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**Article — Published Version**

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International Finance

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*Suggested Citation:* Baumgärtner, Martin; Klose, Jens (2021) : Why central banks announcing liquidity injections is more effective than forward guidance, International Finance, ISSN 1468-2362, Wiley, Hoboken, NJ, Vol. 24, Iss. 2, pp. 236-256, <https://doi.org/10.1111/inf.12389>

This Version is available at:

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# Why central banks announcing liquidity injections is more effective than forward guidance

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## Abstract

We distinguish the announcement effects of conventional and unconventional monetary policy measures on macroeconomic variables using a high-frequency data set that measures the impact of the European Central Bank's monetary policy decisions. For the period 2002 to 2019, we show that conventional and unconventional monetary policy measures differ considerably in their impact on inflation. While conventional measures show the expected response, that is, an interest rate cut increases inflation, unconventional measures appear to generally have no significant influence. However, this does not hold for quantitative easing, which is found to have a similar influence on inflation as the conventional interest rate changes.

## KEYWORDS

European central bank, high-frequency data, information shock, unconventional monetary policy

## JEL CLASSIFICATION

E52, E58, C36

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## 1 | INTRODUCTION

The financial crisis starting in 2008/2009 changed the traditional monetary policy. The interest rate channel's effectiveness reached its limit, at the zero lower bound (ZLB), and central banks, therefore, broadened their range of instruments. However, these new measures have raised new challenges for researchers. It is not easy to map all policies through a single model and analyze their effects simultaneously. Central bank measures can be roughly broken down into conventional and unconventional measures. While the effects of conventional measures on important macroeconomic variables have been extensively investigated, the empirical effects of forward guidance and quantitative easing (QE) are far less investigated and still a controversial matter in the literature. Forward guidance is difficult to capture, because there is no clear indicator that makes the effect objectively observable.

We fill this gap in the literature by estimating the announcement effect of all monetary policy measures in the euro area (EA) with a single model.<sup>1</sup> This allows for a detailed comparison of the macroeconomic impacts of the various measures. More specifically, we use the findings of Altavilla et al. (2019) and the EA Monetary Policy Event-Study Database (EA-MPD), published by the authors, to estimate the monetary policy surprises around European Central Bank (ECB) meeting dates. These estimations, in turn, are employed to determine the effects of individual measures on the key macroeconomic variables in an external instruments vector autoregression (VAR) approach. Using monthly data for the period between 2002:01 and 2019:06, we indeed find significant differences between conventional and unconventional measures, but also between forward guidance and QE.

We can further show that Delphic shocks can be found through the EA-MPD data. These shocks are events that cannot be explained by basic economic theory. Contrary to expectations, the central bank's expansionary shock does not lead to rising inflation but falling inflation. One explanation is that the markets are reacting to the central bank's negative expectations for the future. The term Delphic refers to Greek mythology, where the Oracle of Delphi makes predictions that need to be interpreted by the individuals, and thus trigger actions. By subdividing the individual measures more precisely, we can further narrow down the effect and increase our knowledge about Delphic shocks. Especially in the case of short-term expectation-forming timing measures, a clear difference in macroeconomic effects can be seen. Information effects seem to play a vital role here. In contrast, the difference is not clear with conventional policies. Based on this result, we can empirically validate the assumption that Delphic shocks are particularly important in forward guidance and less so in conventional policy.

The remainder of the paper proceeds as follows. Section 2 reviews the literature, including an overview of the different approaches to distinguish monetary policy measures. Section 3 describes the methodology, that is, the econometric framework, the construction and justification of the instruments, and the data used in this study. Section 4 presents our estimation results, showing, first, differences between conventional and unconventional measures; second, differences between the various forms of unconventional measures; and, third, differences between market reactions toward unconventional qualitative announcements such as forward guidance. To test if our results are influenced by a structural break around the financial crisis, we conduct a robustness test in Section 5. In Section 6, we present a possible explanation for

<sup>1</sup>Besides announcement effects, application effects of monetary policy can also arise. Although these are not addressed in our high-frequency model, they have already been extensively investigated by Haitsma et al. (2016), Jäger and Grigoriadis (2017), Borralló Egea and Hierro (2019), and Domínguez-Torres and Hierro (2020).

our results by splitting the effects of forward guidance by the different market reactions. Section 7 concludes the paper and draws policy conclusions.

## 2 | RELATED LITERATURE

The financial crisis demonstrated that the existing transmission channels of monetary policy can be affected by uncertainty. At the same time, empirical evidence shows a negative trend in inflation developments, that could even be beyond the reach of central banks (Bonam et al., 2019). Traditional empirical approaches to identify monetary policy shocks reach their limits because of the common use of a short-term interest rate when the ZLB becomes binding. The ECB, as other central banks in industrialized countries, therefore switched its policy to include additional unconventional measures. Therefore, other ways must be found to model these kinds of shocks.<sup>2</sup>

The simplest and most straightforward way is to switch to longer-term interest rates as a policy variable, to avoid the problem of variables that equal zero. However, this approach is also influenced by the ZLB, that is, long-term interest rates can approach zero if the zero-interest period lasts too long (Swanson & Williams, 2014). Moreover, when relying on longer-term interest rates, the risk of factors besides monetary policy (e.g., changing market expectations) biasing this variable increases.

A second approach besides classical interest rates involves artificial (shadow) rates that include unconventional measures (Krippner, 2013; Wu & Xia, 2016). Recent studies urge caution, since the estimates are very sensitive (Krippner, 2019).

Another method of identification in unconventional times is a combination of sign and zero restrictions (Arias et al., 2018). A large strand of the literature combines this method with central bank assets (Boeckx et al., 2017; Burriel & Galesi, 2018; Gambacorta et al., 2014). Whether this combination identifies unconventional shocks is currently being discussed (Boeckx et al., 2019; Elbourne, 2019; Elbourne & Ji, 2019).

Since Kuttner (2001), there has been a growing literature using high-frequency data sets. The author has shown that financial variables react to changes in US Federal Reserve policy. Building on these insights, Gürkaynak et al. (2005) identify different monetary shocks, namely, a target factor and a path factor. Brand et al. (2010) develop this method further concerning the ECB, not only by considering the differences before and after the decision, but also by separating the effect of the press release and subsequent press conference. To the best of our knowledge, Gertler and Karadi (2015) are the first to use these high-frequency monetary shocks in an external instrument VAR. The assumption made in these kinds of estimations is that no other shocks distort the results if the time window is small enough. The authors find different effects of conventional and high-frequency identification in VAR models. Swanson (2017) expands the previous identification of shocks. The author shows that it is possible to extract the effects of large-scale asset purchases (LSAP/QE) for the period from 2009 to 2015 in the United States.

An even more accurate approach to identifying shocks from high-frequency data is made by Andrade and Ferroni (2018). They combine principle component analysis and sign restrictions to distinguish between Delphic and standard forward-guidance shocks. These shocks were first established by Campbell et al. (2012). In their theory, a Delphic shock lowers interest rates, but has a dampening effect on stock prices due to new, worse information from the central bank.

<sup>2</sup>For a detailed overview of these approaches, see Rossi (2019).

Jarociński and Karadi (2018) and Kerksenfischer (2019) show that Delphic shocks from central banks play an essential role in both the United States and the EA.

Altavilla et al. (2019) build on the previous findings and address the reality of Delphic and monetary shocks. They provide a high-frequency data set for the EA and extract various orthogonal shocks for the press release and press conference. The authors provide a first insight into how the shocks affect individual financial variables, but they do not address the macroeconomic effects.

