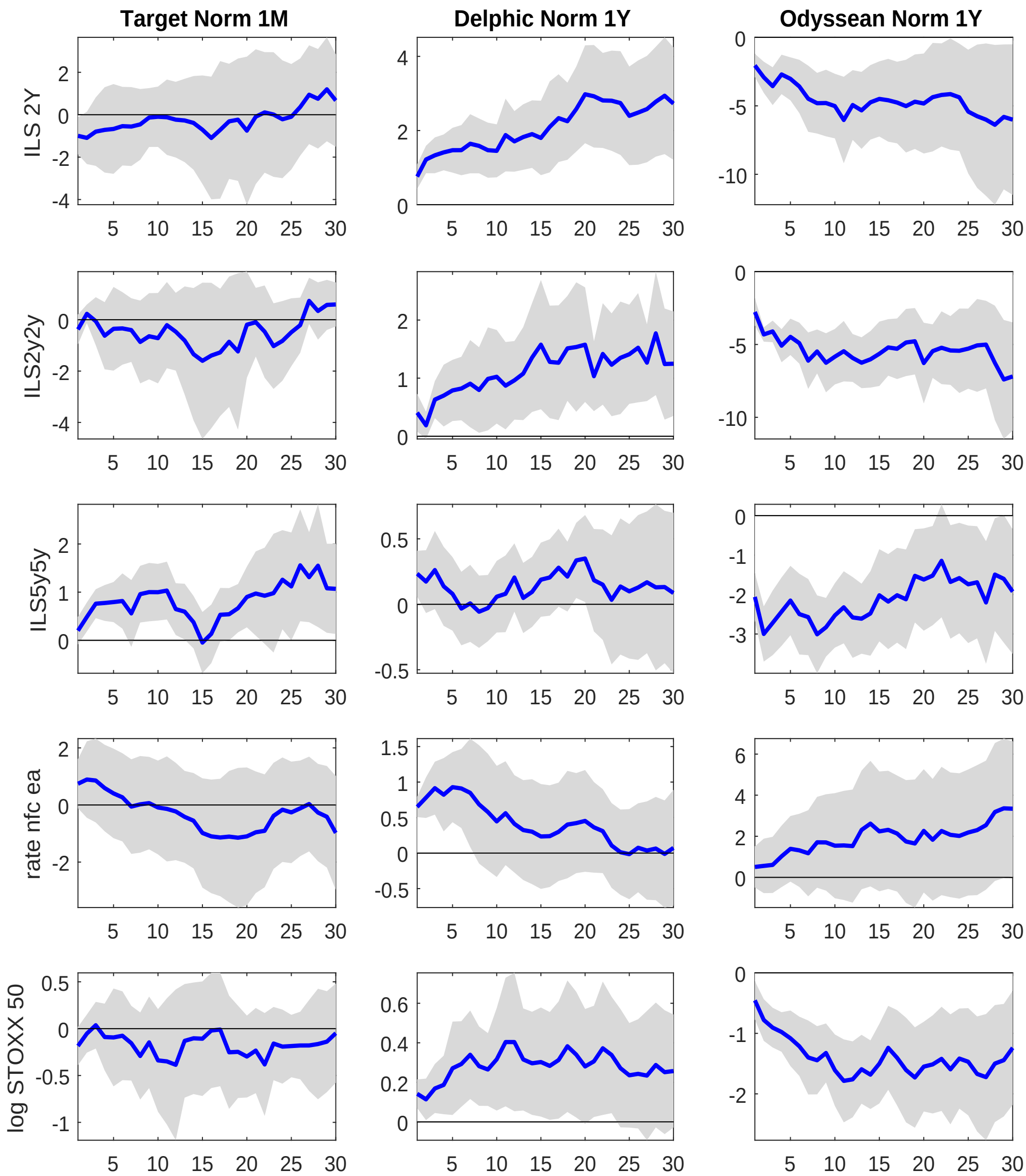


Figure 3: Persistence of Monetary Policy shocks. Impact of MP shocks on 2, 5 and 10 year ILS, NFC borrowing rates and Log STOXX x days after the monetary policy announcement.

daily financial instruments in accordance with our priors about an announcement of future monetary policy tightening (or accommodation) and displays some form of persistence which goes behind the immediate business days of the monetary policy announcements.

3.3 Impact on Survey Expectations

Table 6 reports the regressions estimating the monthly variation of GDP and inflation expectation from Consensus Economics on various factors (and a constant). In particular, we

	Target	Path	Adj R^2	Target	Delphic	Odyssean	Adj R^2
$GDP_{current\ Y}$	-0.73	0.01	-0.01	-3.12	1.42	0.01	-0.01
$GDP_{next\ Y}$	-0.51	0.50	-0.01	-0.03	1.43**	-1.98**	0.02
$\pi_{current\ Y}$	0.04	-0.17	-0.01	-0.34	-0.38	0.69	-0.02
$\pi_{next\ Y}$	-0.15	0.13	-0.01	-0.33	0.78**	-1.06*	0.03

Table 6: Regression Estimating the monthly variation Consensus on factors. OLS estimates and statistical significance, 1(5 and 10) % indicated with $***$ (** and $*$) with robust SE.

considered the following specifications,

$$\Delta^m F_{h,t}^{consenus} = \alpha_0 + \alpha_1 f_t^{Target} + \alpha_2 f_t^{Path} + e_t$$

and

$$\Delta^m F_{h,t}^{consenus} = \beta_0 + \beta_1 f_t^{Target} + \beta_2 f_t^{Delphic} + \beta_3 f_t^{Odyssean} + v_t$$

where $h = current\ Y, next\ Y$. Overall, the fit is very poor. It improves marginally for the end of next year forecasts when we account for the Delphic and Odyssean components, i.e the adjusted R^2 improve from -0.01 to 0.03/0.02. However and more importantly, the signs on the Delphic and Odyssean factors are in line with the identification using market based inflation expectations. These regressions only focus on contemporaneous impact effects. Next section offers a quantitative estimate of the dynamic propagation of Odyssean and path shocks on output and prices and on survey expectations about output growth and inflation.

