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Information effects of euro area monetary policy: New evidence from high-frequency futures data

Mark Kerssenfischer

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

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Non-technical summary

Research Question

Why do central bank announcements move markets? The standard answer is by changing market participants' expectations on current and future monetary policy. A growing body of literature, however, suggests that announcements also reveal information about the central bank's economic outlook, and that these non-monetary news are responsible for a considerable share of the observed market reactions.

Contribution

I study the immediate response of financial markets to ECB announcements using high-frequency futures data. As a naive measure of monetary policy shocks, I use changes in the two-year German bond yield. To distinguish "pure policy" from "central bank information" shocks, I use changes in yields and stock prices and impose the following sign restrictions: if an announcement raises yields because of a contractionary policy surprise, stock prices should decline, because a monetary tightening lowers future expected dividends and raises the discount rate at which those dividends are discounted. If, on the other hand, yields rise because the central bank reveals favourable information about the economic outlook, stock prices should rise.

Results

The naive policy shock measure – which neglects any potential information effects – reproduces many familiar empirical findings. That is, the shock has strong and intuitive effects on bond yields and exchange rates, but puzzlingly small effects on stock prices and economic expectations. The "pure policy" and "central bank information" shocks, by contrast, have intuitive effects on a wide set of financial market prices and survey expectations. Overall, my results suggest that central bank information effects are a key channel through which ECB announcements affect markets.

Nichttechnische Zusammenfassung

Fragestellung

Wieso führen Zentralbankmitteilungen zu erheblichen Reaktionen auf Finanzmärkten? Die Standardantwort ist, dass Marktteilnehmer aufgrund der Mitteilungen ihre geldpolitischen Erwartungen ändern. Eine wachsende Literatur liefert jedoch Hinweise darauf, dass Mitteilungen auch Informationen über die Konjunkturerwartungen der Zentralbank liefern und dass diese nicht-geldpolitischen Neuigkeiten für einen erheblichen Teil der beobachteten Marktreaktionen verantwortlich sind.

Beitrag

Ich untersuche die unmittelbare Reaktion von Finanzmärkten auf Mitteilungen der EZB anhand hochfrequenter Daten zu Terminkontrakten. Als naives Maß für geldpolitische Schocks benutze ich die Renditeänderung zweijähriger deutscher Staatsanleihen. Um rein geldpolitische Schocks von sogenannten „Zentralbankinformationsschocks“ zu trennen, benutze ich Rendite- und Aktienpreisänderungen und erlege folgende Vorzeichenrestriktionen auf: Wenn eine Zentralbankankündigung Renditen aufgrund kontraktiver Geldpolitik erhöht, sollten Aktienpreise fallen, da eine geldpolitische Straffung zukünftig erwartete Dividenden senkt und den Diskontfaktor erhöht, mit dem diese Dividenden abgezinst werden. Wenn Renditen hingegen steigen, weil die Zentralbank unerwartet positive Informationen über den Konjunkturausblick veröffentlicht, sollten Aktienpreise steigen.

Ergebnisse

Mit Hilfe des naiven Maßes für geldpolitische Schocks – welches potenzielle Informationseffekte außer Acht lässt – lassen sich viele bekannte empirische Befunde replizieren: Der Effekt von Geldpolitik auf Zinsen und Wechselkurse ist stark und entspricht der ökonomischen Intuition, der Effekt auf Aktienpreise und Konjunkturerwartungen ist jedoch überraschend gering. Die rein geldpolitischen Schocks und „Zentralbankinformationsschocks“ haben hingegen intuitive Effekte auf ein breites Spektrum von Finanzmarktpreisen und Umfrageergebnissen zu Konjunkturerwartungen. Insgesamt legen meine Ergebnisse nahe, dass Mitteilungen der EZB ihre Wirkung auf Finanzmärkte zu einem erheblichen Teil dadurch entfalten, dass sie Rückschlüsse auf die Konjunkturerwartungen der EZB zulassen.