### 3 | METHODOLOGY

The publication of the EA-MPD by Altavilla et al. (2019) provided the opportunity to examine the influence of monetary policy measures on the European economy. It is possible to distinguish between individual orthogonal measures, such as interest rate policy, forward guidance, or QE, and examine the different effects. In the following, we will first describe the detailed formulation of our econometric model and then construct our instruments. In a third step, we combine both with data and show that the instruments we have chosen are permissible in our model and produce reliable results.

#### 3.1 | Econometric model

In our model, we want to estimate the reactions of economic variables to different monetary policy shocks  $\epsilon_t^p$ . However, since most of the variables are affected by various shocks simultaneously, we use an approach with exogenous instruments developed by Stock and Watson (2012), Mertens and Ravn (2013), and also applied by Gertler and Karadi (2015). This approach allows us to isolate the individual shocks that simultaneously affect our policy variables.

Let  $Y_t$  be an  $(N \times 1)$  matrix of  $N$  economic variables in  $T$  periods. Consider a VAR in general structural form:

$$AY_t = C + \sum_{j=1}^J C_j Y_{t-j} + \epsilon_t, \quad (1)$$

where  $C$  represents a constant, while  $A$  and  $C_j$  form the coefficient matrices, including  $J$  lags. Inverting  $A$  leads to

$$Y_t = A^{-1}C + \sum_{j=1}^J A^{-1}C_j Y_{t-j} + v_t, \quad (2)$$

with  $v_t$  denoting the reduced-form residuals. They are connected to the structural shocks  $\epsilon_t$  by

$$v_t = A^{-1}\epsilon_t. \quad (3)$$

Replacing  $S = A^{-1}$  and (3) in (2) yields the following model:

$$Y_t = SC + \sum_{j=1}^J SC_j Y_{t-j} + S\epsilon_t. \quad (4)$$

We are especially interested in estimating one column of  $S$ . The column  $s^p$  indicates how the reduced-form residuals  $v_t$  change in response to a unit increase in the structural shock  $\epsilon_t^p$ . We follow Gertler and Karadi (2015) and focus our analysis on column  $s^{mp} = S_{.,mp}$ , which reflects the reaction of our variables to a monetary policy shock. All the other columns are represented by  $s^q = S_{.,q}$ . Together with (3), we obtain the following equations:

$$v_t^{mp} = s^{mp} \epsilon_t^{mp}, \quad (5a)$$

$$v_t^q = s^q \epsilon_t^{mp}. \quad (5b)$$

These can be solved for  $v_t^q$  with

$$v_t^q = \frac{s^q}{s^{mp}} * v_t^{mp}. \quad (6)$$

The fraction corresponds to a unit effect normalization. A unit shock in  $\epsilon_t^{mp}$  increases  $v_t^{mp}$  by the same amount. All the other effects on the variables are expressed proportionally. If we want to solve this equation, we come across an endogeneity problem. To resolve this issue, we use a two-stage approach with an instrument  $Z$ . A good instrument must, according to Stock and Watson (2018), have the following characteristics to obtain consistent estimates:

$$E[\epsilon_t^{mp} Z'] = \alpha \neq 0 \quad (\text{relevance}), \quad (7a)$$

$$E[\epsilon_t^q Z'] = 0 \quad (\text{exogeneity with respect to other current shocks}). \quad (7b)$$

Therefore, an instrument is needed that is highly correlated with the monetary policy shock  $\epsilon_t^{mp}$ , but not correlated with any other shock  $\epsilon_t^q$  at the same time. With a feasible instrument and the reduced-form variance-covariance matrix  $\Sigma$ , we obtain a consistent estimation of  $s$  by using a two-stage approach. In the first stage, we regress  $v_t^{mp}$  on  $Z_t$  to estimate the fitted value  $\hat{v}_t^{mp}$ . We thus obtain the part of the variation in  $v_t^{mp}$  that is only due to a structural shock  $\epsilon_t^{mp}$ . If we insert this in (6), we obtain

$$v_t^q = \frac{s^q}{s^{mp}} * \hat{v}_t^{mp} + \xi_t. \quad (8)$$

The second-stage regression (8) yields a consistent estimation of  $\frac{s^q}{s^{mp}}$ . With  $\Sigma$ , we can then determine all the components of  $s^{mp}$ , which, in turn, allows us to estimate impulse responses from our partially identified structural VAR model (9):<sup>3</sup>

<sup>3</sup>for a detailed derivation, see Gertler and Karadi (2015).

$$Y_t = SC + \sum_{j=1}^J SC_j Y_{t-j} + s\epsilon_t^{mp}. \quad (9)$$

### 3.2 | Instrument choice

Two points must be considered when choosing the instrument: the instrument must be exogenous (7b) and relevant (7a). While we will empirically prove the validity of condition (7a) in the following section, Section (3.3), the validity of (7b) follows from theoretical considerations, which are described below.

We will apply the EA-MPD to extract monetary surprises measured by high-frequency deviations of financial variables around the ECB press release and press conference. The advantage is that these high-frequency deviations are most likely to be driven only by the ECB's decision. According to Kuttner (2001), there will probably be no effects in this period, and certainly no systematically distorting, ones.<sup>4</sup> Therefore, condition (7b) should be fulfilled, since we use a very narrow time window around the press release and press conference.

In the following, we briefly describe the replication of the four different monetary policy surprises, based on the work of Gürkaynak et al. (2005), Brand et al. (2010), Swanson (2017), and Altavilla et al. (2019). Since Kuttner (2001), we know that the central bank's measures influence high-frequency data during central bank announcements. However, it is not easy to attribute changes to specific policies; the effects will overlap and influence each other, so that they cannot be observed directly. Therefore, latent factor models are used to separate the underlying unobservable influences and to determine how many factors are sufficient to describe our high-frequency data accurately.

The factor model has the equation

$$X^w = F^w \Lambda^w + \epsilon^w \quad \text{with } w \text{ in } \{\text{press release, press conference}\} \quad (10)$$

where  $X^w$  is the change in the overnight interest rate swap (OIS) with maturities from 1 month to 10 years,  $F$  is an  $(N \times T)$  matrix of latent factors,  $\Lambda$  comprises the factor loadings, and  $\epsilon$  is the idiosyncratic variation. We can estimate the latent factors (10) by using principal components on  $X^w$ . The matrix rank test of Cragg and Donald (1997) is used to determine the number of underlying factors in each subset. We find one latent factor for the press release window and two factors for the conference window in the pre-QE period and three for the full sample.<sup>5</sup> The factors alone are difficult to interpret in terms of content, since each factor is usually correlated with all OIS futures. This issue can be resolved by introducing restrictions through rotation of the factor matrix to the factor loadings:

