

Kerssenfischer, Mark

Conference Paper

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Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Monetary Policy IV, No. C10-V1

Provided in Cooperation with:

Verein für Socialpolitik / German Economic Association

Suggested Citation: Kerssenfischer, Mark (2019) : Information Effects of Euro Area Monetary Policy: New evidence from high-frequency futures data, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2019: 30 Jahre Mauerfall - Demokratie und Marktwirtschaft - Session: Monetary Policy IV, No. C10-V1, ZBW - Leibniz-Informationszentrum Wirtschaft, Kiel, Hamburg

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Information Effects of Euro Area Monetary Policy: New Evidence from High-Frequency Futures Data*

Mark Kerstenfischer
Deutsche Bundesbank

February 2019

Abstract

Central bank announcements have strong effects on interest rates, but small or even counterintuitive effects on economic expectations. Based on tick-by-tick futures prices on bonds and stock prices, I confirm these seemingly puzzling results for the euro area and provide evidence that they are due to central bank information effects. That is, ECB announcements convey information not only about monetary policy, but also about economic fundamentals. I separate these “information shocks” from “pure policy shocks” via sign restrictions and find intuitive effects of both shocks on a wide set of financial market prices, survey expectations and macroeconomic aggregates.

Keywords: Monetary Policy, High-Frequency Identification, Central Bank Information.

JEL classification: E52, E44, E32, C32.

*Contact address: Deutsche Bundesbank, Wilhelm-Espstein-Str. 14, 60431 Frankfurt am Main, Germany. Email: mark.kerstenfischer@bundesbank.de. The views expressed in this paper are those of the author and do not necessarily coincide with the views of the Deutsche Bundesbank or the Eurosystem.

1 Introduction

Two seemingly uncontroversial assumptions make high-frequency financial market data the ideal candidate to identify monetary policy shocks. First, financial markets quickly incorporate new information and second, the only new information hitting the markets around central bank announcements concerns monetary policy. In fact, based on this high-frequency identification approach, the monetary literature has reached a broad consensus: policy announcements have large effects on interest rates, both on short- and long-term rates and both in nominal and real terms.¹ Several recent findings, however, call into question whether central bank announcements affect markets solely by conveying new information about monetary policy. After a supposedly contractionary announcement – i.e. one that raises interest rates – expected unemployment falls, growth and inflation expectations rise, and stock prices also frequently rise rather than drop.²

To explain these apparent puzzles, a growing literature emphasizes the importance of “central bank information effects”. The idea, dating back to at least [Romer and Romer \(2000\)](#), is that central bank announcements convey information not only about monetary policy, but also about the central bank’s economic outlook. An announcement that raises interest rates, for instance, might reflect an improved outlook, and thus have expansionary rather than contractionary effects.

In this paper, I exploit high-frequency futures data to isolate market reactions to euro area monetary policy announcements. My contribution is twofold. First, using the immediate change in 2-year German bond yields as a naive measure of policy surprises, I find strong effects of ECB announcements on interest and exchange rates, but hardly any effect on stock prices and economic expectations. Second, and more importantly, I show that the puzzlingly small response of economic expectations is resolved when accounting for central bank information effects. In particular, I follow [Jarocinski and Karadi \(2018\)](#) and use the reaction of yields together with the response of stock prices to decompose announcements into two distinct components, namely “pure monetary policy shocks” that raise bond yields and lower stock prices – due to a higher discount rate and lower expected dividends – and “central bank information shocks” that raise stock prices along with yields – by signalling an improved economic outlook.

The two shocks I obtain via these sign restrictions have similar effects on interest and exchange rates, but trigger sharply different revisions in economic expectations. A pure policy tightening leads to downward revisions of expected growth and inflation, in line with basic monetary theory, while a favourable central bank information shock prompts upward revisions in the economic outlook. Using the external instruments approach, lastly, I confirm that macroeconomic aggregates do indeed diverge after both types of shocks.

My paper adds to a growing literature that seeks to isolate non-monetary components from central bank announcements empirically. It is closely related to [Jarocinski](#)

¹For US evidence, see [Kuttner \(2001\)](#); [Cochrane and Piazzesi \(2002\)](#); [Gürkaynak, Sack, and Swanson \(2005\)](#); [Bernanke and Kuttner \(2005\)](#); [Wright \(2012\)](#); [Hanson and Stein \(2015\)](#); [Gilchrist, Lopez-Salido, and Zakrajsek \(2015\)](#). For euro area evidence, see [Bohl, Siklos, and Sondermann \(2008\)](#); [Brand, Buncic, and Turunen \(2010\)](#); [Leombroni, Vedolin, Venter, and Whelan \(2016\)](#); [Altavilla, Brugnolini, Gürkaynak, Ragusa, and Motto \(2018\)](#).

²See [Campbell, Evans, Fisher, and Justiniano \(2012\)](#); [Campbell, Fisher, Justiniano, and Melosi \(2017\)](#); [Nakamura and Steinsson \(2018\)](#); [Jarocinski and Karadi \(2018\)](#).

and Karadi (2018), who apply the above-mentioned sign restrictions in a Bayesian VAR framework, both for the US and the euro area. Instead of financial market prices and survey expectations, they focus on the macroeconomic effects of policy announcements. To capture revisions in expected interest rates, moreover, they use shorter-dated instruments, namely 3-month swap rates in the case of the euro area. Andrade and Ferroni (2018), similarly, use swap rates with up to 2-year maturity to decompose the information content of ECB announcements. Instead of high-frequency stock prices movements, they identify pure policy shocks by imposing a negative effect on the 2-day change in inflation-linked swaps. Cieslak and Schrimpf (2019), moreover, study announcement effects across four major central banks. They focus on the covariances between stocks and yields of different maturities. In addition to conventional monetary policy and central bank information effects, they suggest that announcements have an immediate impact on risk premia. They isolate these risk premia shocks by assuming they affect long-term yields more than short-term yields.³

2 Data

The core of my analysis builds on high-frequency futures prices around monetary policy events. In particular, I compute the immediate change in 2-year German bond yields and the Euro STOXX 50 index around all 186 scheduled ECB Governing Council meetings (GCMs) between March 2002 and December 2018. For each meeting, I compare financial market prices 10 minutes prior to the ECB’s press release with those 20 minutes after the end of the ensuing press conference. The key assumption here is that market reactions within this narrow window should be predominantly due to the information released by the ECB. On regular meeting days, the ECB announces its policy rate decision via a press release at 13:45 (CET), followed by a press conference at 14:30. At the press conference, the ECB president first elaborates on the decision and the underlying rationale in an introductory statement and subsequently answers questions from journalists. Since the duration of press conferences is not fixed, I exploit video recordings and transcripts to determine their length, see Appendix B. Furthermore, I control for any macroeconomic news released around the announcements, see Appendix C.

A major advantage of the high-frequency prices I use is that they are based on actual trades on a centralized exchange. This is particularly relevant for the bond future, since most interest rate instruments in the euro area are traded over-the-counter, i.e. intraday prices usually refer to indicative quotes, where the quoting party is not committed to trade at the posted price. As a further side benefit, 2-year yields on German government bonds are less affected by the lower bound problem compared to short-term money-market rates.⁴

To get a better sense of the high-frequency data I use, Figure 1 plots yield and stock

³An alternative approach to isolate information effects is to orthogonalize policy surprise measures to internal central bank forecasts, see Miranda-Agrippino (2016) for the UK and US and Kane, Rogers, and Sun (2017) for the euro area.

⁴Jarocinski and Karadi (2018) and Andrade and Ferroni (2018) e.g. use OTC quotes on swaps linked to the EONIA rate, which has been increasingly constrained by an effective lower bound. German 2-year yields, in contrast, remained sensitive to ECB announcements throughout the sample period, with yields reaching a low of almost minus one percent in 2017.

price movements around three selected Governing Council meetings.⁵ Panel (a) refers to 7 November 2013, when the ECB surprised markets with a 25bp rate cut. Panel (b) shows market reactions to the previous July meeting. On that day, policy rates were kept unchanged, in line with market expectations, but in the press conference the ECB surprised markets by introducing forward guidance to its policy toolkit. In particular, the introductory statement announced that “the Governing Council expects the key ECB interest rates to remain at present or lower levels for an extended period of time”. Panel (c), lastly, refers to the meeting on 22 October 2015, when ECB president Mario Draghi – in his introductory statement and during the subsequent Q&A session – fueled expectations about an extension of the public sector purchase programme (which was indeed announced in December). All three announcements led to an immediate drop in 2-year bond yields, suggesting they were expansionary policy surprises. And indeed, as yields declined, stock prices climbed each time.

Figure 2, on the other hand, depicts three Governing Council meetings where market reactions are hard to reconcile with monetary policy effects alone. Judged by the response of bond yields – which fell in all three cases – the announcements were expansionary. Stock prices, however, *declined* along with yields, which is exactly the opposite of what we would expect from expansionary policy surprises. Strikingly, stocks mainly declined during press conferences, and in each of these conferences the ECB discussed a deterioration in the economic outlook.

Panel (a) refers to 6 March 2003, when then-president Willem Duisenberg explained in his introductory remarks that the ECB has cut its policy rates by 25bp because “the outlook for economic growth in the euro area in 2003 has weakened compared with previous expectations”. In response to a journalist’s question, he later added that “growth figures and the inflation figures had, sorry to say it, to be revised downward and not insignificantly”. On 2 July 2009, shown in panel (b), Duisenberg’s successor Jean-Claude Trichet declared in his introductory remarks that “economic activity over the remainder of this year is likely to remain weak”. Panel (c), lastly, depicts the Governing Council meeting on 5 July 2012. After lowering policy rates by 25bp, ECB president Mario Draghi commenced the ensuing press conference by saying that “downside risks to the euro area growth outlook have materialised” and that “economic growth in the euro area continues to remain weak”.

According to the central bank information literature, it is these pessimistic statements that might have caused the simultaneous drop in yields and stock prices around all three meetings, namely by inducing downward revisions in the growth forecasts of market participants. Section 3 tries to isolate these information effects via sign restrictions.

3 Identification

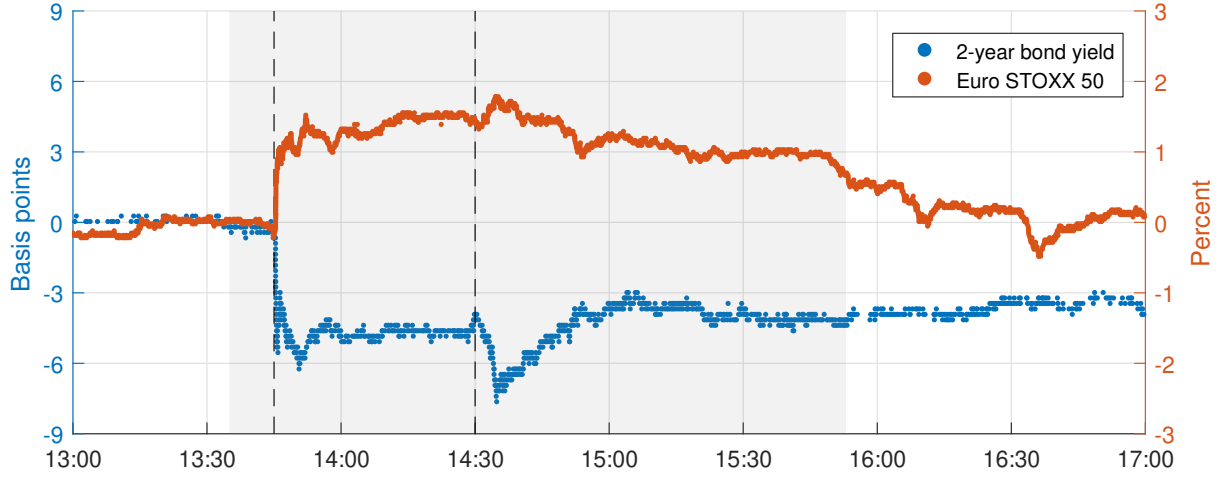
I will employ two different identification schemes, see Table 1.⁶

Since my goal is to differentiate between monetary and non-monetary components of ECB announcements, I treat monetary policy itself as one-dimensional, i.e. I do not