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

Mark Kerssenfischer
Deutsche Bundesbank

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Abstract

Central bank announcements move financial markets. The response of inflation and growth expectations, on the other hand, is often small or even counterintuitive. 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 and survey measures of economic expectations.

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

JEL classification: E52, E44, E32, C32.

*Contact address: Deutsche Bundesbank, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, Germany. Email: mark.kerssenfischer@bundesbank.de. I am grateful to Michele Piffer for helpful suggestions. 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

A major advance in the quest to identify monetary policy shocks is the use of financial market data. The high frequency of this data, namely, allows researchers to focus on a narrow window around central bank announcements, ensuring that any market movements within these windows are solely due to (the unexpected part of) the announcements. Using this basic 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 these effects are driven solely by revised expectations about monetary policy. After a supposedly contractionary shock – 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. If an announcement indicates revisions to the central bank's outlook and induces revisions to private sector expectations in the same direction, this can lead to counterintuitive results. An announcements 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 positive "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 strong and sharply different effects on economic expectations. In particular, a rate rise that is due to a contractionary policy shock prompts downward revisions to growth and inflation expectations, in line with basic monetary theory. An analogous rate rise triggered by a central bank information shock, in contrast, leads to upward revisions in survey expectations. What both shocks have in common, lastly, is their hump-shaped effect along the yield curve and the exchange rate response they trigger. As expected a priori, both a contractionary tightening and an improved domestic

[1] For US evidence, see Kuttner (2001); Cochrane and Piazzesi (2002); Gürkaynak, Sack, and Swanson (2005); Bernanke and Kuttner (2005); 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).

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

outlook lead to a strong appreciation of the euro.

My paper adds to a growing literature which is seeking to isolate non-monetary components from central bank announcements empirically. Jarocinski and Karadi (2018) apply the above-mentioned sign restrictions to high-frequency yield and stock price changes in a VAR framework to estimate the dynamic macroeconomic effects of policy announcements in the US and the euro area. Andrade and Ferroni (2018), similarly, use 2-day changes in inflation-linked swaps to decompose the information content of ECB announcements. They impose a negative response of inflation swaps to pure policy shocks and a positive response to central bank information shocks (which they label "Delphic forward guidance"). Cieslak and Schrimpf (2018), 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 ECB announcements. The bond data offers two main advantages over money market swap rates. First, the data is based on actual trades on a centralized exchange instead of indicative quotes in the OTC market and second, German 2-year yields are less affected by the lower bound problem.[4]

In total, I study all 186 scheduled ECB Governing Council meetings (GCMs) between March 2002 and December 2018. On each of these dates, 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. On regular meeting days, the press release at 13:45 (CET) announces the policy rate decision, 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.

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

[3] An 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.

[4] Jarocinski 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.

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

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.