4 The macroeconomic impact of Odyssean monetary policy surprises

The key question of this section is to quantify 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 of 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 ϵ_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 Φ 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 Ω 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 path factor and the Odyssean 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. The novelty of this paper is to isolate the effect of 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 Ω, 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

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

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

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

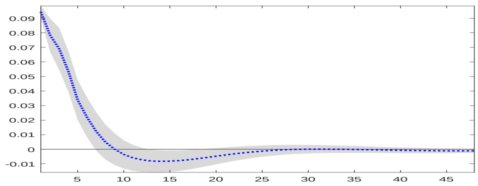
where the second equation is estimable using the sample analog since m_t is observable, e_t is observable conditional on Φ and Σ and they are both stationary. This restriction coupled with the fact that $\Omega\Omega' = \Sigma$ give rise to a set of equations that up to a sign normalization uniquely pin down the first column of the rotation matrix. The econometric approach works as follows. We first run the VAR OLS regression to obtain Φ and Σ. 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 consists of survey data measuring private sector expectations and of macroeconomic data. As monetary policy instruments, we include the difference between the 12 months and the 3 months EONIA swaps, a measure of the slope of the term structure of rates; we instrument the residuals of this equation with our proxies of monetary policy surprises. We then include seasonally adjusted (log) industrial production index (excluding construction), the (log) HICP excluding from energy and food and the Gilchrist and Mojon (2017) credit spread. We also include survey measures of expectations, i.e. the Consensus forecasts about next year GDP growth and next year inflation rate. The data is observed at monthly frequency and spans the period from January 2002 to January 2006.

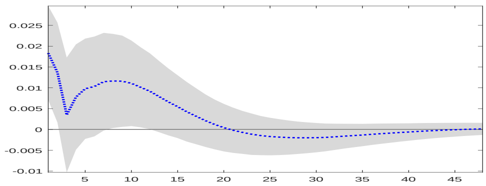
Figures 4 report the estimated impulse responses of the Odyssean monetary policy announcement and a generic monetary policy announcement which does not distinguish between the Delphic and Odyssean components, i.e. the path factor. Both announcements are normalized to generate a future monetary policy tightening, i.e. widen the spread between the 12 and 3 months ahead forecast of the short term nominal interest rate, generating a steepening of the slope of the term structure. While a generic announcement lift the expectations about inflation and output growth suggesting a strong signaling component (panels (i) and (k)), the Odyssean announcement of monetary policy tightening depresses the agents expectations about inflation and output growth (panels (j) and (l)). While both effect are short lasting, the sign impact is consistent with a credible announcement of a commitment to future tightening. The sign implication on output and prices are similar. A generic announcement of monetary policy tightening generate an initial drop in industrial production, which bounces back shortly after. Core prices move up permanently and significantly. The latter result is difficult to rationalize as a standard transmission mechanism of a future monetary policy tightening, unless we acknowledge a strong signaling effect of monetary policy. The dynamic transmission of the Odyssean shock does not lead to this interpretation. Both actual prices and quantities (with a delay) as well as their expectations move in line with a 'well-understood' commitment of a future monetary policy restrictive stance. This gives additional credit to the identification strategy we used to identify future monetary policy shocks.

5 Conclusions

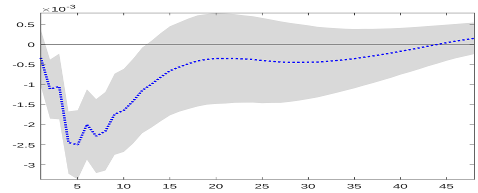
We study the Delphic and Odyssean component of forward guidance shocks. We propose an approach to separately identify them and we measure their dynamic impact on the euro