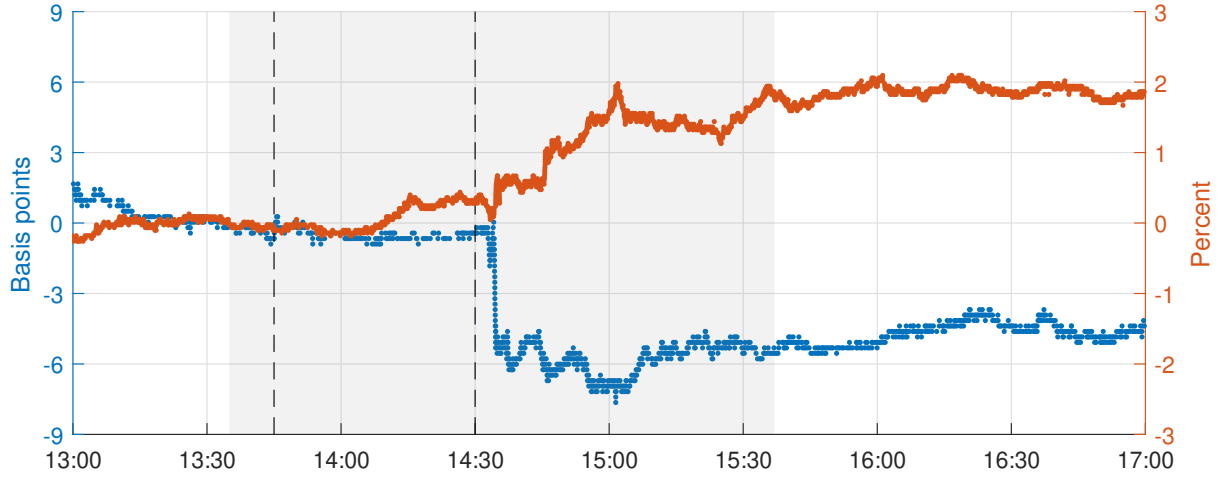
⁵Yield changes are approximated as the percentage change in a futures’ price divided by the modified duration of the underlying cheapest-to-deliver bond, see Appendix C.

⁶The three resulting shock series are available for download at www.sites.google.com/site/markkerssenfischer.

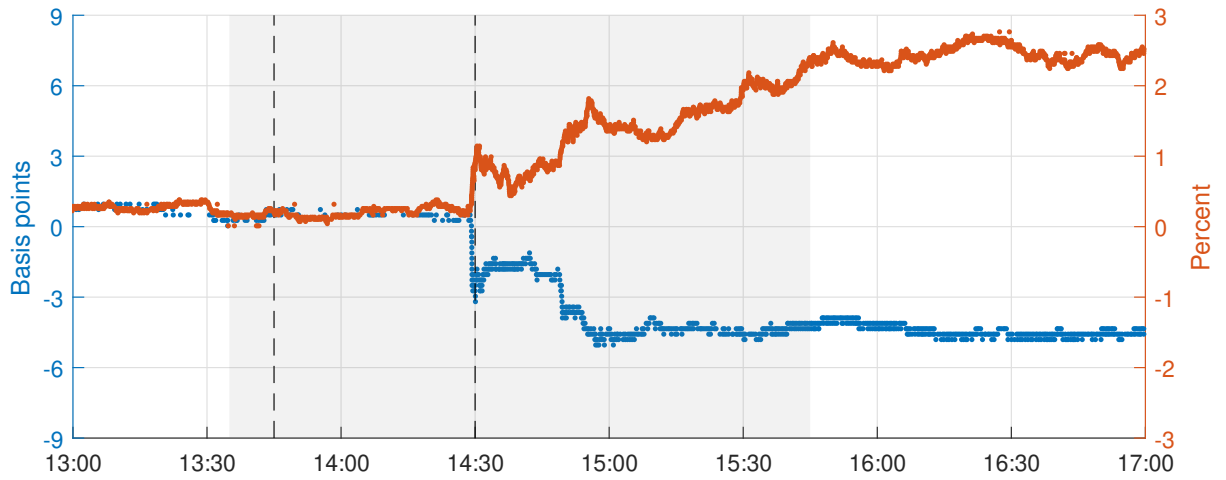
Figure 1: Examples of Expansionary Monetary Policy Surprises



(a) Governing Council Meeting on 7 November 2013



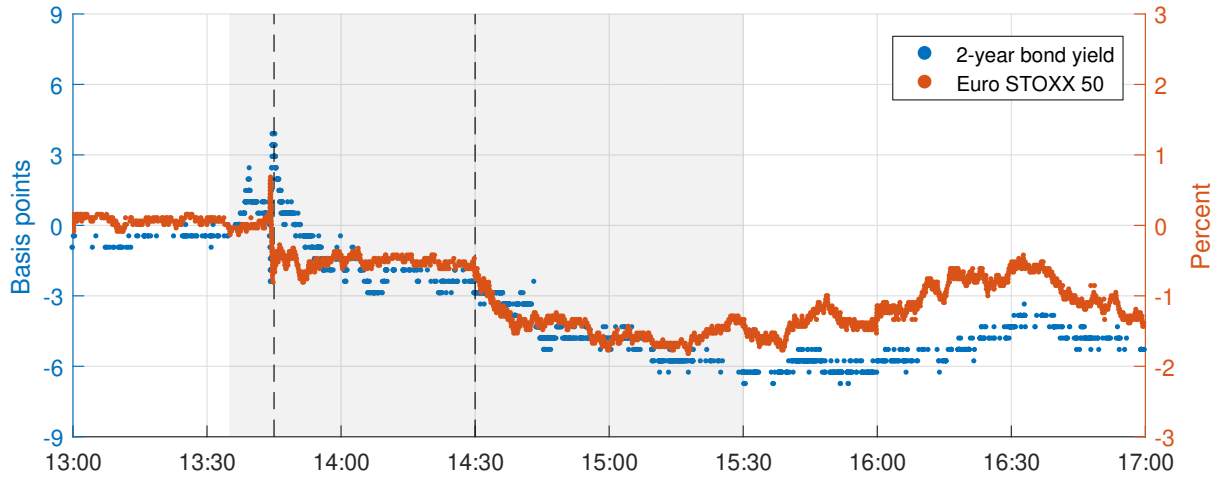
(b) Governing Council Meeting on 4 July 2013



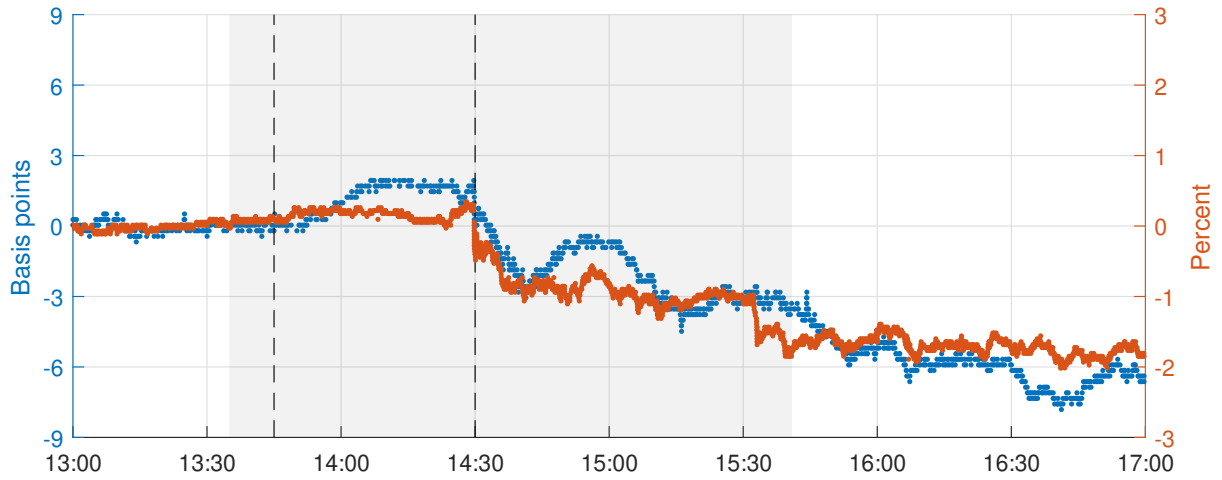
(c) Governing Council Meeting on 22 October 2015

Change in yields (in basis points, left axis) and stock prices (in percent, right axis) normalized to 0 at 13:35. Vertical dashed lines mark the press release at 13:45 and the press conference start at 14:30. The grey area indicates the event window.

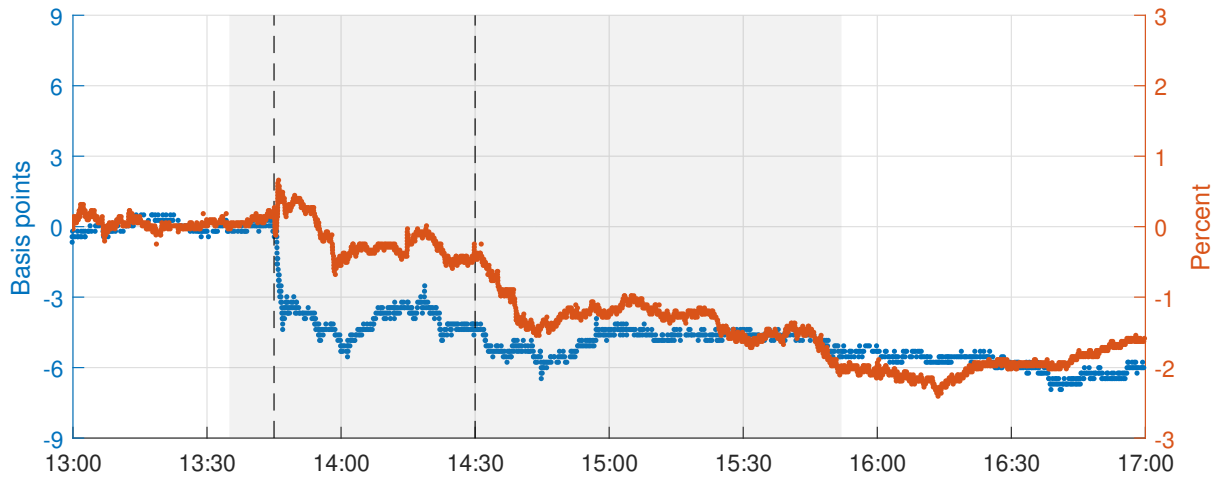
Figure 2: Examples of Adverse Central Bank Information Surprises?



(a) Governing Council Meeting on 6 March 2003



(b) Governing Council Meeting on 2 July 2009



(c) Governing Council Meeting on 5 July 2012

Change in yields (in basis points, left axis) and stock prices (in percent, right axis) normalized to 0 at 13:35. Vertical dashed lines mark the press release at 13:45 and the press conference start at 14:30. The grey area indicates the event window.

Table 1: Identification Overview

		Policy News Z^{PN}	Pure Policy Z^{PP}	Information Z^{I}
<i>High-frequency changes</i>	2-year yield	$\hat{=}$	+	+
	Stock prices		−	+

distinguish different types of policies. The identification schemes should nonetheless be valid, because every expansionary policy surprise – whether it is a cut in the current policy rate, the indication of a future rate cut, or the announcement of unconventional measures like QE – should have the same qualitative effect on bond yields and stock prices.⁷ The drawback of this approach, naturally, is that it does not allow to quantify the relative effectiveness of different monetary policy tools.

3.1 Policy News Shocks

Hanson and Stein (2015) argue that 2-year government bond yields provide a reliable measure of the foreseeable path of monetary policy. I therefore use changes in the 2-year German bond yield around ECB announcements as a naive proxy for “policy news” shocks Z^{PN} . In what follows, Z^{PN} serves as a benchmark: if information effects were negligible, any increase in the 2-year yield should be tantamount to a contractionary policy shock.