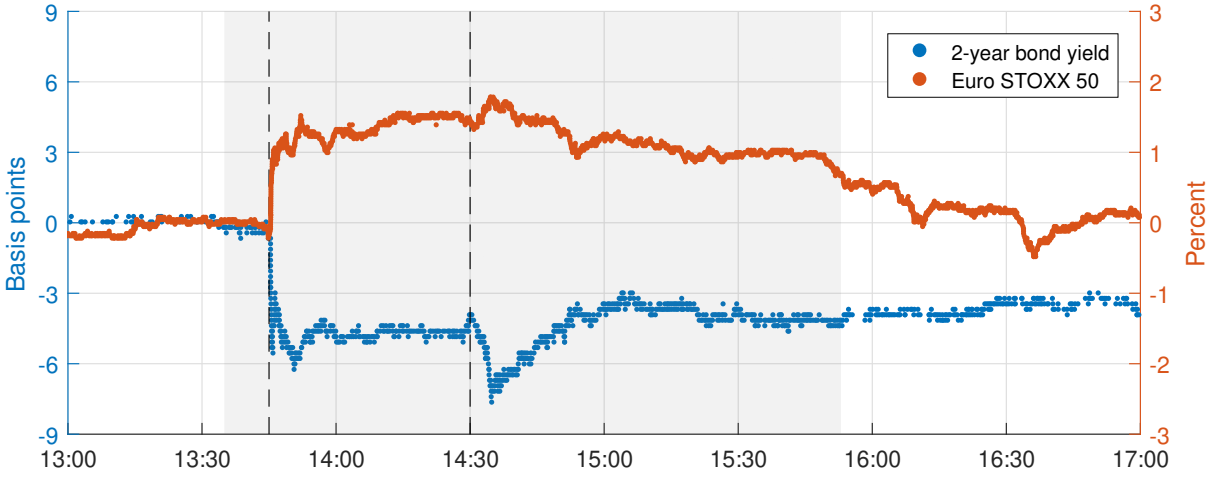
3 Identification

I will employ two different identification schemes, see Table 1.

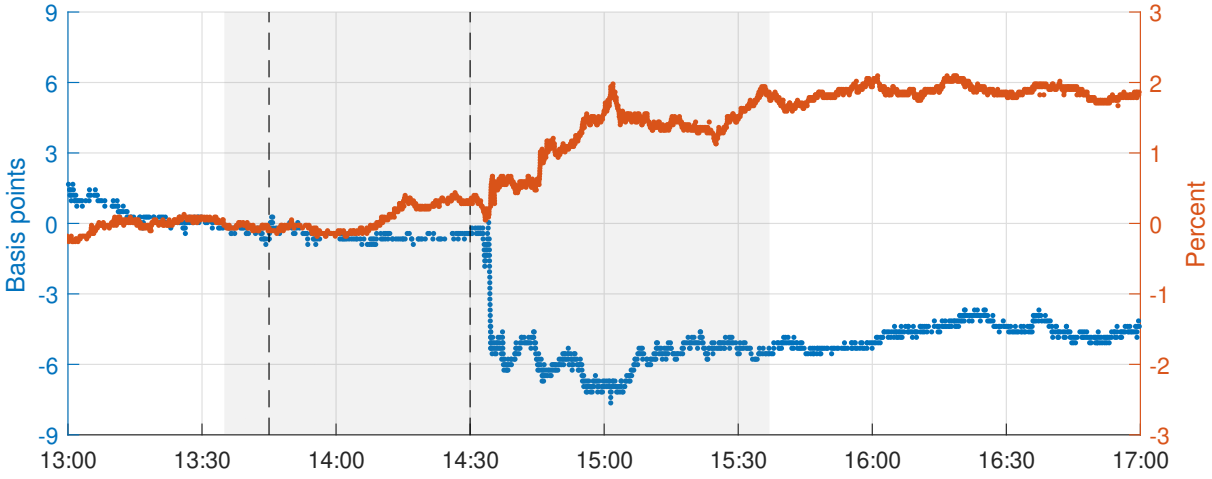
In both cases, monetary policy is treated as one-dimensional. This is of course an oversimplification, but the identification schemes should be valid regardless of the specific policy tools. That is, any contractionary policy surprise – whether it concerns the current policy rate, the future path of rates, or unconventional measures like QE – should raise bond yields and lower stock prices.[6] The drawback of this approach, naturally, is that it

[6]In addition to "target" and "path" or "decision" and "communication" factors (see Gürkaynak et al., 2005; Brand et al., 2010; Leombroni et al., 2016), Swanson (2017) and Altavilla et al. (2018) argue that