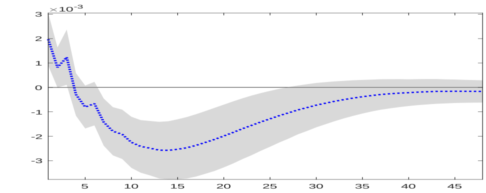
(a) Path to rates slope



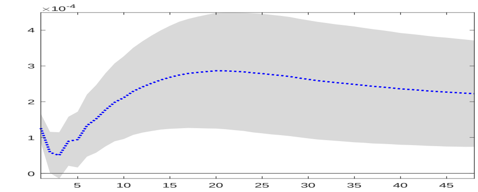
(b) Odyssean to rates slope



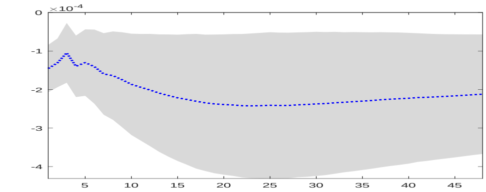
(c) Path to IP



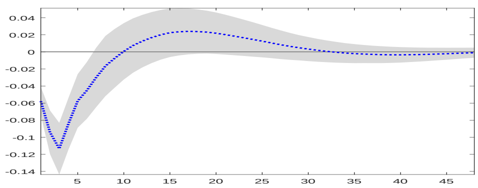
(d) Odyssean to IP



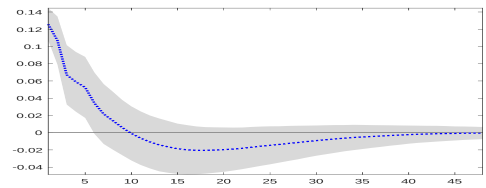
(e) Path to CORE



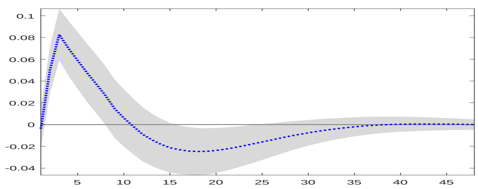
(f) Odyssean to CORE



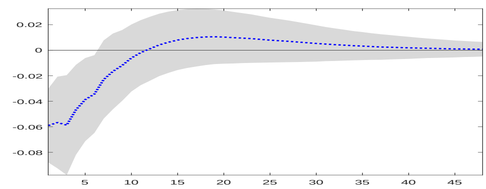
(g) Path to Credit Spread



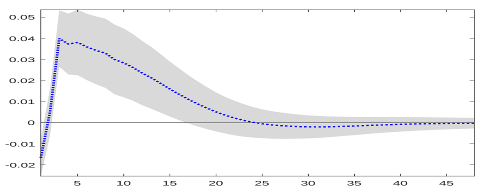
(h) Odyssean to Credit Spread



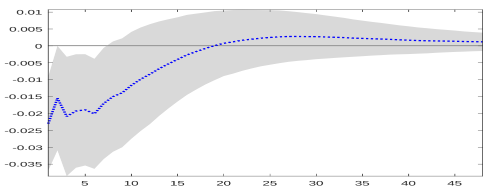
(i) Path to GDP next Y



(j) Odyssean to Expected GDP next Y



(k) Path to CPI next Y



(l) Odyssean to Expected CPI next Y

Figure 4: Impulse responses of the Odyssean monetary policy announcement, and a generic monetary policy announcement on expectations, prices and output. Gray bands 68% confidence sets.

area macroeconomic aggregates and their expectations about future prospects. 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 to a path factor impulse compared to an Odyssean monetary policy impulse. In particular, in the former case an announcement of tightening is expansionary. In the latter, an announcement of future monetary policy tightening interpreted as Odyssean decreases industrial production, core prices and expectations about inflation and output growth.

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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, Λ 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 ΛH 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 ΛH is equivalent to imposing the zero and sign restrictions on $\Lambda_{3:3}H$ which is the top 3×3 submatrix of ΛH. 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 ΛH 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 θ ranging from 0 to π 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

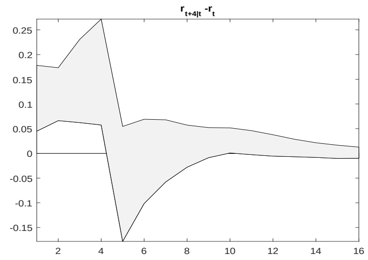
This section provides a quantitative exploration of the correlation between the slope of the term structure of interest rates and inflation expectations conditional on monetary policy announcements in a medium scale DSGE model. We consider the baseline version of the Smets and Wouters (2007) model (henceforth 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.

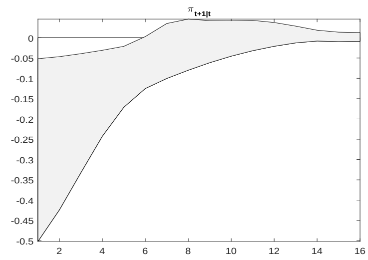
In Figure 5 the gray ares reports all the possible trajectories for the slope of the the term structure of rates, $E_t r_{t+4} - r_t$, and the inflation expectations $E_t\pi_{t+j}$ for $j + 1, ..., 4$ of such announcements. Following the announcement of tightening, the slope of the interest rate term structure increases and inflation expectations rise. Hence, the correlation conditional on monetary policy announcement is negative.

A.3 Information Asymmetries and Central Bank Expectations revisions.

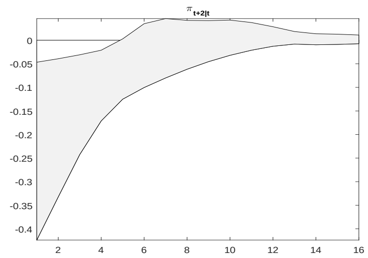
Some authors argue that the central bank can process more information relative to the private sectors. Agents might then close the information asymmetry gap during the conference press and revise their expectations about the future. If this is the case, then variations in interest rate do not reflect 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.



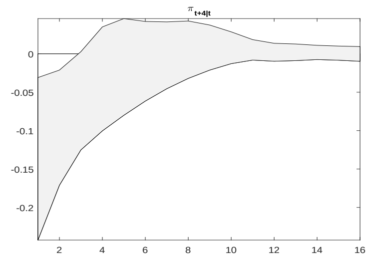
(a) Slope, $E_t r_{t+4} - r_t$



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



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



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

Figure 5: 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.