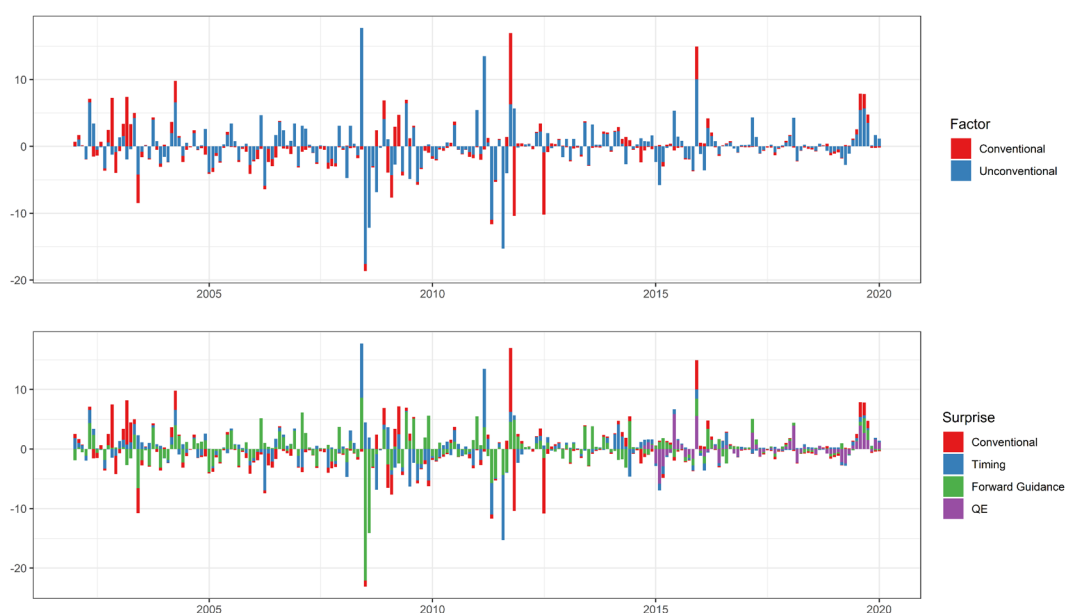
$$F^{w,*} = F^w U, \quad (11)$$

with  $UU' = I$ .

We use the restrictions established by Gürkaynak et al. (2005) to determine the first three factors and that established by Swanson (2017) for the fourth factor. The rotation is performed so that the second and third factors are not correlated with the monthly OIS rate, and, simultaneously, the variance of the third factor is minimal for the precrisis period. Since  $UU' = I$ , the factors are orthogonal to each other.

<sup>4</sup>Furthermore, Brand et al. (2010) and Altavilla et al. (2019) control for a possible effect in this time window, the publication of US labor market figures. They find no evidence of any impact on European financial market variables during this time window.

<sup>5</sup>See Altavilla et al. (2019), for detailed results, which we can reconstruct.



**FIGURE 1** Estimated factors. Sample period: 2002:01–2019:06, accumulated factors in basis points [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

The press release window's resulting factor is called conventional surprise, because it loads strongly on the 1-month OIS rates. This is the theoretical mechanism of a conventional interest rate policy.<sup>6</sup> These results are consistent with the expected functioning: conventional surprises are based on market reactions to the ECB press release directly after the ECB governing council meeting. Till the end of 2014, it contains only the pure policy rate decision. In 2016, there was an announcement that other measures would be intimated. After 2016:03, a short note about the concrete implementation of new measures was attached. Over the vast majority of the observation period, these surprises reflect surprises in interest rates, which are, by definition, conventional monetary policy.

The first factor loads on the OIS rates under 1 year in the press conference window, but not on the 1-month OIS rate. This factor is therefore forward guidance with a short time horizon, and we name it timing. In contrast, the second factor, by design, does not influence the 1-month OIS rates, but loads most strongly on the medium term, that is, 2–5-year OIS rates. We therefore call it forward guidance. The third factor has the greatest influence on 10-year OIS rates. Besides, it has been rotated so that its influence before the financial crisis is minimal. This result corresponds to the theoretical functioning of QE. The combination of the three press conference surprises, moreover, sums up to unconventional surprises. In addition, we construct total surprises, which include all factors simultaneously. The influence of the conventional and unconventional measures at different time points is shown in Figure 1.

By construction, QE started in 2014:10, with the introduction of the Covered Bond Purchase Programme 3, which later became part of the Asset Purchase Programme, which was introduced in 2015:01 and started officially in 2015:03.<sup>7</sup>

<sup>6</sup>Altavilla et al. (2019) call it the conventional shock target. We use the first expression for a more intuitive understanding.

<sup>7</sup>Note that, for this reason, all models that only contain QE shocks are estimated with data starting 2014:10. The approach of Gertler and Karadi (2015) of estimating the different stages for different time spans to increase efficiency is impossible. The problem is not that high-frequency data are not available, but that there was no QE before 2014:10.

Note that expectations already played a role before the financial crisis, even though they were not an official policy tool of the ECB. This can be explained by the influence of central bank communication on market expectations. Before forward guidance was explicitly introduced, ECB press conferences were used to asking about the central bank's expectations regarding its future policies. Even though these questions were answered very restrictively, the answers seem to have affected medium-term OIS rates. However, compared to the period after 2008, when active forward guidance was applied, the shocks were substantially lower in the precrisis period.

Since these surprises are estimated with other macroeconomic variables, the shocks must be transformed into monthly data. Following Gertler and Karadi (2015), we use monthly average surprises. The shock values of the 31 elapsed days are added up and, in the next step, the arithmetic mean of all the accumulated values in each month is formed. This procedure accounts for the effect of variable meeting dates within a month. Shocks at the beginning of a month are given a higher weight, whereas shocks at the end of the month are more relevant to the next period.

### 3.3 | Data

The endogenous variables  $Y_t$  in our model consist of *Output* (ECB industrial production),<sup>8</sup> *Prices* (ECB Harmonised Index of Consumer Prices), *Commodities* (International Monetary Fund Primary Commodity Price index), *Stock prices* (Euro Stoxx 50), *Uncertainty* (ECB Composite Indicator of Systemic Stress, and 2-year German government bonds (*DE2Y*)).<sup>9</sup>

We use German government bonds, since the risk component in interest rates should be minimal here and not distorted by speculation. At the same time, this is potentially not the case for other EA countries. Jarociński and Karadi (2018) also use German government bonds for this reason. The variable *DE2Y* shows the best suitability, since the correlation between all surprises and the residuals are large enough to minimize the risk of biased estimates (see 7a). This is probably because we compare both short- and long-term measures. Therefore, *DE2Y* is a reasonable compromise.<sup>10</sup>

The Akaike information criterion suggests a maximum of  $J = 3$  lags, which seems realistic compared to other VAR studies for the EA (Boeckx et al., 2017; Gambacorta et al., 2014):

The idea is to use different surprises in our model, to compare the impacts on economic variables. Our instruments  $Z$  will be the monetary policy surprises from the previous section. Therefore, we will estimate our model with one instrument each, where our instrument is alternately one of the surprises found before.<sup>11</sup>

When it comes to instrument estimations, the challenge is to find a suitable instrument that meets conditions (7b) and (7a). Condition (7b) should be fulfilled by our choice of instruments, as described above. Condition (7a) means that the instrument should be correlated with our monetary policy shock and therefore have explanatory power. To test whether our instruments are suitable, we regress the 5-year German government bond (*DE5Y*) residual ( $\hat{v}_t^6$ ) on our factors separately. Table 1 reports the regression results for each shock, as well as the unconventional and total shocks, as

<sup>8</sup>To check for the influence of the construction sector, we conducted the analysis with industrial production, but excluding production. The results are very similar and available upon request.

<sup>9</sup>The variables *Output*, *Prices*, *Commodities*, and *Stock prices* are in logarithmic form. All four variables are seasonally adjusted.