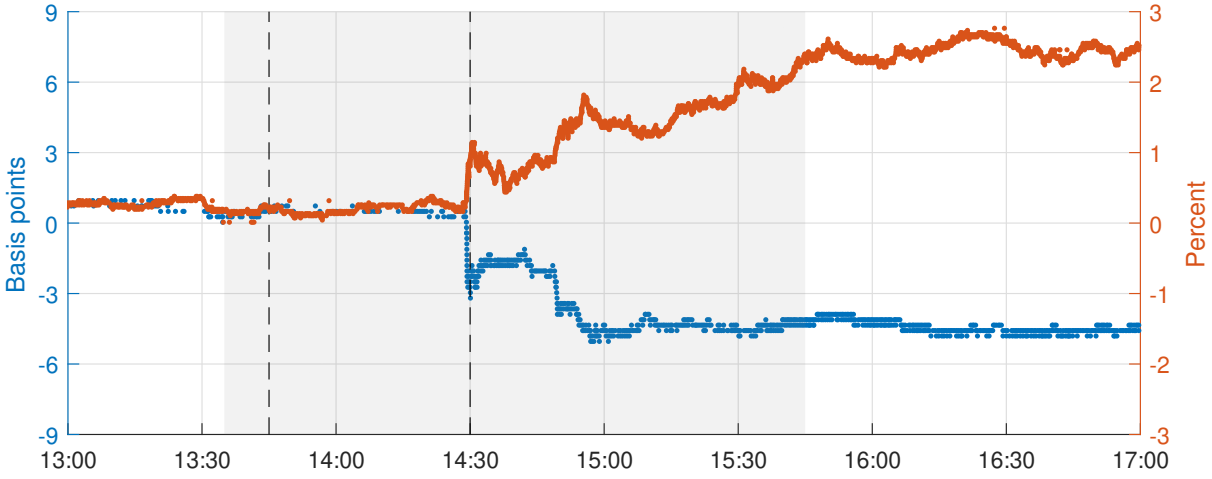
Figure 1: Examples of Expansionary Monetary Policy Surprises



(a) Governing Council Meeting on 7 November 2013



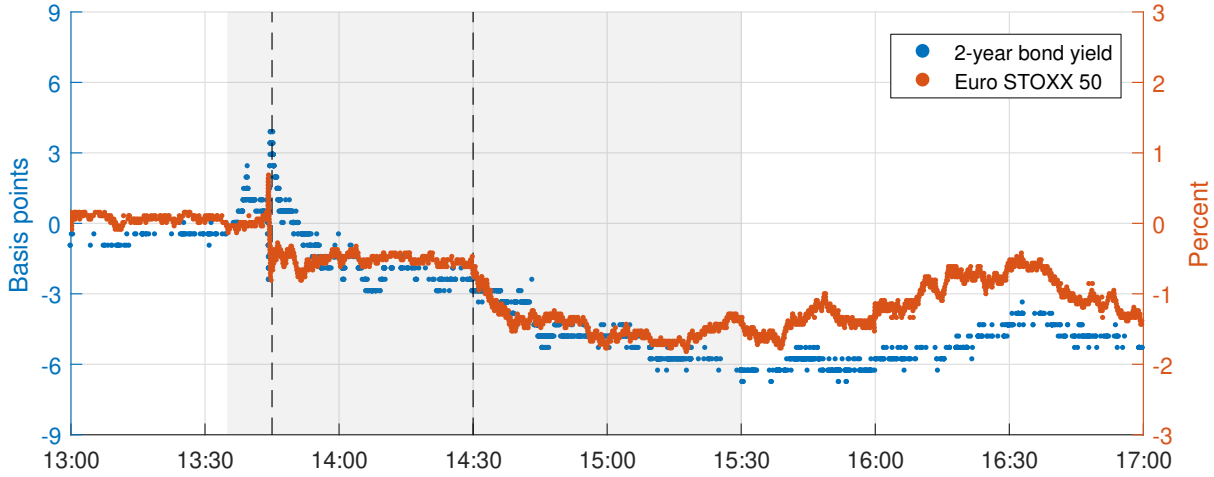
(b) Governing Council Meeting on 4 July 2013