3.2 Pure Policy and Information Shocks

If information effects were important, on the other hand, rising yields after an announcement would not be synonymous with a contractionary shock, but instead could reflect a better-than-expected economic outlook by the central bank. To tell those two causes apart, I follow Jarocinski and Karadi (2018) and impose sign restrictions on the high-frequency comovement of yields and stock prices. In particular, I assume that a pure policy shock Z^{PP} raises yields and lowers stock prices, due to both a higher discount rate and lower expected dividends. An information shock Z^{I} , on the other hand, raises both yields and stock prices, as it signals an improved economic outlook.⁸

In practice, I obtain 2000 candidate shock series that satisfy the sign restrictions in Table 1 and then apply the median target method of Fry and Pagan (2011) to select unique estimates of Z^{PP} and Z^{I} . Appendix E explains the approach in detail.

⁷In addition to “target” and “path” factors (see Gürkaynak et al., 2005; Brand et al., 2010; Leombroni et al., 2016), Swanson (2017) and Altavilla et al. (2018) argue that an additional “QE factor” is needed to fully characterize recent monetary policy in the US and the euro area, respectively. In line with the examples from Figure 1, however, both papers find qualitatively the same effect of all factors on 2-year bond yields and stock prices.

⁸In principle, the effect on stock prices is ambiguous: an improved economic outlook raises cash-flow expectations but at the same time raises the interest rate at which these cash-flows are discounted. Appendix C.3, however, confirms that in my sample the former effect dominates: better-than-expected economic data releases are associated with higher, not lower, stock prices.

4 Effect on Financial Markets and Expectations

With the three different shock measures from Section 3 at hand, I estimate the effect of each shock Z^j on various variables Y_i with the following regression:⁹

$$\Delta Y_{it} = \alpha_j + \beta_i^j Z_t^j + \epsilon_t, \quad \text{for } Z^j \in \{Z^{\text{PN}}, Z^{\text{PP}}, Z^{\text{I}}\} \quad (1)$$

First off, Table 2 reports the one-day response of bond yields, inflation swaps, stocks, and exchange rates. For the sake of comparison, I standardize each shock series such that the impact effect on the 2-year German bond yield is 100bp.

The naive policy news shock Z^{PN} has familiar effects on the yield curve. The effect peaks at the 2-year maturity and monotonically declines at longer horizons. Inflation swaps, in contrast, barely react at all. Since we would expect a clear downward revision of expected inflation in response to a monetary tightening, these results are somewhat puzzling (but confirm recent evidence for the US, see Nakamura and Steinsson, 2018). Even more puzzling is the muted stock market response. Neither prices nor volatility seem to be affected by policy news shocks Z^{PN} . The response of exchange rates, at least, is consistent with Z^{PN} capturing monetary policy shocks: the euro appreciates against all major currencies when an ECB announcement raises rates.

Why do policy news shocks have strong and intuitive effects on bond yields and exchange rates, but at the same time barely affect inflation expectations and stock prices? Central bank information effects offer a simple explanation: a central bank announcement that raises yields leads to an appreciation of the euro, no matter if the yield rise is really due to a contractionary policy surprise or actually reflects a better-than-expected growth outlook in the euro area. The response of stock prices and inflation expectations, in contrast, depends crucially on the root cause of the yield rise. While contractionary monetary policy lowers stock prices and expected inflation, an improved economic outlook raises them. The overall muted response of stock prices and inflation expectations to central bank announcements might thus be due to those two forces offsetting each other.

Indeed, the effect of pure policy shocks Z^{PP} and information shocks Z^{I} are in line with this explanation. Both shocks lead to a euro appreciation, but their effect on inflation expectations is diametrically opposite. Contractionary policy shocks lower inflation-linked swaps (though rarely significantly), while a positive information shock raises them. Both shocks, moreover, have a hump-shaped effect on bond yields along the yield curve, with somewhat larger effects for central bank information shocks at long maturities. The diverging effects on stock prices, lastly, directly follows from the identification scheme in Section 3.2. Importantly, the strong effects of central bank information shocks does not imply that the ECB has less power over the economy via traditional channels. In fact, while pure policy shocks raise nominal rates slightly less than naive policy news shocks, they raise real interest rates considerably more.

A common concern regarding financial market responses is that they might be driven by risk premia – as opposed to revised expectations about monetary policy and economic growth (see e.g. Hanson and Stein, 2015). Inflation-linked swaps, for instance, reflect not

⁹Henceforth, */**/** denotes significance at the 10/5/1% level, based on a bootstrap procedure that takes into account both estimation and identification uncertainty, see Appendix F. Appendix G shows that treating the shocks Z^j as observable and using robust standard errors yields largely similar results.

Table 2: Financial Market Reactions

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
<i>Nominal Bond Yields</i>	1 year	0.72***	0.13	0.73***	0.18	0.69***	0.11
	2 year	1.00***	0.12	1.00***	0.17	1.00***	0.10
	5 year	0.90***	0.12	0.86***	0.19	0.94***	0.10
	10 year	0.59***	0.09	0.56***	0.17	0.62***	0.11
	30 year	0.33***	0.08	0.28*	0.14	0.40***	0.11
<i>Inflation- Linked Swaps</i>	1 year	-0.00	0.11	-0.15	0.15	0.20**	0.09
	2 year	-0.01	0.11	-0.16	0.15	0.21**	0.09
	5 year	-0.03	0.07	-0.16*	0.10	0.15**	0.06
	10 year	0.01	0.04	-0.08	0.06	0.14**	0.06
	30 year	-0.00	0.04	-0.10**	0.05	0.14***	0.05
<i>Stocks</i>	Euro STOXX 50	-1.2	3.7	-18.0***	4.7	20.9***	4.3
	Euro STOXX Banks	1.2	4.7	-20.5***	6.0	29.7***	6.0
	VSTOXX	6.2	12.1	50.3***	18.1	-51.8***	15.7
<i>Exchange Rates</i>	US Dollar	7.7***	1.7	9.5***	2.9	5.3***	1.8
	British Pound	6.4***	1.1	8.1***	1.8	4.1***	1.3
	Swiss Franc	3.8***	1.1	3.4***	1.1	4.3***	1.5
	Japanese Yen	7.2***	2.1	7.3**	3.1	7.2***	2.5
	Chinese Yuan	3.3**	1.3	2.2	1.9	4.8***	1.4

Regression results of Equation (1): Each row refers to the daily response of variable Y_i stated in the left-most column to the three different shocks Z^j stated in the column header. All coefficients refer to percentage points. The number of observations is 186, except for inflation-linked swaps (160 observations, data starts April 2004). Exchange rates are in foreign currency per euro.

only expected inflation over the contract horizon, but also a compensation for the associated risk. Their subdued response to policy news shocks Z^{PN} could thus be consistent with expected inflation going down, but higher risk premia offsetting this decline. In a similar vein, the central bank information shock Z^{I} might simply capture instances where the ECB changed market participants' risk sentiment. A "risk-on" announcement, for instance, should increase the price of relatively risky assets, such as stock prices, and lower the price of relatively safe assets, such as bonds (thus raising bond yields). My identification scheme would misclassify such an announcement as a central bank information shock.¹⁰

To address this concern, I exploit survey data – which is less likely to be contaminated by risk premia effects – to study whether and how market participants revise their economic expectations in response to ECB announcements. In particular, Table 3 reports results for weekly analyst forecasts on corporate earnings and dividends, and monthly survey expectations on main macroeconomic aggregates in the euro area.¹¹

¹⁰The relatively strong effect of information shocks on German long-term yields would indeed be consistent with such risk premia effects (insofar as the safety feature of bonds increases with their maturity, see Cieslak and Schrimpf, 2019).

¹¹Appendix A confirms that the results are robust at the country-level.

Table 3: Revisions of Economic Expectations

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
Euro STOXX 50 Earnings		-0.5	2.4	-5.9***	3.5	7.2**	2.9
Euro STOXX 50 Dividends		1.2	2.1	-3.7	2.9	8.3***	2.9
<i>GDP</i>	Euro area	-0.15	0.31	-0.94***	0.39	0.72	0.52
<i>Growth</i>	Country panel	-0.20	0.31	-0.99***	0.40	0.67	0.51
<i>Ind. Prod.</i>	Euro area	-0.15	0.87	-1.79*	1.06	1.74	1.60
<i>Growth</i>	Country panel	-0.67	0.68	-1.66***	0.76	0.44	1.19
<i>Unemp.</i>	Euro area	0.35*	0.21	0.91***	0.33	-0.28	0.25
<i>Rate</i>	Country panel	0.28*	0.16	0.75***	0.25	-0.25	0.23
<i>CPI</i>	Euro area	-0.03	0.22	-0.41	0.28	0.39	0.35
<i>Inflation</i>	Country panel	0.00	0.26	-0.55**	0.26	0.61	0.48
<i>PPI</i>	Euro area	-0.47	0.59	-1.62**	0.64	0.84	1.11
<i>Inflation</i>	Country panel	-0.11	0.43	-0.73*	0.45	0.58	0.80

All coefficients refer to percentage point revisions of one year ahead forecasts. Earnings and dividend results refer to 2-week revisions in I/B/E/S analyst forecasts for the Euro STOXX 50 index, see Section D.1. The number of observations is 136. Results for macroeconomic aggregates refer to monthly revisions from Consensus Economics surveys, see Appendix D.2. Apart from aggregate euro area forecasts, I estimate a fixed-effects panel regression for forecasts of individual member states. GDP and CPI forecasts are available for eleven countries (see Table A3), industrial production forecasts for ten countries (not for the Netherlands), unemployment rate forecasts for three countries (Germany, France, Italy), and producer price inflation forecasts for two countries (Germany and France). The number of observations is 174 per country.

The effect of policy news shocks Z^{PN} on survey expectations is decidedly inconclusive. Instead of a clear downward revision in output and inflation expectations, most estimates are insignificant and economically rather small.¹²

Separating between pure policy and information shocks, in contrast, yields intuitive results. An interest rate rise that is due to a contractionary policy surprise depresses economic expectations across the board: expected GDP and industrial production growth falls, expected unemployment rises, and CPI and PPI inflation expectations decline. An equivalent rate rise that is due to a central bank information shock, lastly, lifts expectations. While the magnitude of the effects is similar, only the rise in expected corporate profits and dividends is statistically significant. Nonetheless, since risk premia shocks should by definition be unrelated to economic fundamentals, these results suggests that Z^{I} does indeed capture central bank information effects.¹³

Another potential weak point of the identification scheme used in Section 3.2 is the missing distinction between news about supply and demand. The sign restrictions I

¹²Recall that for US data, Campbell et al. (2012) and Nakamura and Steinsson (2018) find significant *expansionary* effects on survey expectations for policy announcements that raise rates.

¹³Also note that a “risk-on” shock should reduce the premium investors require to hold inflation-linked swaps. The fact that inflation swaps rise after a central bank information shock suggests that upward revisions to expected inflation outweigh risk premia effects.

impose work well for demand shocks, since these shocks induce a comovement in output and prices, and hence elicit an unambiguous monetary policy response. Supply shocks, on the other hand, have contrary effects on output and prices, placing the central bank in a dilemma. Even though an adverse supply shock reduces output, for instance, the central bank might tighten its policy to thwart the shocks' positive effect on inflation. Yields could thus rise while stock prices decline, i.e. the above identification scheme could misclassify bad news about aggregate supply as a monetary policy shock. In practice, however, this issue seems to be of limited relevance, as the pure policy shock Z^{PP} lowers inflation expectations, both market-based and survey-based.¹⁴

5 Dynamic Macroeconomic Effects

To investigate the dynamic macroeconomic effects of the three different shocks from Section 3, one can employ them as external instruments in time series models (see e.g. [Gertler and Karadi, 2015](#); [Stock and Watson, 2018](#)).

In particular, I first estimate a standard VAR with five variables: the 2-year German bond yield, euro area industrial production and consumer prices (both in logs), a measure of credit spreads, and the Euro STOXX 50 index (in logs). The spread series is from [Gilchrist and Mojon \(2016\)](#) and refers to value-weighted spreads of non-financial euro area corporate bonds with respect to their domestic sovereign counterpart. The VAR is estimated on data from January 1999 to October 2018 and the benchmark specification includes six lags.¹⁵ Identification is achieved by regressing the reduced-form VAR residuals on the respective shock Z^j .