<sup>10</sup>We also checked other possible candidates that could have similar properties, that is, Euribor rates, OIS, other EA countries' bonds, and different maturities. The *DE2Y* model performed the best in this respect. The results for the other variables are available from the authors upon request.

<sup>11</sup>For the QE surprises, the series will start in 2014:10 due to design.

TABLE 1 F-Statistic of the regression of residuals on Z

	Dependent variable					
	Residual	DE5Y				
	(1)	(2)	(3)	(4)	(5)	(6)
Conventional	0.013* (0.004)					
Timing	0.022* (0.007)					
Forward-guidance	0.014* (0.003)					
QE	0.005* (0.002)					
unconventional	0.016* (0.003)					
Total	0.014* (0.002)					
Constant	0.001 (0.009)	0.001 (0.009)	0.0001 (0.009)	0.001 (0.005)	0.001 (0.008)	0.002 (0.009)
R <sup>2</sup>	0.028	0.101	0.096	0.069	0.178	0.191
Robust F-statistic	9.668	11.063	21.162	10.992	36.624	50.105

\*p < .01.



TABLE 2 Data overview

Variable	Proxy	Source	Seasonal adjusted and logarithms
Output	ECB industrial production excluding construction	ECB <a href="https://sdw.ecb.europa.eu/quickview.do?sessionId=1B6F694499BF0ED2B614A9DEA050AB21?SERIES_KEY=132.STS.M.I8.Y.PROD.NS0010.4.000">https://sdw.ecb.europa.eu/quickview.do?sessionId=1B6F694499BF0ED2B614A9DEA050AB21?SERIES_KEY=132.STS.M.I8.Y.PROD.NS0010.4.000</a>	Yes
Prices	ECB harmonized index of consumer prices	ECB <a href="https://sdw.ecb.europa.eu/quickview.do?sessionId=DD4948EADEB317B8D6FF22CB720C9473?SERIES_KEY=122.ICP.M.U2.Y.000000.3.INX">https://sdw.ecb.europa.eu/quickview.do?sessionId=DD4948EADEB317B8D6FF22CB720C9473?SERIES_KEY=122.ICP.M.U2.Y.000000.3.INX</a>	Yes
Commodities	IMF Primary Commodity Price index	IMF <a href="https://www.imf.org/-/media/Files/Research/CommodityPrices/Monthly/ExternalData.ashx">https://www.imf.org/-/media/Files/Research/CommodityPrices/Monthly/ExternalData.ashx</a>	Yes
Stock prices	Euro Stoxx 50	ECB <a href="https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=143.FM.M.U2.EUR.DS.EI.DJES50I.HSTA">https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=143.FM.M.U2.EUR.DS.EI.DJES50I.HSTA</a>	Yes
Uncertainty	ECB Composite Indicator of Systemic Stress (CISS)	ECB <a href="https://sdw.ecb.europa.eu/browseSelection.do?node=qview&amp;SERIES_KEY=290.CISS.D.U2.Z0Z.4F.EC.SS_CI.IDX">https://sdw.ecb.europa.eu/browseSelection.do?node=qview&amp;SERIES_KEY=290.CISS.D.U2.Z0Z.4F.EC.SS_CI.IDX</a>	No
Bond	2-year German government bonds	Bundesbank <a href="https://www.bundesbank.de/statistic-rmi/StatisticDownload?tsId=BBK01.WT0202&amp;its_csvFormat=en&amp;its_fileFormat=csv&amp;mode=its">https://www.bundesbank.de/statistic-rmi/StatisticDownload?tsId=BBK01.WT0202&amp;its_csvFormat=en&amp;its_fileFormat=csv&amp;mode=its</a> and Altavilla et al. (2019) Replication data <a href="http://www.bilkent.edu.tr/refet/ABGMR_replication_files.zip">http://www.bilkent.edu.tr/refet/ABGMR_replication_files.zip</a>	No

described above. It should be noted that  $F$ -statistics do not reflect the importance of the factor in the period, but only the strength of the link between the shocks and the residuals of the model (Tables 2).

The robust  $F$ -statistic is above the value of 10 for all factors, except conventional ones.<sup>12</sup> This is a guideline for making a strong instrument (Stock & Yogo, 2001). Therefore, we conclude that our factors are suitable instruments. The combination of individual shocks (unconventional and total) is also highly significant and therefore provides a powerful instrument for the ECB's overall monetary policy strategy. The fit of the data as modeled by the  $R^2$  value is similar to that in papers using US data and the same methodology (Gertler & Karadi, 2015). To avoid the risk of a weak instrument bias, we use the robust confidence intervals developed by Montiel Olea et al. (2020). These intervals are not affected by instrument strength and convergence toward the standard confidence set when the instrument is vital. The Wald statistic for the covariance between the instrument and the normalized variable is high enough that the robust confidence set will be a bounded interval for every horizon.

<sup>12</sup>We tried other variables and other VAR specifications. In the few cases in which the  $F$ -statistics increase slightly for conventional factors, they drop sharply for the other factors. To establish comparability, we stick to DE2Y in our analysis. A similar VAR, with DE5Y as the monetary policy variable, yields a sufficiently large  $F$ -statistic for the conventional factor in the full sample that the risk of a weak instrument can be ruled out, and it provides very similar impulses responses and confidence intervals. The results are available from the authors upon request.

## 4 | RESULTS

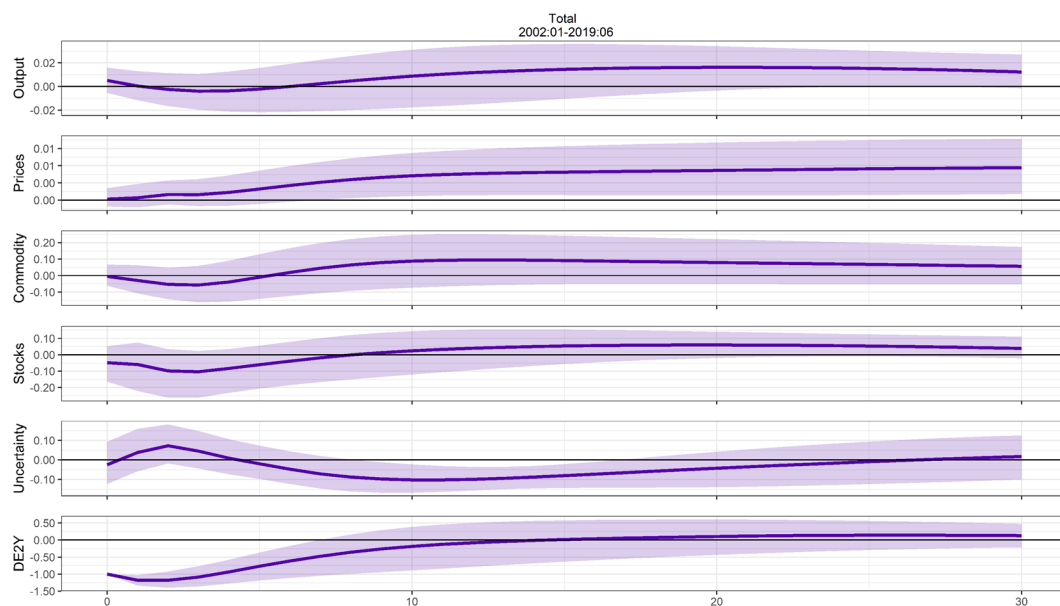
To present the results, we use a general-to-specific approach. Thus, we begin by presenting the influence of the total factor shock before disentangling it into conventional and unconventional shocks in a second step and splitting up the unconventional shock into the three subcategories (timing, forward guidance, and QE).