The problem is that it is not easy to measure information sets. Campbell et al. (2017) 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. (2017) 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[11]. Tables 11 and 12 report the available figures at quarterly frequency. Unfortunately, there is a delay in the timing of the publication of the SPF forecasts and the ECB staff macroeconomic projections; the latter are published on the day of the press conference and the former between 3 to 4 weeks days before. This generates a discrepancy of information set that - we believe - is mostly due to the timing of the information flow then to different expectations about the current and future states of the economy.

For what is worth it, 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 gaps, contemporane-

[11]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

	R2	P-values					F test
		Const	HICP	HICP(+1)	RGDP	RGDP(+1)	
				Lagged $k = 1$			
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
				Contemporaneous, $k = 0$			
target	0.15	0.37	0.03	0.04	0.19	0.32	2.29
path	0.04	0.06	0.37	0.35	0.28	0.19	0.57

Table 7: 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.

ously and lagged

$$\begin{aligned}\eta_t^j =&\beta_0 + \beta_1(HICP_{t-k}^{SPF} - HICP_{t-k}^{ECB}) + \beta_2(HICP(+1)_{t-k}^{SPF} - HICP(+1)_{t-k}^{ECB}) \\ &+ \beta_3(GDP_{t-k}^{SPF} - GDP_{t-k}^{ECB}) + \beta_4(GDP(+1)_{t-k}^{SPF} - GDP(+1)_{t-k}^{ECB}) + v_t\end{aligned}$$

for $j = t, p$ and $k = 0, 1$ and where (+1) () indicates the next (current) year forecasts. sWe report the results in Table 7. Regression results are poor. R^2 are low and either singularly or jointly we fail to reject the singularity of coefficients. And even for $k = 0$, the path factor is not explained by the discrepancy between central bank and private sector forecasts.

Miranda-Agrippino and Ricco (2017) propose to remove the component of the interest rate variations predictable by the Central Bank forecasts and forecast revisions and use the residual as a proxy for monetary policy shock. We tried to construct the Miranda-Agrippino and Ricco (2017) informationally robust instrument for the euro area using ECB and Euro system staff macroeconomic projections and forecast revisions. Along the lines of their analysis on the US monetary policy, we specified the following regression

$$f_t^j = \alpha_0 + \beta(L)f_{t-1}^j + \gamma' ECB_t^{proj} + \theta' \Delta^q ECB_t^{proj} + e_t$$

where $j = Target, Path, Odyssean, Delphic$ and
$ECB_t^{proj} = [\pi_{current\ Y},\ \pi_{next\ Y},\ GDP_{current\ Y},\ GDP_{next\ Y}]'$ contains current and next year projections for output and inflation, and $\Delta^q ECB_t^{proj}$ their revision relative to the previous quarter. The residual of this regression is the informationally robust MP instrument

The major complication with this approach is the sample size reduction. The EBC projections are released quarterly and the monetary policy surprises are monthly. We considered the MP surprises that are paired with the staff macro projections. This reduces our sample size from 135 to 46 for Delphic and Odyssean and from 169 to 55 for target and path. Notice that since we are removing two thirds of the observations, the new series f_t^j might not be centered in zero and with zero autocorrelation.

We run the full regression specification, see table 9, and two separate regressions with either the ECB projections or the ECB forecast revisions, see table 8. OLS estimates,

	Target	Path	Delphic	Odyssean
const	0.02	0.00	0.04	0.02
$\pi_{currentY}$	0.01**	-0.02	0.01	-0.00
$\pi_{next\ Y}$	-0.02**	0.04	-0.01	-0.01
$GDP_{current\ Y}$	0.00	0.00	0.01	0.00
$GDP_{next\ Y}$	-0.00	-0.02	-0.01	0.00
Adj R2	0.06	-0.03	-0.04	-0.07
F test	1.91	0.55	0.59	0.31
const	0.00	0.02*	0.01**	0.01
$\Delta\pi_{currentY}$	0.01	0.03	0.01	0.00
$\Delta\pi_{next\ Y}$	-0.02	-0.01	-0.02	-0.00
$\Delta GDP_{current\ Y}$	-0.00	-0.01	0.00	-0.00
$\Delta GDP_{next\ Y}$	0.00	0.01	-0.01	0.00
F test	0.48	0.36	0.63	0.09
Adj R2	-0.04	-0.05	-0.03	-0.09
Sample size	56	56	46	46

Table 8: Monetary policy surprises and ECB staff projections and forecast revisions. OLS estimates and statistical significance, 1(5 and 10) % indicated with $***$ ($**$ and $*$) with robust SE. Top panel ECB forecasts, bottom panel ECB forecast revisions.

statistical significance, Adjusted R^2 and F test are reported. Standard errors are computed with robust covariance estimates for ordinary least squares. In the stripped down regressions (table 8), MP target surprises are explained by the ECB projections of inflation for the current and next year; the sign for the next year is puzzling. Nothing else is statistically significant (except for constants) and the measures of fit are low. In the full specification, results are similar for the MP target surprises. For the path factor, a ECB forecast and revision are statistically significant at the 10% confidence level. However, the fit of the specification is worse than the one obtained with the stripped down regressions, i.e. the Adjusted R^2 is -0.08 in the full specification regression and 0.01 or -0.03 in the stripped down regressions.