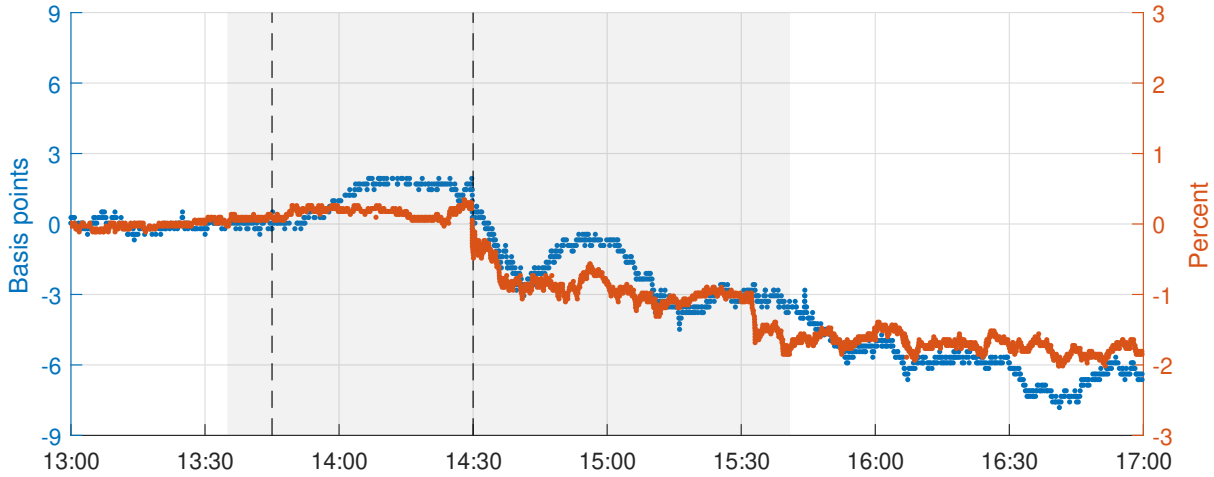
(c) Governing Council Meeting on 22 October 2015

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 press conference start at 14:30. The grey area indicates the event window.

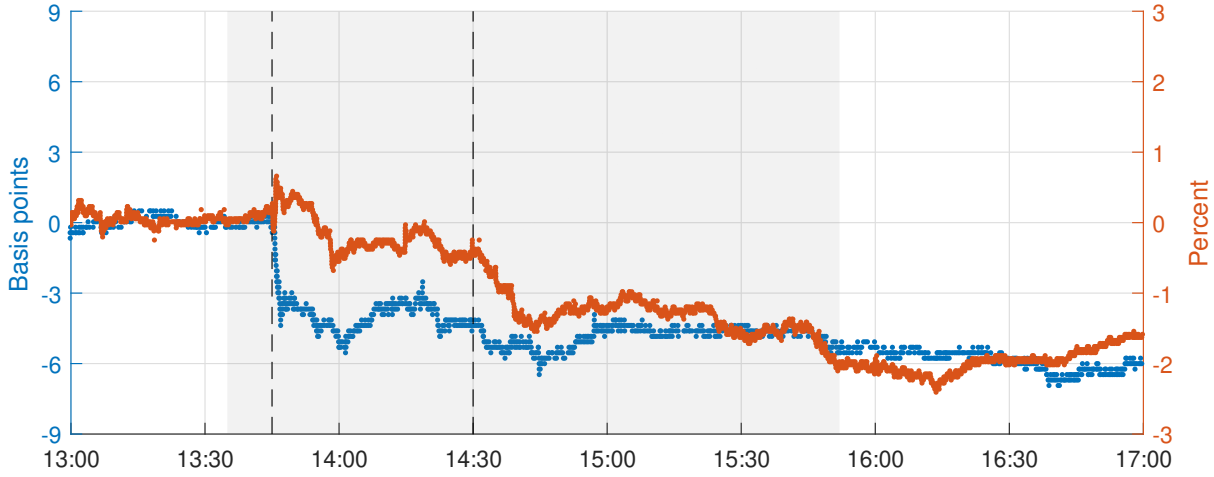
Figure 2: Examples of Adverse Central Bank Information Surprises?