### 4.1 | Total shock

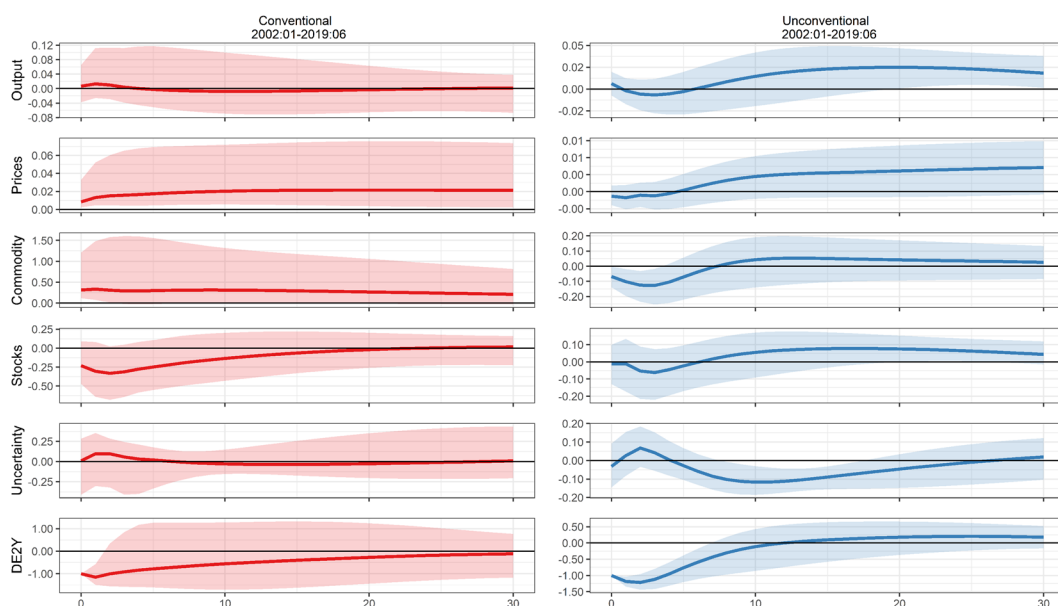
Starting with the total effect of monetary policy shocks in the EA (Figure 2), we find the expected results for the full sample. An expansive monetary policy shock lowers *DE2Y* on impact. Uncertainty declines in the medium term, and inflation increases with a short time lag and is significant at the 90% confidence level.

### 4.2 | Conventional versus unconventional shocks

In the next step, we distinguish monetary policy shocks into conventional and unconventional policies. We also examine the difference between the press release announcement and the subsequent press conference. Therefore, we calculate two different VAR models (Figure 3). The point estimates for conventional measures are always higher than those for unconventional



**FIGURE 2** Effect of total expansive monetary-policy shock. The shaded area show the upper and lower bands of the 90% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**FIGURE 3** Effect of conventional and unconventional monetary-policy shock. The shaded area show the upper and lower bands of the 90% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

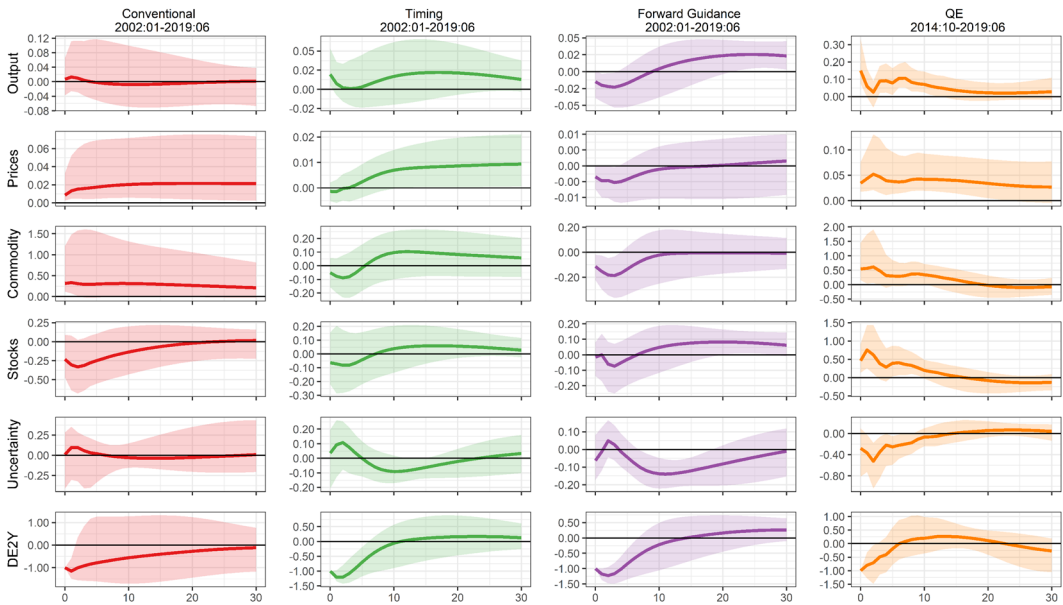
measures. Moreover, the aggregated unconventional monetary policy shocks appear to be even nonsignificant throughout the entire period.

Therefore, it must be concluded at this point that the price increase observed for the overall surprises is exclusively due to the conventional measures and that the accumulated unconventional measures have no joint influence on the price level. We will discuss a possible explanation for this in Section 6.

However, the fact that unconventional measures do not affect inflation does not necessarily mean that all submeasures also do not affect inflation. Figure 4 shows the result of splitting the unconventional measures into three individual surprises (timing, forward guidance, and QE).

Timing and forward guidance are relatively similar and have no significant impact on prices. The effect of QE is quite different compared to the other measures. A positive QE shock, such as the unexpected introduction of a bond-buying program, lowers uncertainty and almost instantly increases stock prices. The reason could be that QE has already been tested in the United States and the markets considered it a suitable reaction by the central bank. Thus, markets have experience with these kinds of measures. When it comes to the inflation response, the QE reaction differs entirely from those of the other two unconventional measures. While the latter are somewhat similar and found to have no significant impact on inflation, the effectiveness of QE moves at the level of conventional measures and is significantly different from both zero and the other unconventional shocks, at least in the first 3 months.<sup>13</sup>

<sup>13</sup>Note that a shorter data set had to be used for the QE analysis, so the results are not fully comparable. Nevertheless, the data provides very interesting preliminary results.