Our takeaway is consistent with the results on the predictability of MP surprises. We found that the target responds to the factor 5 of table 3. And factor 5 is associated with measures of inflation. Therefore, it is not surprising to see that the target responds to the ECB forecasts of inflation. Anyhow, we do not think that there is enough evidence in order to say that the path factor responds to ECB forecasts and forecast revisions.

	Target	Path	Delphic	Odyssean
const	-0.00	0.03	0.02	-0.00
AR1	-0.09	-0.04	0.11	-0.15
AR2	0.10	-0.09	-0.00	-0.07
AR3	-0.42**	-0.18	-0.26	-0.15
$\pi_{currentY}$	0.04***	-0.05*	0.00	0.00
$\pi_{next\ Y}$	-0.04**	0.08*	0.01	-0.01
$GDP_{current\ Y}$	-0.00	0.01	0.00	-0.00
$GDP_{next\ Y}$	-0.00	-0.04*	-0.02	0.01
$\Delta\pi_{currentY}$	-0.01	0.05*	0.01	-0.00
$\Delta\pi_{next\ Y}$	0.01	-0.04	-0.03	0.00
$\Delta GDP_{current\ Y}$	0.00	-0.02	-0.00	0.00
$\Delta GDP_{next\ Y}$	0.01	0.03	0.00	-0.00
Adj R2	0.24	-0.08	-0.10	-0.31
F test	2.44	0.65	0.66	0.13
Sample size	51	51	41	41

Table 9: Monetary policy surprises and ECB staff projections and revisions. OLS estimates and statistical significance, 1(5 and 10) % indicated with $***$ ($**$ and $*$) with robust SE.

A.4 Time variation of the response of ILS

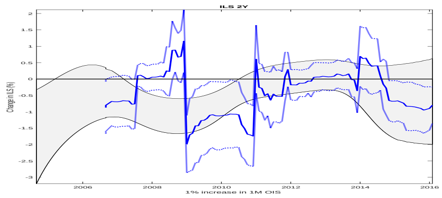
To gauge more evidence on the possible time variation in the impact of the target and path factor on inflation expectations we conducted two complementary exercises where we do not arbitrarily select the subsamples. The first exercise is based on rolling window regression and the second on local kernel 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

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

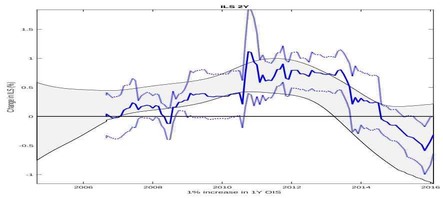
where $K_f(.)$ is the Gaussian kernel function and h is the bandwidth, where η_t collect the path and target factors (and a constant). Data points far form τ will have small weights, yet non zero as in the rolling window[12]. Figure 6 reports the rolling sample estimates of the impact of the target (left panels) and path (right panels) factor on market-based inflation expectations. In particular, the blue solid and dashed lines reports the OLS estimates of regressing the financial instrument on the target and path factor along with the 90% confidence bands in a 24 month window. The gray areas report the same information using a local linear kernel

[12] 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_τ.

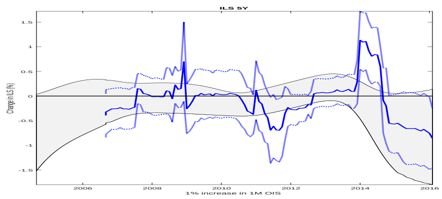
estimator. The impact of the target factor tends to be relatively stable over the rolling windows, i.e. fluctuating between negative or non significant values. The impact of the path factor instead displays slow moving time variation, switching from positive to negative values.



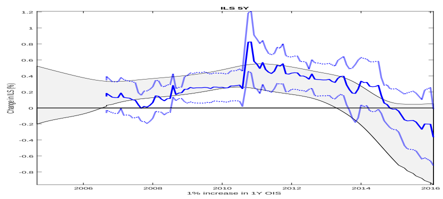
(a) Target on 2Y ILS



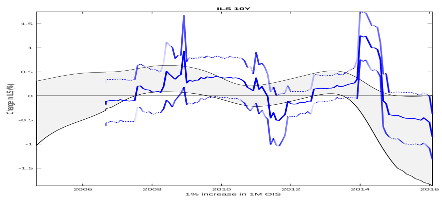
(b) Path on 2Y ILS



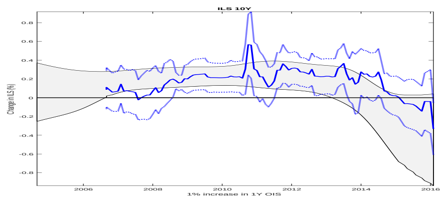
(c) Target on 5Y ILS



(d) Path on 5Y ILS



(e) Target on 10Y ILS



(f) Path on 10Y ILS

Figure 6: Impact of the path factor on the ILS over rolling windows or with a local kernel estimator

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

	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 11: 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 12: SPF projections for the euro area, Inflation and Real GDP