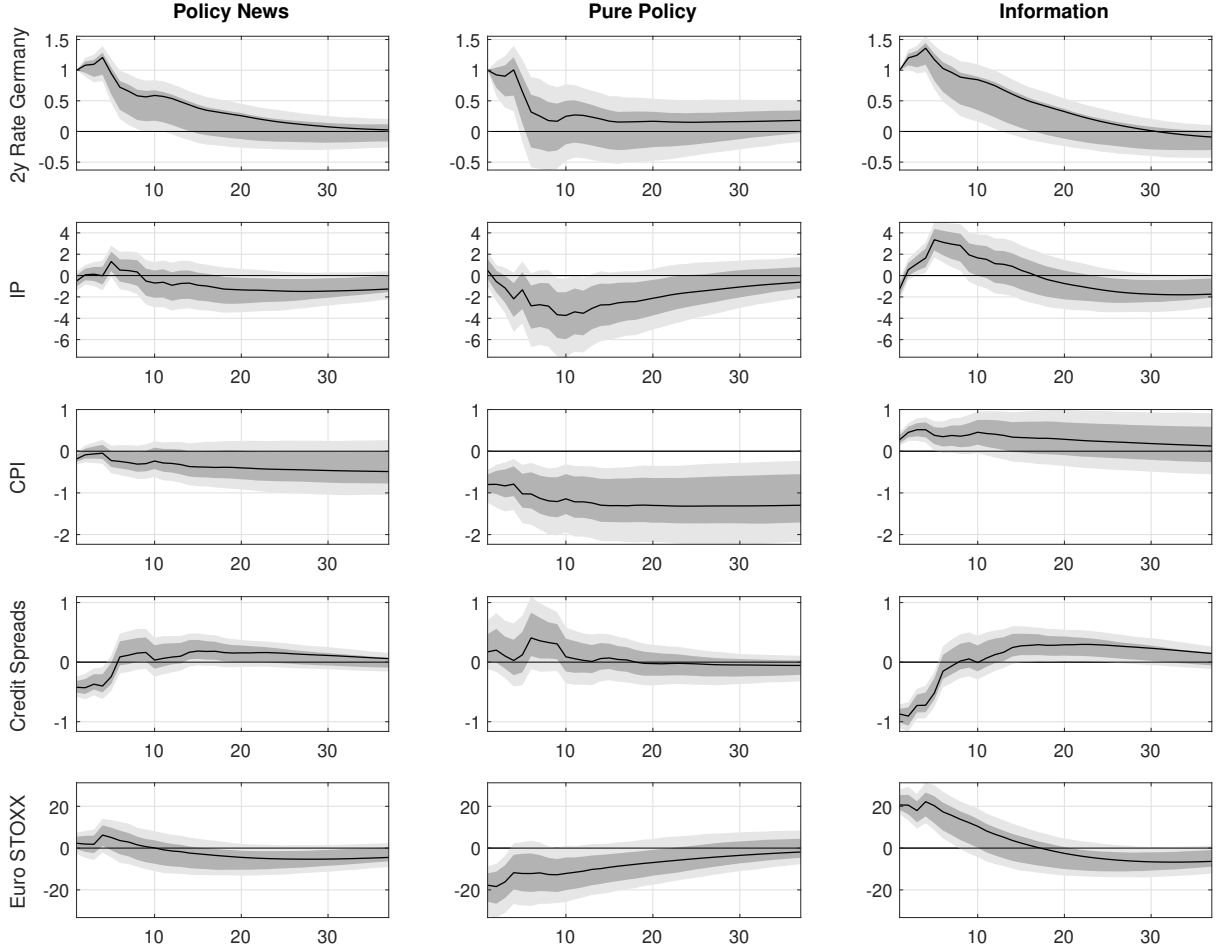
Figure 3 shows the impulse responses to shocks that increases the 2-year German bond yield by 100 basis points, as before. As the first column in Figure 3 shows, using the policy news shocks Z^{PN} as an external instrument yields puzzling results. Instead of a clear decline, neither industrial production nor consumer prices exhibit a significant response. Even more implausibly, stock prices increase and credit spreads narrow after a supposedly contractionary shock.

The effects of a pure policy shock Z^{PP} shown in the second column, in contrast, are in line with basic economic theory. Output and prices decline after a monetary tightening, while credit spreads widen (though barely significantly) and stock prices fall. The information shock Z^{I} shown in the third column, moreover, has expansionary effects across the board. Both industrial production and consumer prices rise in a hump-shaped fashion after a favourable information shock, while credit spreads narrow and stock prices rise immediately. All these responses are statistically significant and they are exactly what we would expect from a central bank announcement that signals a better-than-expected economic outlook. Reassuringly, the impact effect on stock prices closely matches the daily effects estimated in Table 2.

¹⁴[Jarocinski and Karadi \(2018\)](#) use daily responses of break-even inflation rates to separately identify central bank information shocks about supply and demand. In line with my results, they find little evidence for adverse supply shocks that are accompanied by rising rates.

¹⁵Confidence bands are based on the wild bootstrap procedure by [Goncalves and Kilian \(2004\)](#), which generates artificial data samples by changing the sign of the VAR residuals and the external instrument for randomly selected time periods. Note, however, that the instruments Z^j are treated as observable, which may understate true uncertainty.

Figure 3: External Instrument VARs



Black lines refer to point estimates, grey areas to 68% and 90% confidence bands. All responses are in percent and based on the same underlying VAR model, with each column referring to a different external instrument used for identification. The first column shows results for the policy news shock Z^{PN} , the second column for the pure policy shock Z^{PP} and the third column for central bank information shocks Z^{I} , see Section 3.

One potential worry about VAR results, however, is the sparse number of variables these models can capture.¹⁶ To address this concern, I estimate a factor-augmented VAR (FAVAR). In particular, I extract four factors (principal components) from a set of 46 variables that are arguably important for the ECB’s decision-making process but that are omitted from the VAR.¹⁷ These factors are added to the five observable VAR variables. As Figure 4 shows, the FAVAR produces similar results as the small-scale VAR. The main difference is that the FAVAR model finds stronger effects of a monetary tightening on real activity, prices and credit spreads.

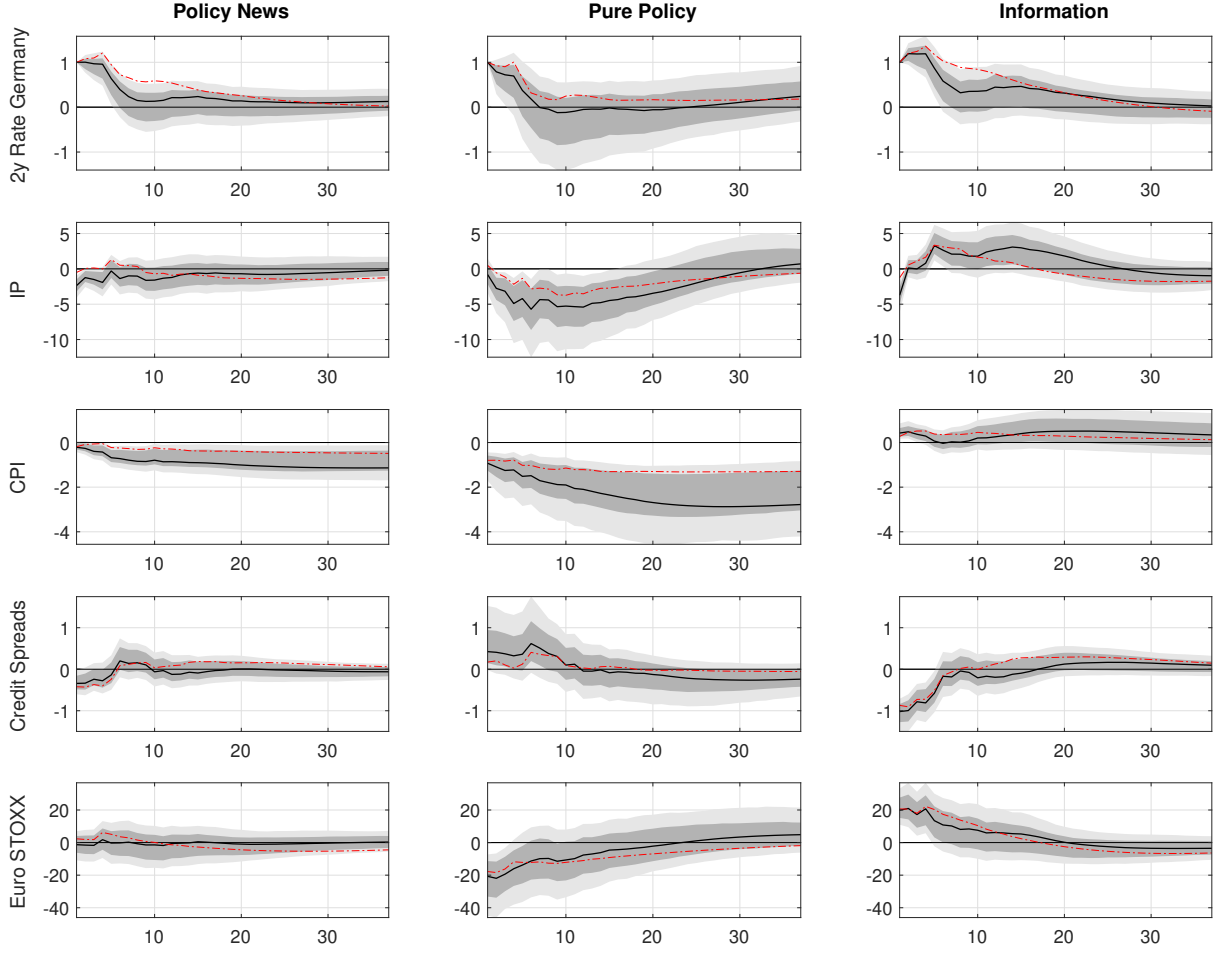
Taken together, the macroeconomic effects shown above are largely in line with the financial market reactions and the revisions in survey expectations found in Section 4.¹⁸

¹⁶The sparse number of variables may lead to an informational problem known as “nonfundamentality”, see e.g. Forni and Gambetti (2010, 2014); Kerssenfischer (2019). In particular, since central banks take into account vastly more information than is included in a typical VAR, monetary policy shocks might not be recoverable from VAR residuals.

¹⁷See Table A9 in the Appendix for the list of variables.

¹⁸The VAR results are robust with respect to the chosen lag length and the FAVAR results are robust

Figure 4: External Instrument FAVARs



Black lines refer to point estimates, grey areas to 68% and 90% confidence bands. The FAVAR augments the VAR with four principal components extracted from a euro area macro dataset, see Section D.3 in the Appendix. Red dash-dotted lines reproduce the VAR point estimates shown in Figure 3.

Both sets of results suggest that ECB announcements do not only convey information about future monetary policy, but also about the ECB's economic outlook. Changes in interest rates, even in a narrow window around central bank announcements, are thus not necessarily valid instruments for monetary policy shocks.

6 Conclusions

An extensive literature documents the strong effects central bank announcements have on nominal and real interest rates. If these market reactions were solely due to revised expectations about future policy, every announcement that raises interest rates would be tantamount to a contractionary policy shock. According to standard theory, such a shock should lead to downward revisions in expected growth and inflation. A growing literature, however, provides evidence to the contrary.

Based on high-frequency futures data, I estimate the effect of policy announcements with respect to the number of added factors, see Figure A1 and A2 in the Appendix.

in the euro area and largely replicate the empirical findings of both strands of literature. That is, I find strong announcement effects on interest rates, even far out the term structure, but puzzlingly small revisions in market participants' economic expectations. A potential explanation for these findings are so-called information effects, referring to the information about economic fundamentals the central bank reveals (implicitly or explicitly) with its announcement. To test the validity of this explanation, I follow [Jarocinski and Karadi \(2018\)](#) and decompose policy announcements into pure policy and central bank information shocks via sign restrictions. In particular, I assume that pure policy shocks raise 2-year bond yields and reduce stock prices, while an information shock – signalling an improved economic outlook – raises stock prices along with yields. This identification scheme yields intuitive results across the board, both for financial market prices and market participants' economic expectations.