**FIGURE 4** Effect of monetary-policy shocks. The shaded area show the upper and lower bands of the 90% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

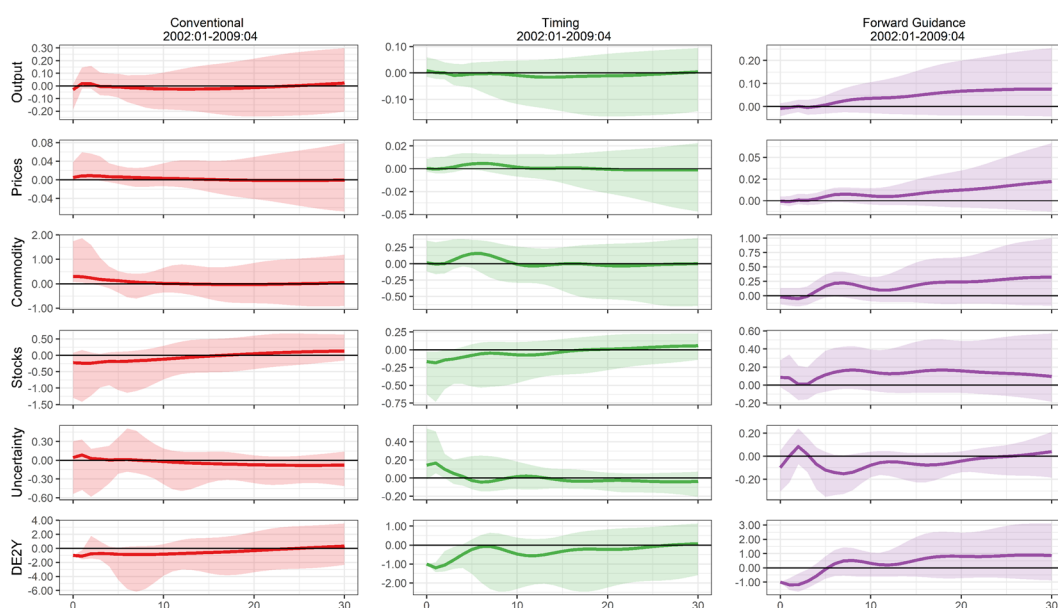
## 5 | THE FINANCIAL CRISIS

So far, we have considered the entire ECB period from 2002 to 2019 as a whole. However, the financial crisis of 2008–2009 led to significant changes in the economy. The ECB reached the ZLB with a strongly expansionary policy and implemented new measures. All these changes could indicate a potential structural break in our model. To take into account the risk of a structural break around 2008–2009, we split our data set into two samples. We estimate the model with the finest distinction for each shock from 2002:01 to 2009:05 (precrisis) and from 2009:06 to 2019:06 (postcrisis), which allows us to compare the impacts of different measures on macroeconomic developments before and after the financial crisis.

The  $F$ -statistics of the shocks in the subsamples vary (Table 3). Especially in the period before the crisis, there is less correlation between the conventional, timing, and forward guidance shocks and the DEZY residuals. Unconventional and total shocks are significantly correlated, at levels above 10.

**TABLE 3**  $F$ -statistic of the regression of residuals on  $Z$  (subsample)

Shock	Full		Precrisis		Postcrisis	
	$F$ -robust	Obs	$F$ -robust	Obs	$F$ -robust	Obs
Conventional	9.668	207	2.367	85	27.949	119
Timing	11.063	207	2.960	85	5.910	119
Forward-guidance	21.162	207	7.253	85	7.300	119
QE					10.992	54



**FIGURE 5** Effect of monetary-policy shocks 2002:01–2009:04. The shaded area show the upper and lower bands of the 90% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

In the subsample, timing and forward guidance shocks are also correlated, but at levels below 10, whereas the correlation with conventional shocks is significantly above 10. The smaller correlation can potentially be explained by the smaller sample size, which is due to its design. We use robust intervals to avoid the risk of a weak instrument bias Montiel Olea et al. (2020).

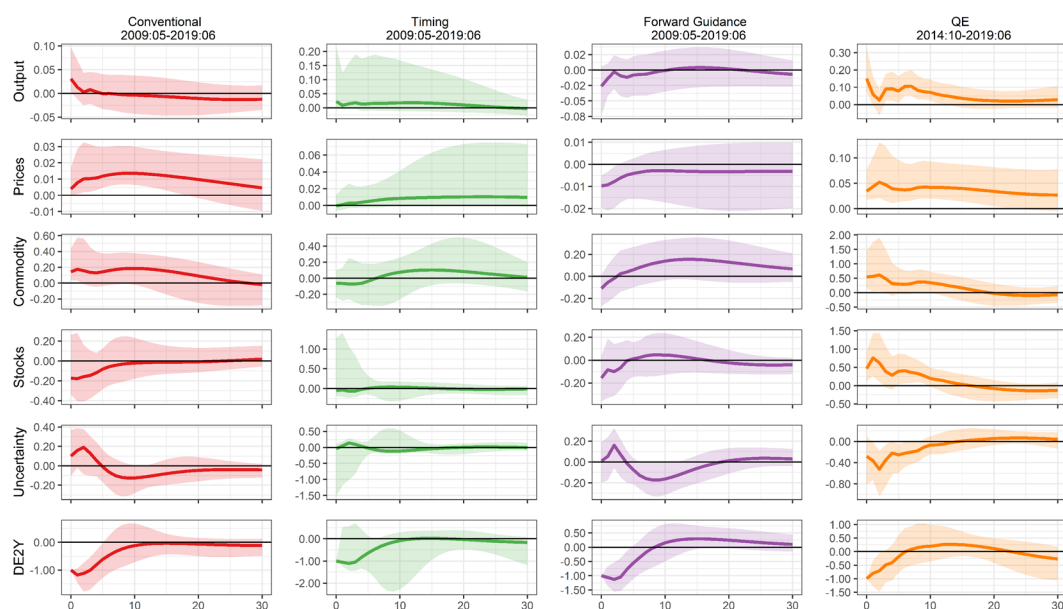
The results for the period before the financial crisis are not particularly meaningful (Figure 5). The small number of observations leads to large confidence intervals, making reliable statements about the effects difficult. However, the period that is more important for this paper allows for more precise results. In Figure 6, it is first noticeable that the impulse responses do not differ significantly from the results in Figure 4. Expansive conventional and QE shocks increase prices, while timing and forward guidance shocks make no significant impact.

However, there are small interesting differences. On the one hand, the effect of conventional shocks is not as persistent as in the whole sample. On the other hand, for timing surprises, the effects on prices are much higher, but they are still not significantly different from zero. This result is surprising, since, especially after the financial crisis, particular emphasis has been placed on these forward-looking expectation-building measures.

All in all, this robustness test shows that our results from the total sample are not significantly altered by the structural break of the financial crisis. Even after the crisis, the ECB still could influence prices through its policies.

## 6 | DELPHIC AND ODYSSEAN SHOCKS

The question arises as to why timing and forward guidance shocks not affect inflation, whereas QE and the conventional shock demonstrate theory-conforming behavior. One reason could be that the former are not correctly identified. It can be shown in high-frequency data that some



**FIGURE 6** Effect of monetary-policy shocks 2009:05–2019:06. The shaded area show the upper and lower bands of the 90% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