	EU 1Y	EU 2Y	EU 3Y	EU 4Y	EU 5Y	EU 6Y	EU 7Y	EU 8Y	EU 9Y	EU 10Y	EU 12Y	EU 15Y
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
Target	0.31	-0.37	-0.49	-0.19	-0.02	0.10	-0.08	0.00	0.05	0.18	0.13	0.11
Path	0.48***	0.38***	0.37***	0.23***	0.28***	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	0.18	0.09	0.10	0.09	0.12	0.18	0.09
Target	-0.73	-0.64	-0.64*	-0.62**	-0.73**	-0.78***	-0.86***	-0.84***	-0.72***	-0.83***	-0.66***	-0.58**
Path	-0.83***	-0.64***	-0.76***	-0.83***	-0.69***	-0.73***	-0.68***	-0.63***	-0.65***	-0.63***	-0.70***	-0.81***
Adj R^2	0.29	0.24	0.28	0.29	0.27	0.36	0.39	0.43	0.46	0.51	0.51	0.55

Table 13: Regression Estimating Responses of the revision (2 day) of Market Inflation Forecast (Spot rates) to Target and Path factors, full sample and subsamples.

	EU 1Y	EU 2Y	EU 3Y	EU 4Y	EU 5Y	EU 6Y	EU 7Y	EU 8Y	EU 9Y	EU 10Y	EU 12Y	EU 15Y
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
Target	0.43	-0.37	-0.56*	-0.38	-0.20	-0.05	-0.13	-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	0.04	0.05	0.03	0.05	0.03	0.01
Target	-0.61	-0.32*	-0.15	-0.25	-0.34	-0.36*	-0.35*	-0.30	-0.34*	-0.54**	-0.45**	-0.21
Path	-0.31	-0.28*	-0.42**	-0.39**	-0.37	-0.44*	-0.43**	-0.41*	-0.36*	-0.30	-0.36*	-0.43*
Adj R^2	0.07	0.01	0.09	0.09	0.07	0.16	0.20	0.14	0.12	0.14	0.19	0.16

Table 14: Regression Estimating Responses of the revision (1 day) of Market Inflation Forecast (Spot rates) to Target and Path factors, full sample and subsamples.

	ILS1y1y	ILS2y2y	ILS5y5y	ILS10y5y	ILS1y1y	ILS2y1y	ILS3y1y	ILS4y1y	ILS5y1y	ILS6y1y	ILS7y1y	ILS8y1y
Target	-1.05	-0.06	0.31*	-0.08	-1.05	-0.64**	0.05	0.08	0.16	-0.32	0.02	0.04
Path	0.26	0.04	0.09	0.07	0.26	0.32***	0.05	0.29***	0.27***	0.11	0.17***	0.15*
Adj R^2	0.06	-0.01	0.04	-0.01	0.06	0.14	-0.01	0.10	0.09	0.03	0.04	0.03
Target	-1.06	-0.01	0.39**	-0.05	-1.06	-0.61**	0.11	0.15	0.23	-0.27	0.08	0.09
Path	0.28	0.08	0.13*	0.12	0.28	0.36***	0.09	0.32***	0.32***	0.14	0.20***	0.18**
Adj R^2	0.06	-0.01	0.08	0.00	0.06	0.17	0.00	0.14	0.14	0.03	0.08	0.05
Target	-0.55***	-0.59*	-0.93**	-0.07	-0.55***	-0.63	-0.60**	-0.84**	-0.83***	-0.95***	-0.81***	-0.60***
Path	-0.45***	-1.01***	-0.58**	-1.17***	-0.45***	-0.88***	-0.89***	-0.55**	-0.78***	-0.63***	-0.58**	-0.67***
Adj R^2	0.07	0.23	0.63	0.50	0.07	0.25	0.28	0.21	0.45	0.41	0.43	0.48

Table 15: Regression Estimating Responses of the revision (2 day) of Market Inflation Forecast (Forward rates) to Target and Path factors, full sample and subsamples.

	ILS1y1y	ILS2y2y	ILS5y5y	ILS10y5y	ILS1y1y	ILS2y1y	ILS3y1y	ILS4y1y	ILS5y1y	ILS6y1y	ILS7y1y	ILS8y1y
Target	-1.15*	-0.39	0.15	-0.25	-1.15*	-0.73**	-0.21	-0.06	0.07	-0.22	-0.08	-0.15
Path	0.73**	0.08	0.11*	-0.03	0.73**	0.21***	0.05	0.11	0.16**	0.04	0.16**	0.07
Adj R^2	0.15	0.03	0.03	0.00	0.15	0.13	0.00	0.01	0.02	0.02	0.04	0.01
Target	-1.18*	-0.38	0.21	-0.27	-1.18*	-0.75**	-0.20	-0.03	0.11	-0.21	-0.06	-0.13
Path	0.75**	0.10	0.13**	-0.01	0.75**	0.24***	0.06	0.12	0.19**	0.06	0.18**	0.09
Adj R^2	0.15	0.03	0.05	0.00	0.15	0.14	-0.00	0.02	0.04	0.02	0.05	0.01
Target	-0.03	-0.18	-0.73***	0.44***	-0.03	0.02	-0.35	-0.43*	-0.39*	-0.34	-0.24	-0.38*
Path	-0.25	-0.51**	-0.22	-0.69***	-0.25	-0.56**	-0.37*	-0.35	-0.50**	-0.42**	-0.39*	-0.32
Adj R^2	-0.09	0.09	0.18	0.22	-0.09	0.13	0.07	0.04	0.24	0.22	0.07	0.10

Table 16: Regression Estimating Responses of the revision (1 day) of Market Inflation Forecast (Forward rates) to Target and Path factors, full sample and subsamples.