Overall, my results suggest that central bank information effects are a key channel via which ECB announcements operate. Even the immediate market reactions to policy announcements should thus not be interpreted as unambiguous effects of monetary policy, as is e.g. standard practice in event studies.

A Additional Results

To show that the yield responses in the top panel of Table 2 are not unique to Germany, Table A1 reproduces the results for French sovereign bonds.¹⁹

Table A1: Response of French Government Bond Yields

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
<i>Nominal Bond Yields</i>	1 year	0.69***	0.13	0.67***	0.18	0.79***	0.11
	2 year	0.96***	0.12	0.99***	0.16	0.92***	0.10
	5 year	0.85***	0.12	0.94***	0.19	0.75***	0.10
	10 year	0.52***	0.11	0.62***	0.20	0.38***	0.11
	30 year	0.28***	0.08	0.35**	0.15	0.18*	0.10

This table reproduces the top panel of Table 2 for French instead of German nominal bond yields. The number of observations is 173 at the 1-year maturity (data starts December 2002) and 186 otherwise.

Table A2, furthermore, shows that the response of stock prices and analyst forecasts are broadly similar when looking at national stock market indices instead of the aggregate Euro STOXX 50 index.

Table A2: Stock Prices and Analyst Revisions Across Countries

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
Stock Prices							
	Germany	-2.3	3.9	-17.8***	5.0	18.1***	4.4
	France	-0.7	3.8	-16.7***	4.8	20.2***	4.3
	Italy	-0.3	3.6	-17.9***	5.1	22.8***	4.6
	Spain	-0.2	3.6	-17.6***	4.9	22.6***	4.5
Earnings Revisions							
	Germany	-1.7	3.8	-7.2*	5.3	6.2*	3.5
	France	-0.2	2.0	-4.7**	2.5	6.3*	3.7
	Italy	0.8	2.0	-3.3	2.4	6.6*	3.6
	Spain	0.8	3.5	-5.7*	3.5	8.9*	4.3
Dividend Revisions							
	Germany	-0.9	3.1	-5.2	4.3	5.2	3.1
	France	0.5	1.2	-1.7	1.8	3.6	2.4
	Italy	1.8	2.9	2.9	4.0	0.4	6.3
	Spain	-0.4	2.9	-6.4**	3.2	7.8*	4.4

Results for Germany refer to the DAX index, for France to the CAC index, for Italy to the FTSE MIB index, and for Spain to the IBEX index. The top panel shows daily responses of national stock prices (analogous to Table 2). The two lower panels show 2-week revisions in I/B/E/S analyst forecasts (analogous to Table 3; for Italy, forecasts are available only since June 2009).

Similarly, Table A3 reports survey revisions on macroeconomic aggregates for individual euro area member states, confirming the aggregate results shown in Table 3.

¹⁹Yields of euro area periphery countries, in contrast, exhibit a substantially different response to ECB announcements. Leombroni et al. (2016) show that this wedge is due to the sovereign debt crisis, during which periphery yields contained a substantial “euro-area break-up premium”.

Table A3: Macroeconomic Survey Revisions Across Countries

	Policy News			Pure Policy			Information		
	GDP	IP	CPI	GDP	IP	CPI	GDP	IP	CPI
Germany	-0.32	0.19	0.04	-1.31***	-1.77*	-0.27	0.77	2.38	0.37
France	-0.08	-0.30	0.06	-0.74**	-1.77**	-0.31	0.66*	1.33	0.46
Italy	-0.21	-0.89	-0.11	-0.89***	-2.59***	-0.38	0.55	1.02	0.19
Spain	0.09	-0.87	-0.20	-0.62	-1.61	-0.75*	0.88**	-0.04	0.41
Netherlands	-0.39		-0.04	-1.36***		-0.15	0.70		0.08
Austria	-0.29	-1.63*	-0.33	-0.94***	-2.33**	-0.64**	0.44	-0.78	0.02
Belgium	-0.38	-0.92	-0.17	-0.97***	-1.81*	-0.38	0.28	0.08	0.07
Finland	-0.62*	-2.03**	-0.06	-1.14***	-2.91***	-0.00	-0.02	-1.02	-0.12
Greece	-0.03	0.13	-0.04	-0.64	0.69	0.27	0.66	-0.48	-0.39
Ireland	0.15	0.71	0.07	-1.29*	-1.01	-0.41	1.76**	2.50	0.61
Portugal	-0.22	0.22	0.11	-0.60	-1.79	-0.19	0.21	2.34	0.44

Results refer to monthly revisions in GDP growth, industrial production growth, and CPI inflation, see Table 3 for details.

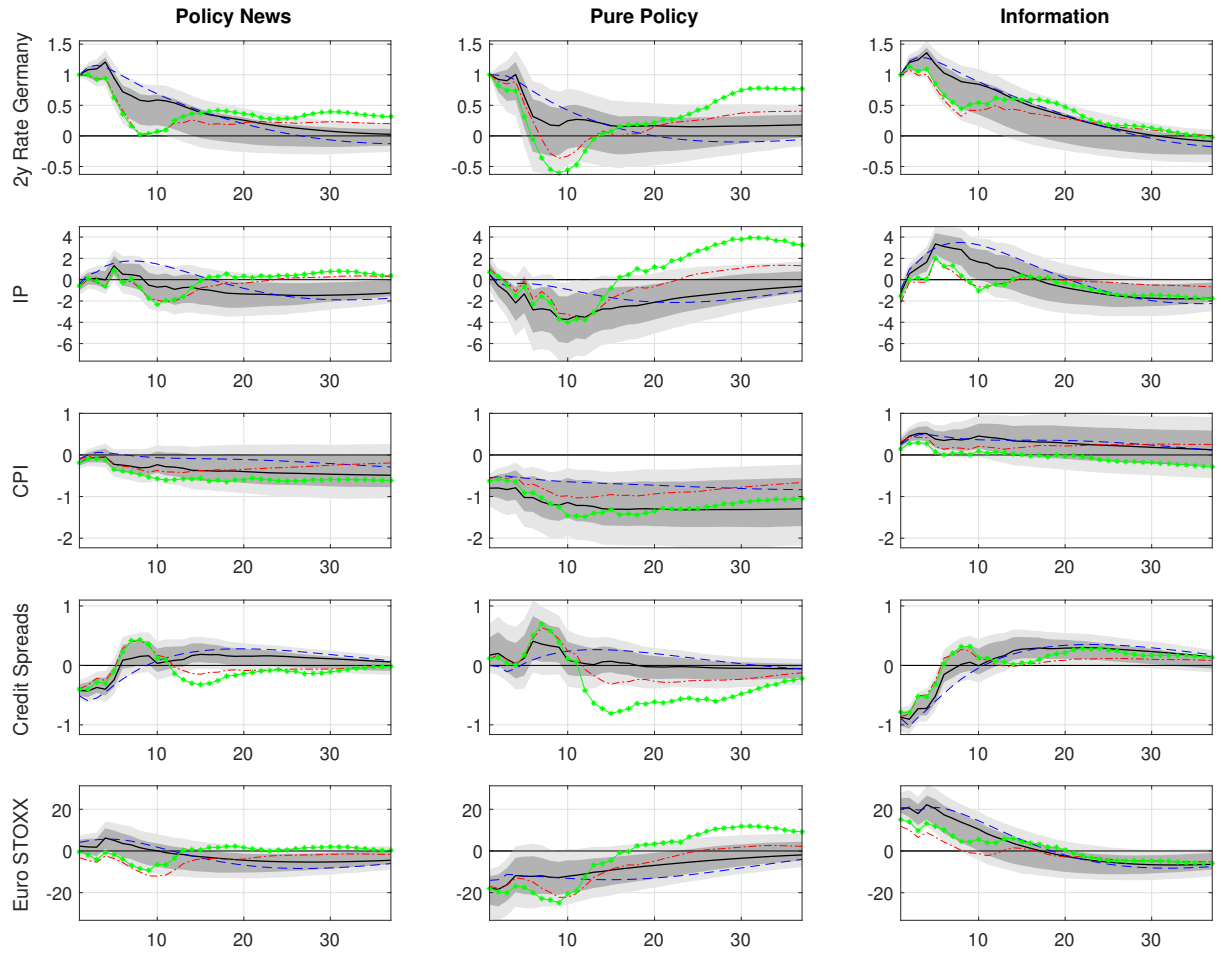
Table A4, lastly, reports analyst revisions of earnings and dividends in the Euro STOXX 50 for different revision horizons. Recall that the benchmark results in Table 3 show revisions over the two weeks following ECB announcements, because stock analysts update their forecasts infrequently, see Section D.1. In line with this, Table A4 shows that revisions accumulate gradually.

Table A4: Analyst Revisions for the Euro STOXX 50

	Policy News		Pure Policy		Information	
	$\hat{\beta}$	<i>s.e.</i>	$\hat{\beta}$	<i>s.e.</i>	$\hat{\beta}$	<i>s.e.</i>
Earnings Revisions after ...						
1 week	-1.7	2.4	-4.4	3.6	2.1	1.8
2 weeks	-0.5	2.4	-5.9***	3.5	7.2**	2.9
3 weeks	-1.1	3.5	-7.8*	5.1	8.2**	4.0
4 weeks	-0.1	4.4	-8.3*	6.2	11.6**	5.0
Dividend Revisions after ...						
1 week	-0.6	2.3	-2.7	3.3	2.4	2.0
2 weeks	1.2	2.1	-3.7	2.9	8.3***	2.9
3 weeks	1.1	3.1	-5.4	4.3	10.1***	3.5
4 weeks	2.3	3.9	-5.0	5.0	12.7***	4.7

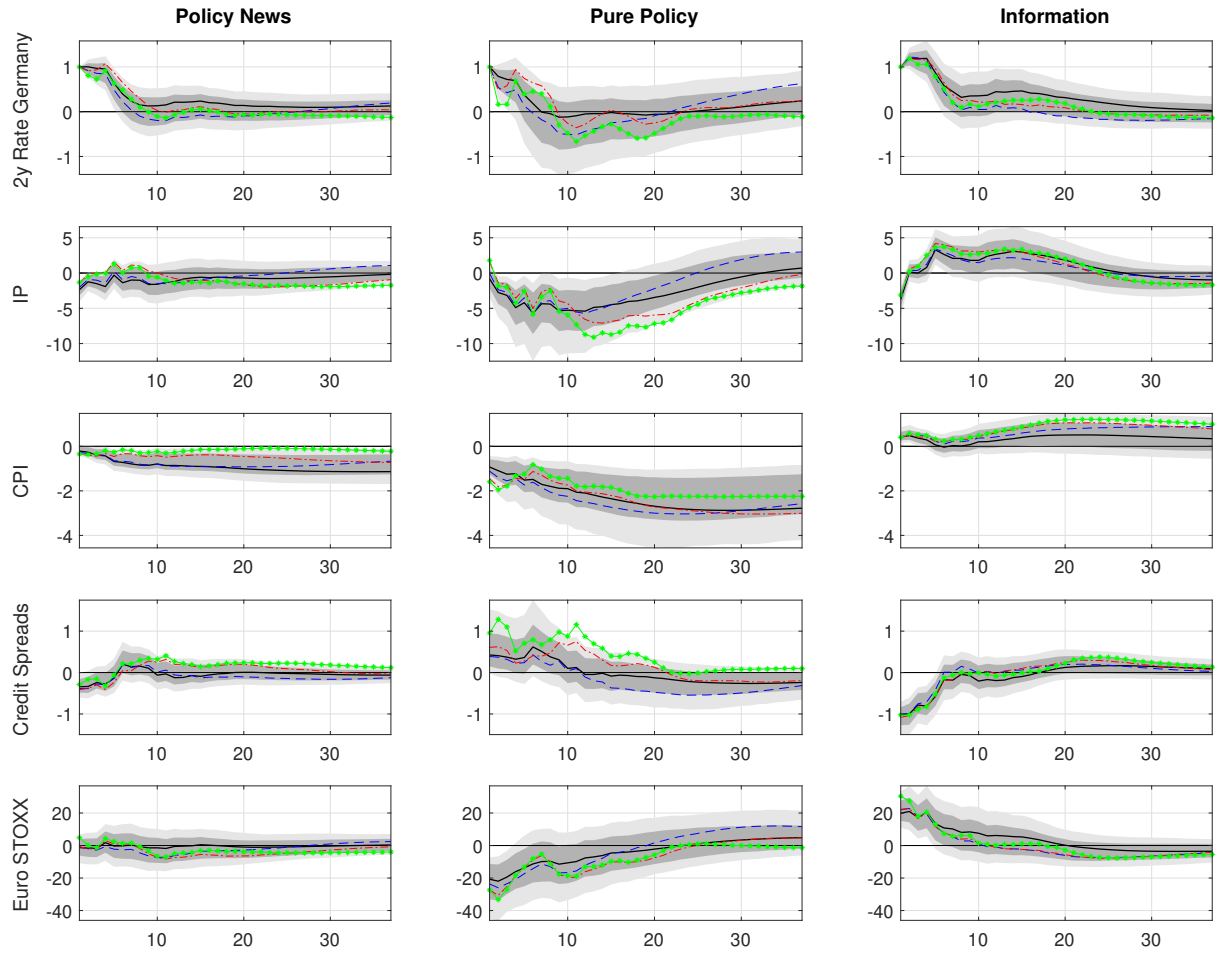
This table reproduces the top two rows from Table 3 for different revision periods.