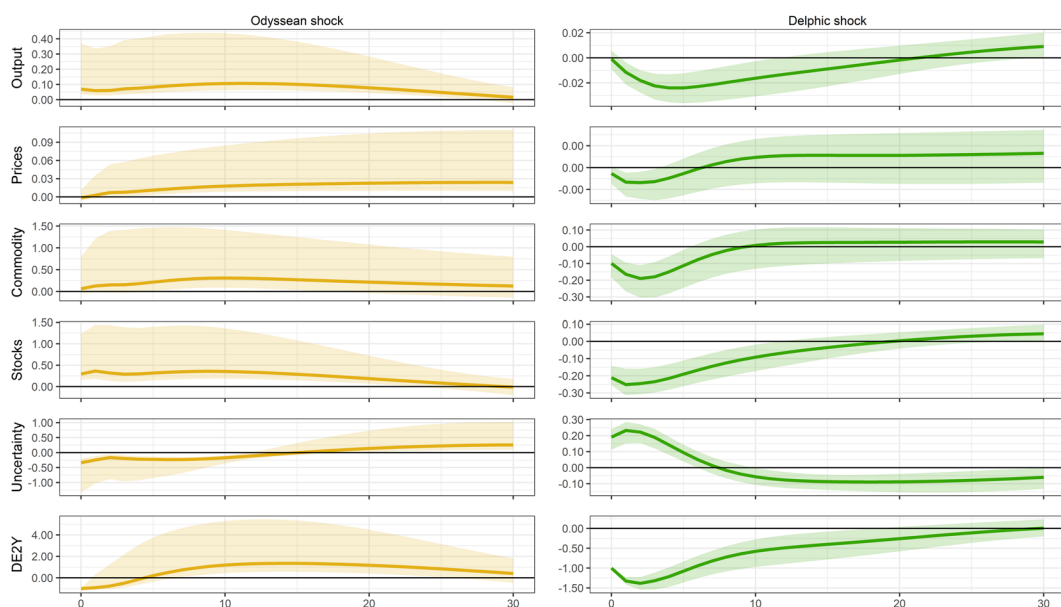
central bank decisions cause an unusual reaction, where an expansive central bank shock lowers interest rates, but stock prices fall as well. This contradicts the results of Bernanke and Kuttner (2005), that falling interest rates lead to rising stock prices, and vice versa. A possible explanation for this result is provided by Campbell et al. (2012) and Andrade and Ferroni (2018). These authors develop a theory based on the idea that forward guidance shocks can have different effects, depending on how financial market participants interpret them. The first interpretation is an Odyssean forward guidance shock.

In this case, the central bank is completely credible and clear in its communication. Thus there is no reason for the markets to deviate from the signals coming from the central bank. The name Odyssean goes back to the Greek mythology where Odysseus bound himself to his ship facing the sirens. In an Odyssean forward guidance shock, the markets behave as the central bank expects. If the central bank communicates expansionary forward guidance, such as keeping the interest rate lower for longer, the markets react to it by investing more, for example, in stocks or other assets.

In contrast, Delphic forward guidance shocks work the other way around. If the central bank commits to keeping the interest rates lower for longer, the markets judge this as a signal that the economic situation is even worse than expected and sell assets. The term Delphic refers to the Oracle of Delphi making predictions that need to be interpreted by the individuals, and thus trigger actions.

So, Odyssean shocks could be expected to increase inflation. Simultaneously, the reverse is true for Delphic shocks.<sup>14</sup> However, a new study by Bauer and Swanson (2020) finds results

<sup>14</sup>Other terms in the literature for Delphic and Odyssean shocks are information and monetary shocks, respectively.



**FIGURE 7** Effect of Odyssean and Delphic timing shock. The shaded area show the upper and lower bands of the 68% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

that cast doubt on the theory's basic assumptions. A survey of US forecasters shows that they have never improved their forecast after a restrictive shock.

Although we cannot distinguish Delphic channel's origin, it seems reasonable to distinguish between these two kinds of forward guidance shocks. To do so, we use the “poor man's sign restrictions,” which create very similar results compared to more complex procedures (Jarociński & Karadi, 2018). The idea is to determine from the markets' immediate reaction whether they interpret a shock as Delphic or Odyssean, according to the following:

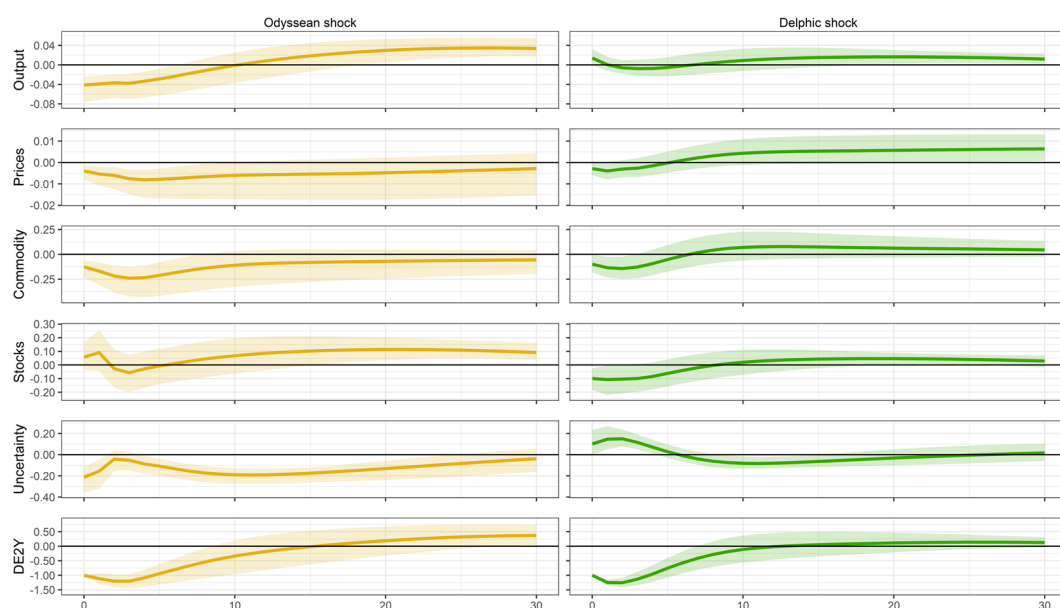
$$C_{i,w} = \begin{cases} \text{sgn}(OIS2Yd_{i,w}) \neq \text{sgn}(STOXX50d_{i,w}) & \rightarrow \text{Odyssean event} \\ \text{sgn}(OIS2Yd_{i,w}) = \text{sgn}(STOXX50d_{i,w}) & \rightarrow \text{Delphic event} \end{cases} \quad (12)$$

$$w = \{\text{press release, press conference}\}$$

For each monetary policy decision  $i$ , we compare the reaction in DE2Y and Euro Stoxx 50 around the high-frequency window  $w$ . If both reactions show the same sign, we label this event as Delphic, and Odyssean otherwise.<sup>15</sup> First, we look at the unconventional measures and therefore use  $w = \text{press conference window}$ . This gives us four new factors: Odyssean timing surprises, Delphic timing surprises, Odyssean forward guidance surprises, and Delphic forward guidance surprises.

With these four new surprises, we re-estimate our external instruments VAR with the same variables as our baseline model: *Output* (ECB industrial production), *Prices* (ECB Harmonised

<sup>15</sup>We stick to this simple identification scheme based on Jarociński and Karadi (2018) and do not include inflation expectations, as Jarociński and Karadi (2018) and Altavilla et al. (2019). This scheme has the advantage that each decision is uniquely assigned to either an Odyssean or Delphic shock. Additionally, we can use the EA-MPD, which excludes other effects due to the narrow time window around the decision.