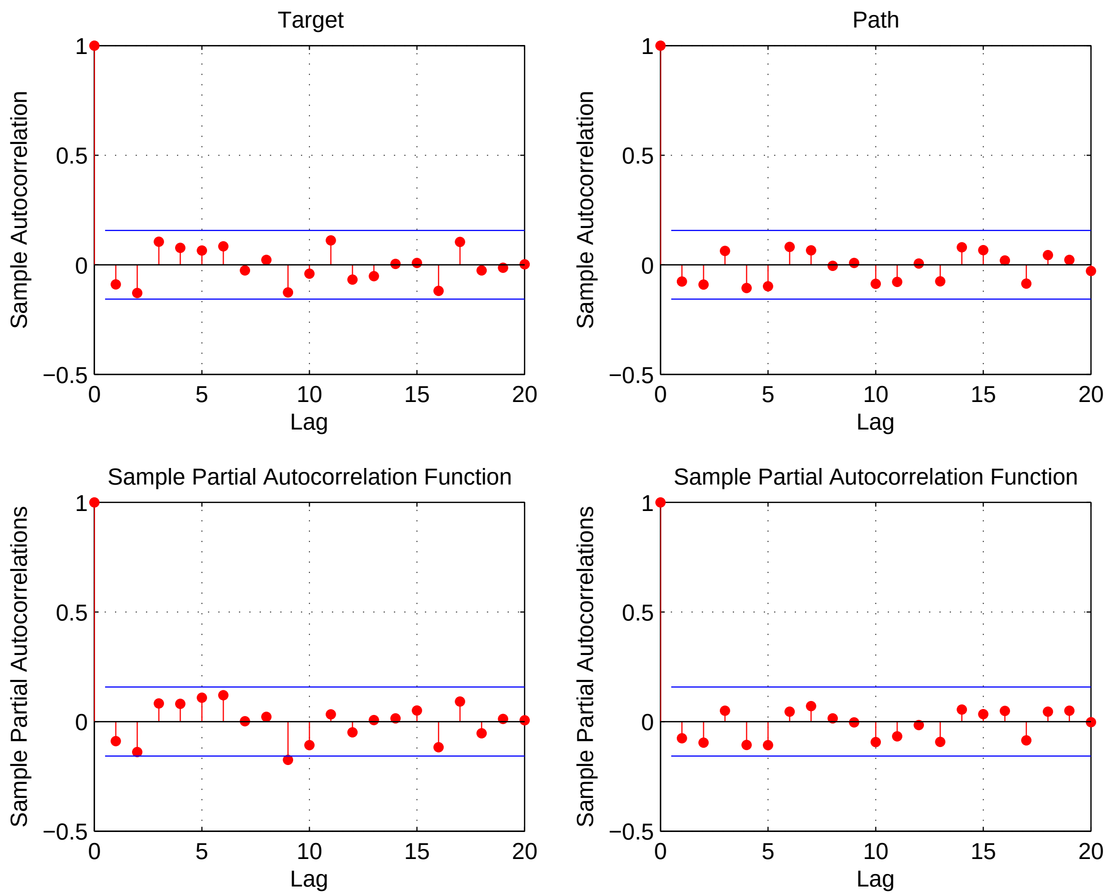


Figure 7: Autocorrelation and Partial Autocorrelation function for the path and the target factor. Blue bands indicate statistical significance.