Figure A1: Robustness of VAR Results to Different Lag Length



Black lines and grey areas reproduce Figure 3, based on a VAR with 6 lags. Blue dashed lines refer to a VAR with 3 lags, red dash-dotted lines to a VAR with 9 lags, and green lines (marked with an asterisk) to a VAR with 12 lags.

Figure A2: Robustness of FAVAR Results to Different Number of Factors



Black lines and grey areas reproduce Figure 4, based on a FAVAR with 4 factors added to the five observable variables.

Blue dashed lines refer to a FAVAR with 6 factors, red dash-dotted lines to a FAVAR with 8 factors, and green lines (marked with an asterisk) to a FAVAR with 10 factors. All models include 6 lags.

B Policy Announcement Events

As mentioned in Section 2, I study high-frequency futures prices on ECB Governing Council meeting (GCM) days. From late 2001 onwards, GCMs took place on the first Thursday of each month, with a few exceptions during the summer recess. Since 2015, meetings dedicated to monetary policy changed to a new six-week cycle, whereas non-monetary policy meetings continue to be held at least once a month.²⁰ As is standard in the literature, I only study GCMs dedicated to monetary policy. As is also standard, I exclude the unscheduled meeting on 8 October 2008, in which the ECB announced a coordinated rate cut with other major central banks. In total, my sample consists of 186 meetings, the exact dates of which are shown in Table A5. Seven times, the GCM

Table A5: Overview of Governing Council Meeting Days

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002			7	4	2	6	4	1*	12	10	7	5
2003	9	6	6	3	8	5	10,31*		4	2	6	4
2004	8	5	4	1	6	3	1	5*	2	7	4	2
2005	13	3	3	7	4 [#]	2	7	4*	1	6	3	1
2006	12	2	2	6	4	8	6	3,31		5	2	7
2007	11	8	8	12	10	6 [#]	5	2*	6	4	8	6
2008	10	7	6	10	8	5	3	7	4	2	6	4
2009	15	5	5	2	7	4	2	6	3	8	5	3
2010	14	4	4	8	6	10	8	5	2	7	4	2
2011	13	3	3	7	5	9	7	4	8	6	3	8
2012	12	9	8	4 [#]	3	6 [#]	5	2	6	4	8	6
2013	10	7	7	4	2	6	4	1	5	2 [#]	7	5
2014	9	6	6	3	8	5	3	7	4	2	6	4
2015	22		5	15 [#]		3 [#]	16		3	22		3
2016	21		10	21		2	21		8	20		8
2017	19		9	27		8	20		7	26		14
2018	25		8	26		14	26		13	25		13

was postponed to a Wednesday (marked with a hash character). On five of the selected GCM dates, no press conference was held (marked with an asterisk). In the latter cases, I extract future price movements only around the press release at 13:45 (CET), i.e. I use an event window from 13:35 till 14:05.²¹ For all other GCMs, I use an event window from 13:35 until 20 minutes after the end of the press conference. While the start of press conferences is fixed at 14:30, their duration is not. Hence, I use video recordings to manually determine the duration D_t when possible. Otherwise, I obtain an estimate \hat{D}_t

²⁰See www.ecb.europa.eu/press/pr/date/2014/html/pr140703_1.en.html

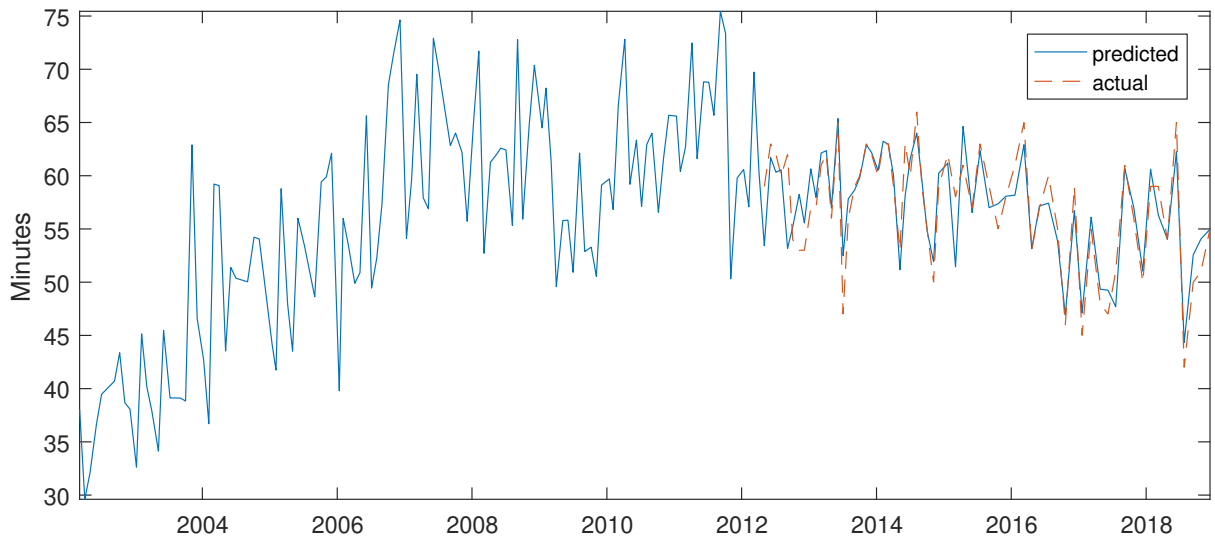
²¹Up until 2014, press releases only announced policy rate decisions. In January and December 2015, the releases contained an additional note that “*further monetary policy measures will be communicated [...] at [the] press conference [...] today*” (in the ensuing press conferences, the introduction and extension of the public sector purchase programme were announced, respectively). Since March and July 2016, press releases contain even more detailed information about non-standard policy measures, namely about purchase programmes (e.g. regarding volumes and horizons) and future policy rates, respectively.

of their length as follows:²²

$$\begin{aligned} \text{I regress} \quad D_t &= \mu + \delta_t \#Words_t + \zeta_t & \text{for } t = \{62 \text{ GCMs with video recording}\} \\ \text{and predict} \quad \hat{D}_t &= \hat{\mu} + \hat{\delta}_t \#Words_t & \text{for } t = \{117 \text{ GCMs without video recording}\} \end{aligned}$$

where $\#Words$ is the number of words in each press conference transcript. The regression yields an R^2 of 78% and, as Figure A3 shows, the transcripts document a substantial variation in the length of press conferences over time (as also shown by Ehrmann and Fratzscher, 2009). Most notably, ECB press conferences in the early 2000s were often only half as long as those since the financial crisis.

Figure A3: Length of ECB Press Conferences



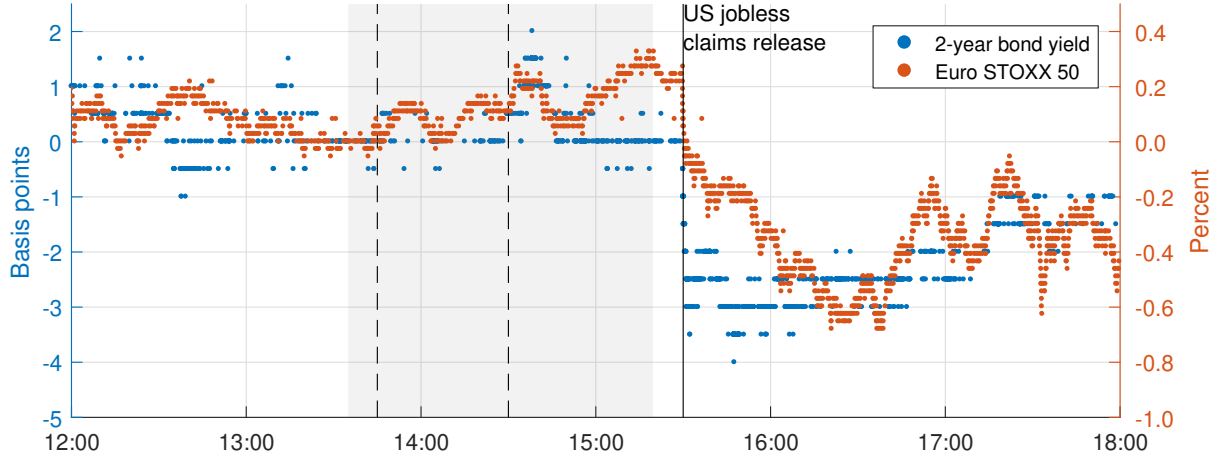
The dashed red line shows the actual length of all press conferences for which a video recording is available. The solid blue line shows the predicted press conference length based on the number of words in the respective conference transcript.

Figure A4, moreover, shows how important the precise timing of press conferences can be. In particular, the figure shows future prices on the GCM day of 4 April 2002. This day is noteworthy for three reasons: First, the press conference on that day was particularly brief (according to the transcript word count it lasted only about half an hour). Second, US initial jobless claim numbers were released at 15:30 (CET) that day, not at 14:30 as usual (due to different daylight saving time periods between Europe and the US).²³ Third, the released jobless claim numbers were much higher than expected (constituting the second-largest surprise throughout the sample). As the figure shows, the unexpected bad news about the US economy led to an immediate and sizeable drop in German bond yields and stock prices beginning at 15:30. If one were to use a fixed event window end at 15:50 or even later – as is commonly done in the literature – one

²²Video recordings are available for all press conferences since May 2012 at www.ecb.europa.eu/press/tvservices/webcast, transcripts of all conferences at www.ecb.europa.eu/press/pressconf.

²³In Europe, daylight saving time applied between the last Sunday in March and the last Sunday in October throughout my sample. In the US, the corresponding dates were the first Sunday in April and the last Sunday in October (till 2006), and the second Sunday in March and the first Sunday in November (from 2007 onwards).