**FIGURE 8** Effect of Odyssean and Delphic forward-guidance shock. The shaded area show the upper and lower bands of the 68% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

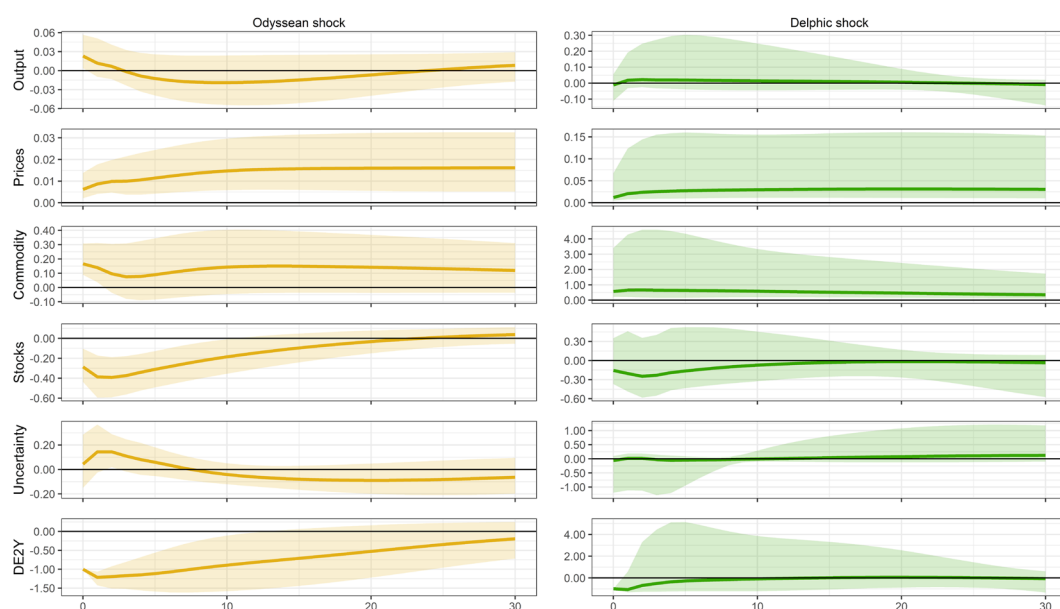
Index of Consumer Prices), *Commodities* (IMF Primary Commodity Price index), *Stock prices* (Euro Stoxx 50), *Uncertainty* (CISS), and *DE2Y*. The results are shown in Figures 7 and 8.<sup>16</sup> The timing surprises' impulse responses show a different course, depending on whether the shock is Delphic or Odyssean. Both Delphic and Odyssean forward guidance shocks lower bond yields. However, if the announcement is Delphic, this influences the markets negatively in various ways: uncertainty rises, stock prices collapse, and commodity prices decrease, possibly because of demand-side effects. This lowers output and has even a significant negative impact on inflation. An Odyssean timing shock shows exactly the opposite behavior. A price increase results, with a short time lag but roughly at the level of a conventional or QE shock.

The reactions differ from the preceding ones in terms of the forward guidance shocks (Figure 8). Again, we can observe the different behaviors of Odyssean and Delphic shocks in uncertainty and stock prices. However, in contrast to Odyssean timing shocks, Odyssean forward guidance shocks do not lead to an increase in commodity prices. The output does not increase on impact, but only after some time. There is now a negative effect on prices. Longer-term expectation management by the central bank does not appear to have the desired effect on inflation.<sup>17</sup>

We conclude from this result and following the literature, that a more precise distinction between timing and forward guidance shocks is reasonable. It seems that the ECB can influence its primary target inflation more successfully if it influences short-term expectations. A prerequisite for this is, however, that the central bank can consciously send an Odyssean shock. Whether a central bank can influence its shocks as being viewed as Odyssean or Delphic

<sup>16</sup>For statistical reasons, we do not create subsamples here. The results from the previous chapter also show that the financial crisis does not significantly influence the results.

<sup>17</sup>This finding is in line with the study by McKay et al. (2016).



**FIGURE 9** Effect of Odyssean and Delphic conventional shock. The shaded area show the upper and lower bands of the 68% of the confidence intervals. The intervals shown are robust for weak instruments (Montiel Olea et al., 2020) [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

has not yet been investigated, to the best of our knowledge. That topic would be a promising starting point for further research.

Our data set allows us to investigate another interesting point. So far, it is not clear in the literature where exactly a distinction between Odyssean and Delphic shocks can be useful. While Campbell et al. (2012) and Andrade and Ferroni (2018), by assumption, only refer to forward guidance shocks in their analysis of Delphic shocks, Jarociński and Karadi (2018) examine a monetary policy aggregate effect. Therefore, the question arises as to whether the central bank, by setting interest rates, also discloses information on its assessment of the economic situation. If this were the case, the conventional policy would also have a Delphic component.<sup>18</sup>

We therefore slightly adjust the above-mentioned poor man's sign restriction. To distinguish the conventional surprises, we now use changes in the high-frequency variables around the publication of the press release  $w = \text{press release window}$ . We again apply the resulting new surprise series in our VAR framework. Figure 9 shows the resulting impulse response functions.

The effects on inflation and output differ slightly, but not in their sign. A Delphic shock has a slightly smaller effect on inflation. The classification scheme is not appropriate for conventional policy, which we see as an indication that Delphic shocks are indeed mainly reflected in forward guidance. In this respect, we can empirically support the assumption of Campbell et al. (2012) and Andrade and Ferroni (2018). A difference in timing shocks also exists in the EA.

<sup>18</sup>The same would be conceivable for the QE components, but the subdivision of the data set makes a reliable estimate impossible for such a short time. Therefore, we postpone this analysis for future research.

## 7 | CONCLUSION

This paper distinguished the responses of conventional and unconventional monetary policy measures on macroeconomic variables using a high-frequency data set that measures the impact of the ECB's monetary policy decisions. Our framework allows us to estimate the various macroeconomic effects of central bank policies using a single methodology, facilitating policy comparisons. We show that unconventional and conventional monetary policy measures are somewhat similar in terms of their influence on uncertainty and output, but differ considerably concerning commodity prices and the ECB's primary target, the inflation rate. While conventional measures show the expected response of an increase in inflation following an expansionary monetary policy shock, unconventional measures appear to have no significant influence.

In detail, this result holds for timing and forward guidance shocks, but not for QE, which is found to have an influence on inflation equivalent to that of conventional interest rate changes. To explain this finding, timing shocks and forward guidance are divided into two parts. We show that there is indeed a difference for the short-term timing shock, depending on how the markets interpret the signal given by the ECB. Whereas Odyssean shocks exhibit the expected behavior in this case—that is, an expansionary shock tends to increase inflation—Delphic shocks show no effect or even a negative effect on inflation. Even worse, concerning medium-term forward guidance shocks, both Odyssean and Delphic shocks tend to decrease inflation if the ECB wants to send an expansionary signal. Furthermore, we can show that this classification by high-frequency variables for conventional shocks does not allow for a clear distinction. We conclude that the assumption that Delphic shocks are a forward guidance-specific phenomenon is justified and empirically verifiable.

What do these results mean for monetary policy? We would call for central banks, such as the ECB, to conduct a conventional monetary policy for as long as possible, which the ECB did in large parts of the crisis period. The preferred measure among these is QE, because the “gentler” communication measures always carry the risk of a Delphic shock. It is unclear whether the central bank can precisely control the effect of its announcement and thus intentionally trigger an Odyssean shock. Only in this case would an expansionary shock indeed raise inflation. This result suggests that the use of communication measures as a whole cannot steer the markets in the way the ECB expects. Therefore, a safe option would be to focus on quantitative measures such as conventional policies and QE, since the risk of Delphic shocks is much lower in these cases.

## ACKNOWLEDGEMENTS

We thank the editor Benn Steil and two anonymous reviewers for helpful suggestions and seminar participants in Giessen for critical discussions.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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**How to cite this article:** Baumgärtner, M., Klose, J. (2021). Why central banks announcing liquidity injections is more effective than forward guidance. *International Finance*, 24, 236–256. <https://doi.org/10.1111/infi.12389>