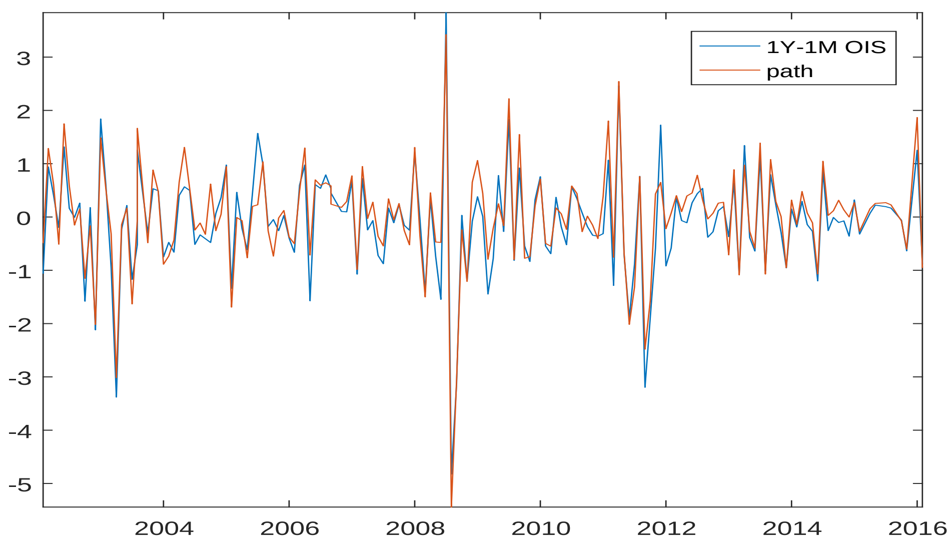


Figure 8: Plot of the path factor and the slope of (1y-1m) OIS swaps

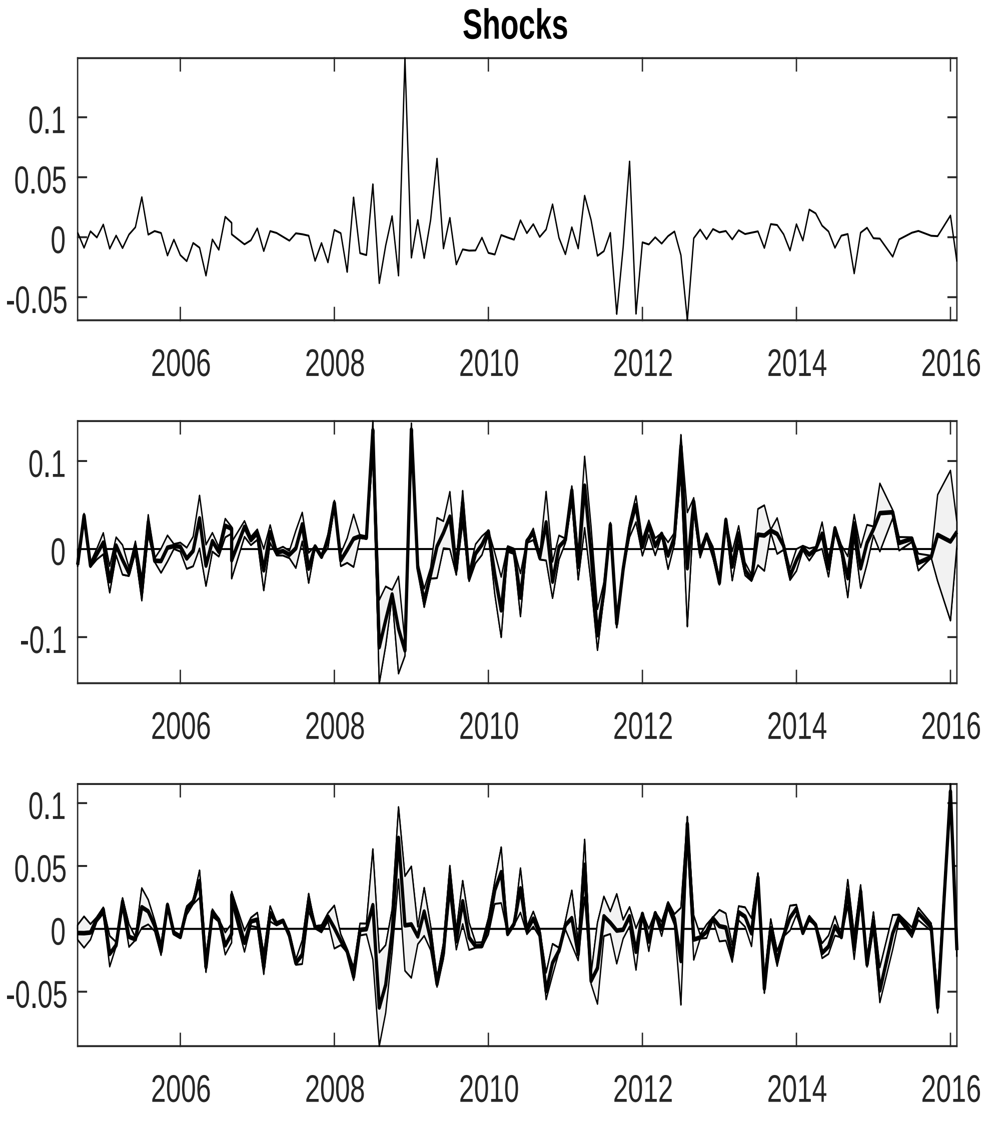


Figure 9: Plot of the target, Delphic and Odyssean factors with the set identification bands.

	R^2	OLS Coeff
CORE	0.29	1.82
HICP	0.27	1.99
TURNOVERRET	0.07	0.04
ESI	0.06	-0.22
DJ50	0.05	-0.07
SP500	0.05	-0.09
IPIEN	0.05	-0.05
CCI	0.04	-0.21***
NAPM	0.04	-0.08
UNRATEPER	0.02	0.17*
EONIA	0.01	1.24*
IPINOCOSTR	0.01	-0.18
M3	0.01	-0.38***
IPIINTER	0.01	-0.01
IPINOCOSTREN	0.01	-0.14
TURNOVERMAN	0.01	0.02
UNRATE	0.01	1.84***
UKEUROSPOT	0.01	8.27
GS10	0.01	-0.68
PCOMM	0.01	-0.04*
1YEURIBOR	0.01	-0.76***
UNRATEUS	0.01	0.71***
BRENT	0.01	0.01
CE16OV	0.01	-0.47***
TB3MS	0.00	-0.55***
3MEURIBOR	0.00	-0.51
CPIUS	0.00	0.20
NEWORDER	0.00	-0.03***
CARREG	0.00	-0.00
DOLEUROSPOT	0.00	-1.53*
REXRATE	0.00	-0.03
YENEUROSPOT	0.00	0.01
RRSFS	0.00	0.04
IPICONS	0.00	-0.00**
IPITOT	0.00	0.00
LOANS	0.00	-0.03
IPIDUR	0.00	0.00

Table 17: Regression Estimating f_5 on each observable variables in the factor model, i.e. $f_{5,t} = \alpha_0 + \alpha_0 X_{j,t} + e_t$. OLS estimates and statistical significance, 1(5 and 10) % indicated with $***$ ($**$ and $*$) with robust SE.