Figure A4: Intraday Futures Data on 4 April 2002

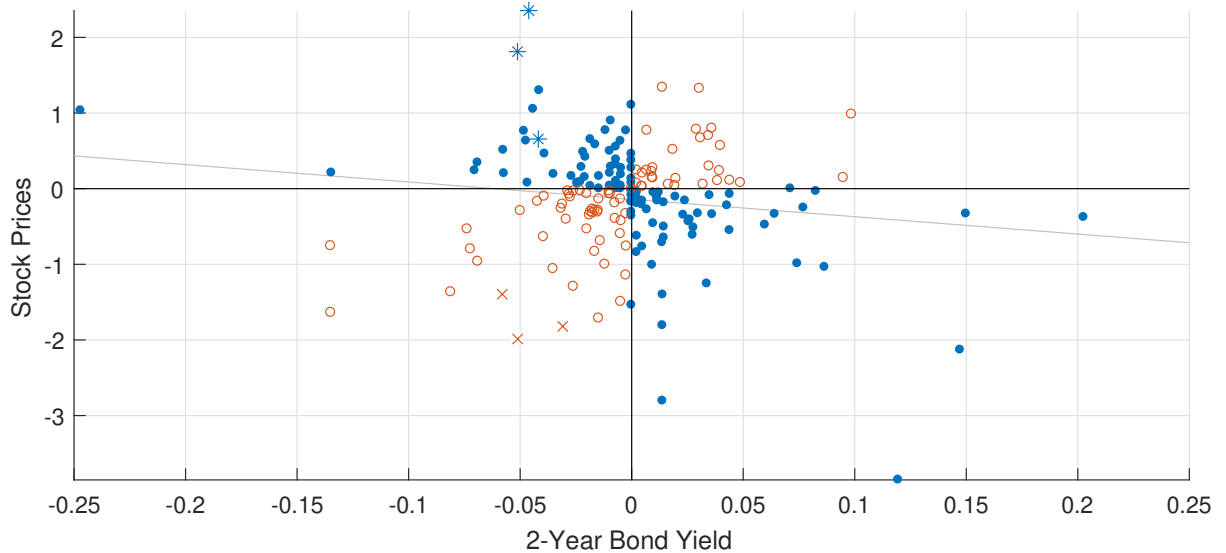


The grey area indicates the event window from 13:35 to 15:20 (CET), i.e. 10 minutes prior to the press release and 20 minutes after the end of the press conference. At 15:30, unexpectedly high US initial jobless claim numbers were released.

might falsely attribute these market reactions to the ECB press conference, which had already ended at about 15:00. Note that I use data releases like the one on 4 April 2002 – i.e. releases that occurred outside of event windows – to purge the effect of releases that occurred within event windows, see Section C.2.

To highlight the empirical relevance of central bank information effects, Figure A5 provides a scatter plot of yield and stock price changes around the 186 event windows. If yield changes captured only monetary policy surprises, one should expect a clear negative relationship with stock prices. Instead, the relationship is basically flat with yields and stock prices co-moving in 42% of all cases, confirming Jarocinski and Karadi (2018).

Figure A5: Yield and Stock Price Changes around Event Windows



Blue dots indicate events during which stock prices and 2-year German bond yields moved in opposite directions, red circles indicate a co-movement between the two. Blue asterisks refers to the three meetings shown in Figure 1, red crosses refer to the three meetings shown in Figure 2. The solid grey line is the OLS estimate based on all observations.

C High-Frequency Futures

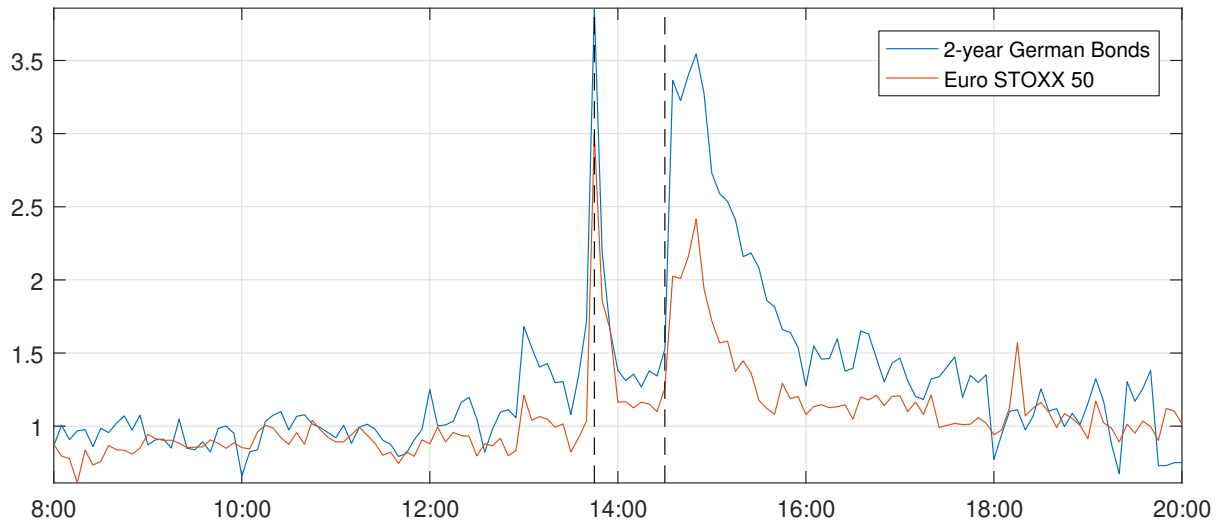
The core of my analysis is based on tick-by-tick data on two futures traded on the derivatives exchange Eurex, see Table A6.²⁴

Table A6: Overview High-Frequency Futures

	Underlying	avg. trading volume on GCM days	avg. abs. change around event window
2-year yield	German bonds maturing in 1.75-2.25y	581,525	3.0 bp
Stock prices	Euro STOXX 50 index	762,527	50.8 bp

Both futures are highly liquid, ensuring that any new information released by the ECB is quickly incorporated into market prices. In line with this, Figure A6 compares the intraday trading volume pattern on Thursdays with Governing Council meetings to those without. The figure documents two obvious spikes in trading activity. The first one coincides with the ECB’s press release at 13:45, when the number of traded contracts is roughly three times as high as usual. Consistent with the brief and highly standardized text of those releases, market participants seem to digest the new information quickly, as trading decreases almost back to normal within a few minutes. The second spike in trading activity occurs right after the press conference start at 14:30 and is more persistent, roughly matching the average conference length of one hour.

Figure A6: Intraday Trading Activity on Governing Council Meeting Days



Ratio of average trading volume on event days versus control days, in five-minute intervals. Trading volume refers to the number of traded contracts of the shortest-dated future. Event days refer to the 186 Governing Council Meetings listed in Table A5. Control days are all 657 Thursdays between March 2002 and December 2018 without an ECB announcement.

Vertical dashed lines refer to 13:45 and 14:30.

²⁴For each future, three contracts with different expiring horizons can be traded on Eurex (one for each of the three nearest quarterly months of the March, June, September and December cycle). Throughout, I use only data on the shortest-dated futures, which account for over 90% of all traded contracts. German bond futures have a contract value of EUR 100,000. The Euro STOXX 50 future has a contract value of EUR 10 per index point, with a base value of the index of 1000 on 31 December 1991.

C.1 Movements around ECB announcements

For each future and each announcement, I select P_1 , the last trading price prior to the event window (i.e. before 13:35), and P_2 , the first trading price after the event window (i.e. 20 minutes after the press conference ended). For the stock market future, the “raw” intraday change \tilde{x}_t refers to simple percentage changes

$$\tilde{x}_t^{stocks} = \frac{P_t^2 - P_t^1}{P_t^1} * 100. \quad (A1)$$

For the bond future, which is quoted in percent of the par value, I follow [Rogers, Scotti, and Wright \(2014\)](#) and transform price changes into approximate yield changes as

$$\tilde{x}_t^{2y\ yield} = \left(\frac{P_t^2 - P_t^1}{P_t^1} * 100 \right) / -D_t \quad (A2)$$

where D_t is the modified duration of the cheapest-to-deliver bond at time t , taken from Bloomberg. This procedure is necessary because at expiration of the contract, the seller of a bond future can fulfill his delivery obligation with any German government bond that matures within 1.75 to 2.25 years. In practice, however, only one of the eligible bonds is used: the so-called cheapest-to-deliver.²⁵ Thus, to translate price changes in a future into the implied yield changes in the underlying, one has to adjust for the duration of the cheapest-to-deliver bond.

C.2 Purging the Effect of Contemporaneous US Data Releases

As Figure A4 shows by way of example, data releases about the US economy can have a large impact on the futures I study. This is problematic because many data releases occur on Thursdays at 8:30 (ET), i.e. simultaneously to the start of the ECB’s press conference at 14:30 (CET). US data releases might thus invalidate the key assumption from Section 3 that ECB announcements are the main driver of the intraday future movements I study.

To address this issue, I run the following regression for each future i :

$$x_{it}^{30min} = \gamma_i + \Theta_i s_t + e_{it} \quad \text{for } t = \{1465 \text{ releases outside event windows}\}. \quad (A3)$$

The vector s_t contains “surprise components” of US economic indicators that may be released during ECB event windows. Surprise components are defined as the difference between the actual release and its median forecasted value, divided by the standard deviation of forecasts. The dependent variable x_{it}^{30min} is the 30-minute future movement corresponding to each release date (10 minutes prior and 20 minutes after the release). When there is no data release for a series on a particular date t – or the released value is identical to the expected value – the corresponding entry in s_t is zero. Since I want to estimate the independent effect of US macro releases, I exclude any releases that occurred within ECB event windows. As Table A7 shows, most US data releases have a highly significant impact on European futures. Furthermore, during all but six of the 186

²⁵Since bond futures refer to notional bonds with a coupon of 6%, Eurex provides conversion factors for all deliverable bonds in each future contract, see www.eurexchange.com/exchange-en/market-data/clearing-data/deliverable-bonds-and-conversion-factors.

Table A7: Reaction of Futures to US Data Releases

	2-year yield		Stock prices		# releases in event windows
	$\hat{\Theta}$	<i>s.e.</i>	$\hat{\Theta}$	<i>s.e.</i>	
Constant	0.00	0.03	2.07**	0.92	
Initial Jobless Claims	-0.30***	0.04	-8.34***	1.20	167
Continuing Claims	-0.11**	0.05	-2.07	1.33	155
Nonfarm Productivity	0.04	0.13	8.36***	2.90	48
Trade Balance	0.17**	0.08	5.37**	2.42	16
Employment Change (ADP Report)	0.35***	0.08	11.32***	2.56	11
Philadelphia Fed Business Outlook	0.42***	0.10	10.86***	3.06	6
Retail Sales Advance MoM	0.34***	0.10	15.50***	3.01	5
Change in Nonfarm Payrolls	1.64***	0.24	36.38***	3.99	3
PPI MoM	0.24**	0.11	-4.53	3.19	3

Each column refers to a separate regression, see Equation (A3). The dependent variable is the 30-min movement in the future listed in the column header. Rows refer to explanatory macro releases. Coefficients refer to basis point changes to one standard deviation surprises. The number of observations is 1527, the total number of non-zero surprises is 2493.

event windows from Section B, at least one US indicator has been released. As the last column of Table A7 shows, US jobless claim figures most frequently coincide with ECB announcements.

To control for these contemporaneous releases, I purge the “raw” futures movements from Section C.1 as follows:

$$x_{it} = \tilde{x}_{it} - \hat{\Theta}_i s_t, \quad \text{for } t = \{180 \text{ releases within event windows}\}. \quad (\text{A4})$$

C.3 Effect of Domestic Macroeconomic Data Releases

As mentioned in the main body of the text, the effect of an improved economic outlook on stock prices is a priori ambiguous: higher output raises not just dividend expectations, but also the interest rates at which these dividends are discounted. The positive cash flow effect, in other words, could be outweighed by the negative discount rate effect.

To test the relevance of this concern, I run the same regression as in Equation (A3) for eight European data releases. Table A8 shows that higher-than-expected output increases both yields and stock prices. The same is true for surveys: positive surprises to the current and expected economic situation lift both yields and stock prices. Most of these effects are also highly significant. In sum, the results are in line with the assumption from Section 3 that a positive central bank information shock raises stock prices.

Table A8: Reaction of Futures to Domestic Macroeconomic Releases

		2-year yield		Stock prices	
		$\hat{\Theta}$	<i>s.e.</i>	$\hat{\Theta}$	<i>s.e.</i>
Output	Constant	0.05**	0.02	0.95	0.69
	Euro area Industrial Production	0.16**	0.07	2.87*	1.72
	Germany Industrial Production	0.17**	0.07	4.10**	1.84
	Germany Factory Orders	0.36***	0.09	10.76***	2.70
Surveys	Euro area Economic Sentiment Index	0.23***	0.05	0.64	2.02
	ifo Current Situation	0.65***	0.14	9.68***	2.28
	ZEW Current Situation	0.07	0.06	3.59**	1.60
	ifo Expectations	0.26**	0.11	-2.34	2.28
	ZEW Expectations	0.42***	0.07	4.37***	1.41

Each column refers to a separate regression, as in Table A7. The dependent variable is the 30-minute movement in the future listed in the column header. Rows refer to explanatory macro releases. Coefficients refer to basis point changes to one standard deviation surprises. The number of observations is 1200, the total number of non-zero surprises is 1558.

D Lower Frequency Data

In Section 4, I study the response of various financial variables to policy announcements. Daily sovereign bond yields, exchange rates, and stock market indices are sourced from Bloomberg. As a market-based measure of inflation expectations I use data on inflation-linked swaps from Datastream, since the inflation-indexed bond market is still comparatively small in the euro area. Sections D.1 and D.2 describe the two surveys I use to investigate whether market participants revise their economic expectations in response to ECB announcements. In both cases, I use constant-horizon 1-year forecasts, computed as a weighted average of forecasts for the current and next year. Section D.3, lastly, lists the monthly macroeconomic variables I use to extract principal components for the FAVAR estimation in Section 5.

D.1 I/B/E/S Analyst Forecasts

Forecasts of earnings and dividend growth for the Euro STOXX 50 index are from the Institutional Brokers Estimate System (I/B/E/S). The weekly forecasts are available since 2006 and refer to the cap-weighted averages of individual stock forecasts. These individual stock forecasts in turn are based on the average forecast across analysts (each of the 50 constituent stocks is covered by roughly 30 analysts). Since forecasts are “sticky”, I study analysts’ revisions over the two-week period following ECB Governing Council meetings (the frequency of revisions fluctuates in sync with the quarterly earnings season; on average, about 22% of all analysts revise their earnings forecasts from one week to the next, while 11% revise their dividend forecasts). Table A4 confirms that results are similar when using shorter or longer (one- to four-week) revision horizons.

D.2 Consensus Economics Forecasts

Forecasts of macroeconomic aggregates are based on monthly surveys from Consensus Economics, covering GDP growth, industrial production growth, the unemployment rate, and CPI and PPI inflation. Besides aggregate euro area figures, forecasts are available for up to eleven individual member states (Germany, France, Italy, Spain, the Netherlands, Austria, Belgium, Finland, Greece, Ireland and Portugal). I define forecast revisions as the difference between the first forecasted value after a Governing Council Meeting and the previous forecast. In the few cases where two announcements took place between the forecasts, I cumulate the shock series.

One important caveat regarding the Consensus data is that the survey schedule overlaps with the day of ECB Governing Council meetings (at least till 2015, see Table A5). In particular, Consensus Economics dispatches its survey on the first Wednesday of every month (i.e. often the day before the ECB meeting) and accepts responses until the following Monday. This is problematic, because survey responses could be sent before or after the policy announcement, invalidating any Granger causality tests. In private correspondence, however, Consensus Economics confirmed that very few participants answer the survey immediately. Most participants reply on Monday, i.e. any news released by the ECB on the previous Thursday ought to be incorporated into their forecasts.

D.3 Macro Dataset

Apart from the five variables included in the benchmark VAR of Section 5, the ECB arguably considers further variables in its decision-making process. Table A9 lists 46 such series, covering exchange rates, confidence indicators, macro aggregates for the four largest euro area member states, and US financial market indicators.²⁶ The benchmark

Table A9: List of Variables

#	Description	tcode
1	EONIA rate	0
2	EURIBOR 3-month rate	0
3	Real effective Euro exchange rate (38 trading partners, CPI based)	1
4	US Dollar per Euro	1
5	Japanese Yen per Euro	1
6	Swiss Franc per Euro	1
7	British Pound per Euro	1
8	Euro STOXX Financial	1
9	Euro STOXX Industrial	1
10	VSTOXX volatility index	0
11	US data: VIX volatility index	0
12	US data: S&P 500 price index	1
13	US data: 10-year sovereign yield	0
14	Euro area high yield option-adjusted corporate spread	0
15	Retail sales volume index	2
16	Construction production index	2
17	Industrial production: consumer durables	2
18	Industrial production: capital goods	2
19	New orders: manufacturing	2
20	New orders: capital goods	2
21	New orders: consumer durables	2
22	Unemployment rate	0
23	Industrial confidence indicator	0
24	Consumer confidence indicator	0
25	Economic sentiment indicator	0
26	Business climate Indicator	0
27	Euro-Coin real time indicator	0
28	HICP: energy	2
29	HICP: food	2
30	HICP: goods	2
31-34	10-year sovereign yield Germany, France, Italy and Spain	0
35-38	Industrial production Germany, France, Italy and Spain	2
39-42	Consumer price index Germany, France, Italy and Spain	2
43-46	Unemployment rate Germany, France, Italy and Spain	0

Note: tcode refers to the applied transformation code (0: levels, 1: log-levels, 2: first log-difference). The sample period for all variables is January 1999 to October 2018. If not otherwise indicated, variables refer to the aggregate euro area.

FAVAR model in Section 5 uses four principal components extracted from this dataset. These four principal components already explain more than 60% of the variance of the

²⁶In principle, the “nonfundamentalness” issue suggests to include as many potentially important variables as possible. Apart from the fact that the number of euro area macro series with a sufficiently long data history is limited, however, Boivin and Ng (2006) show that more data can lead to worse factor estimates, especially when the idiosyncratic errors are cross-correlated.

entire dataset, see Table [A10](#).

Table A10: Fraction of Variance explained by Principal Components

1	2	3	4	5	6	7	8	9	10
26.3%	44.6%	53.5%	61.7%	69.1%	72.8%	75.8%	78.2%	80.4%	82.5%

E Sign Restriction Implementation

Denote by X the $T \times N$ (186×2) matrix containing the purged high-frequency movements x_{it} from Section C.2:

$$\begin{aligned} X &= Z \Pi \\ \begin{matrix} T \times N & T \times N & N \times N \end{matrix} & \\ \iff (2y \text{ yield}, \text{stocks}) &= (Z^{\text{PP}}, Z^{\text{I}}) \begin{pmatrix} \Pi_{2y \text{ yield}}^{\text{PP}} & \Pi_{stocks}^{\text{PP}} \\ \Pi_{2y \text{ yield}}^{\text{I}} & \Pi_{stocks}^{\text{I}} \end{pmatrix} \end{aligned}$$

The sign restrictions are then implemented by generating 2×2 matrices $\hat{\Pi}$, such that

- $\hat{\Pi}_{2y \text{ yield}}^{\text{PP}} > 0$ and $\hat{\Pi}_{2y \text{ yield}}^{\text{I}} > 0$, i.e. both shocks raise the 2-year bond yield
- $\hat{\Pi}_{stocks}^{\text{PP}} < 0$, i.e. a pure policy shock lowers stock prices
- $\hat{\Pi}_{stocks}^{\text{I}} > 0$, i.e. a central bank information shock raises stock prices
- and Z^{PP} and Z^{I} are orthogonal to each other.

In practice, I obtain candidate matrices $\hat{\Pi}$ by applying a QR decomposition to 2×2 matrices drawn from a standard normal distribution.

Having drawn 2000 matrices $\hat{\Pi}$, I apply the median target criterion of [Fry and Pagan \(2011\)](#) to select a unique matrix Π . In particular, I compute the median of each entry across all draws of $\hat{\Pi}$, and select the matrix Π that minimizes the sum of squared deviations from these median values.²⁷

F Bootstrap Algorithm

Since the shock series Z are generated rather than directly observed, I apply a bootstrap procedure to obtain standard errors that incorporate the associated additional uncertainty.²⁸ In particular, for each bootstrap repetition, I

- randomly select $T=186$ time periods τ with replacement from $\tau \in \{1, \dots, T\}$
- collect the high-frequency futures movements $x_{i\tau}$ in matrix \mathbf{X}
 - define \mathbf{Z}^{PN} as the resampled 2-year yield changes (see Section 3.1)
 - obtain \mathbf{Z}^{PP} and \mathbf{Z}^{I} by applying the identification scheme from Section E to \mathbf{X}
- obtain $\hat{\beta}_i^j$ by regressing $\Delta Y_{i\tau}$ on \mathbf{Z}^j , for $j \in \{PN, PP, I\}$, see Equation (1)

²⁷Note that [Cieslak and Schrimpf \(2019\)](#) and [Andrade and Ferroni \(2018\)](#) define Π by averaging matrix entries across all admissible rotations $\hat{\Pi}$. I apply the median target criterion instead to ensure that Π yields exactly orthogonal shocks Z .

²⁸The bootstrap algorithm is identical to the one proposed by [Gürkaynak et al. \(2005\)](#), see their footnote 24. [Swanson \(2017\)](#), in contrast, generates artificial data by resampling residuals from a factor model instead of resampling the observed data.

The bootstrapped standard errors in Section 4 are based on the empirical distribution of $\hat{\beta}_i^j$ using 2000 bootstrap repetitions. To keep the algorithm manageable, I draw only 200 admissible rotations $\hat{\Pi}$ for each bootstrap sample (instead of 2000 for the point estimates, see Section E).

G Results with robust standard errors

The following two tables reproduce Tables 2 and 3 from the main body of the text, but instead of using the bootstrap algorithm from Section F, I follow Andrade and Ferroni (2018) and treat the shocks Z^j from Section 3 as observable regressors and use robust standard errors.

Table A11: Financial Market Reactions

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.	$\hat{\beta}$	s.e.
<i>Nominal Bond Yields</i>	1 year	0.72***	0.13	0.73***	0.20	0.69***	0.17
	2 year	1.00***	0.12	1.00***	0.20	1.00***	0.18
	5 year	0.90***	0.12	0.86***	0.19	0.94***	0.15
	10 year	0.59***	0.09	0.56***	0.16	0.62***	0.13
	30 year	0.33***	0.08	0.28**	0.14	0.40***	0.11
<i>Inflation- Linked Swaps</i>	1 year	-0.00	0.11	-0.15	0.15	0.20**	0.09
	2 year	-0.01	0.11	-0.16	0.14	0.21**	0.09
	5 year	-0.03	0.07	-0.16	0.10	0.15**	0.06
	10 year	0.01	0.04	-0.08	0.06	0.14**	0.06
	30 year	-0.00	0.04	-0.10**	0.05	0.14***	0.05
<i>Stocks</i>	Euro STOXX 50	-1.2	3.6	-18.0***	4.1	20.9***	3.9
	Euro STOXX Banks	1.2	4.6	-20.5***	5.1	29.7***	5.4
	VSTOXX	6.2	11.7	50.3***	16.7	-51.8***	15.0
<i>Exchange Rates</i>	US Dollar	7.7***	1.7	9.5***	2.6	5.3**	2.2
	British Pound	6.4***	1.0	8.1***	1.4	4.1***	1.5
	Swiss Franc	3.8***	1.1	3.4***	1.0	4.3**	1.6
	Japanese Yen	7.2***	2.0	7.3***	2.8	7.2***	2.7
	Chinese Yuan	3.3***	1.3	2.2	2.0	4.8***	1.4

See Table 2 for details.

Table A12: Revisions of Economic Expectations

		Policy News		Pure Policy		Information	
		$\hat{\beta}$	<i>s.e.</i>	$\hat{\beta}$	<i>s.e.</i>	$\hat{\beta}$	<i>s.e.</i>
Euro STOXX 50 Earnings		-0.5	2.4	-5.9*	3.3	7.2***	2.7
Euro STOXX 50 Dividends		1.2	2.0	-3.7	2.7	8.3***	2.8
<i>GDP Growth</i>	Euro area	-0.15	0.30	-0.94**	0.36	0.72	0.50
	Country panel	-0.20**	0.07	-0.99***	0.08	0.67***	0.13
<i>Ind. Prod. Growth</i>	Euro area	-0.15	0.82	-1.79*	0.98	1.74	1.54
	Country panel	-0.67**	0.23	-1.66***	0.32	0.44	0.36
<i>Unemp. Rate</i>	Euro area	0.35*	0.20	0.91***	0.30	-0.28	0.23
	Country panel	0.28**	0.06	0.75***	0.11	-0.25**	0.06
<i>CPI Inflation</i>	Euro area	-0.03	0.21	-0.41	0.27	0.39	0.34
	Country panel	0.00	0.08	-0.55***	0.15	0.61*	0.27
<i>PPI Inflation</i>	Euro area	-0.47	0.59	-1.62***	0.58	0.84	1.13
	Country panel	-0.11	0.09	-0.73*	0.30	0.58**	0.22

See Table 3 for details.

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