(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}
High-frequency changes	2-year yield	$\widehat{=}$	+	+
	Stock prices		−	+

does not allow to quantify the relative effectiveness of different types of policies.

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, Z^{PN} should be a good proxy for monetary shocks, i.e. any increase in the 2-year yield should be tantamount to a contractionary shock that should reduce stock prices, expected inflation, and expected real activity. In Section 4, I will add to the growing literature that fails to find such clear-cut effects.

3.2 Pure Policy and Information Shocks

One possible explanation for these seemingly puzzling results are central bank information effects. In particular, if policy announcements reveal information about the economic outlook, a yield increase might simply reflect an improved outlook, thus raising stock prices along with inflation and growth expectations.

To tell the two dimensions of policy announcements apart, I follow Jarocinski and Karadi (2018) and impose sign restrictions on the high-frequency market movements. In particular, a "pure policy" shock Z^{PP} that raises yields should lower stock prices, due to both a higher discount rate and lower expected dividends. An "information" shock Z^{I}, on the other hand, raises interest rates because it signals an improved economic outlook and should thus be accompanied by rising stock prices.[7]

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.

an additional "QE factor" is needed to fully characterize recent monetary policy in the US and the euro area, respectively. The effect on 2-year bond yields and stock prices, however, is qualitatively the same for all these different factors, in line with the examples from Figure 1.

[7] In 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:[8]

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

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 intuitive 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 the ECB tightens policy.

Why do policy news shocks have strong and intuitive effects on bond yields and exchange rates, while the response of inflation expectations and stock prices is largely muted? "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.

A common concern regarding the financial market responses shown thus far 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 only expected inflation over the contract horizon, but also risk premia. Their subdued response to policy news shocks Z^{PN} could thus be consistent with expected

[8] Henceforth, $*/**/***$ denotes significance at the 10/5/1% level, based on bootstrapped standard errors that take into account both estimation and identification uncertainty. Appendix F explains the employed bootstrap procedure and 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.*
Nominal Bond Yields	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
Inflation-Linked Swaps	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
Stocks	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
Exchange Rates	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.

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.[9]

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.[10]

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

[9]The 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, 2018).

[10]Appendix 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
GDP Growth	Euro area	-0.15	0.31	-0.94***	0.39	0.72	0.52
	Country panel	-0.20	0.31	-0.99***	0.40	0.67	0.51
Ind. Prod. Growth	Euro area	-0.15	0.87	-1.79*	1.06	1.74	1.60
	Country panel	-0.67	0.68	-1.66***	0.76	0.44	1.19
Unemp. Rate	Euro area	0.35*	0.21	0.91***	0.33	-0.28	0.25
	Country panel	0.28*	0.16	0.75***	0.25	-0.25	0.23
CPI Inflation	Euro area	-0.03	0.22	-0.41	0.28	0.39	0.35
	Country panel	0.00	0.26	-0.55**	0.26	0.61	0.48
PPI Inflation	Euro area	-0.47	0.59	-1.62**	0.64	0.84	1.11
	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.

are insignificant and economically rather small.[11]

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.[12]

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 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

[11] Recall 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.

[12] Also 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.

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.[13]

5 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, any 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 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.

[13] 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.

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.[14]

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.*
Nominal Bond Yields	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.

[14] Yields 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	
	$\hat{\beta}$	*s.e.*	$\hat{\beta}$	*s.e.*	$\hat{\beta}$	*s.e.*
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.

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.[15] 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 preponed 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.[16] 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 $\hat{D}_t$

[15] See www.ecb.europa.eu/press/pr/date/2014/html/pr140703_1.en.html

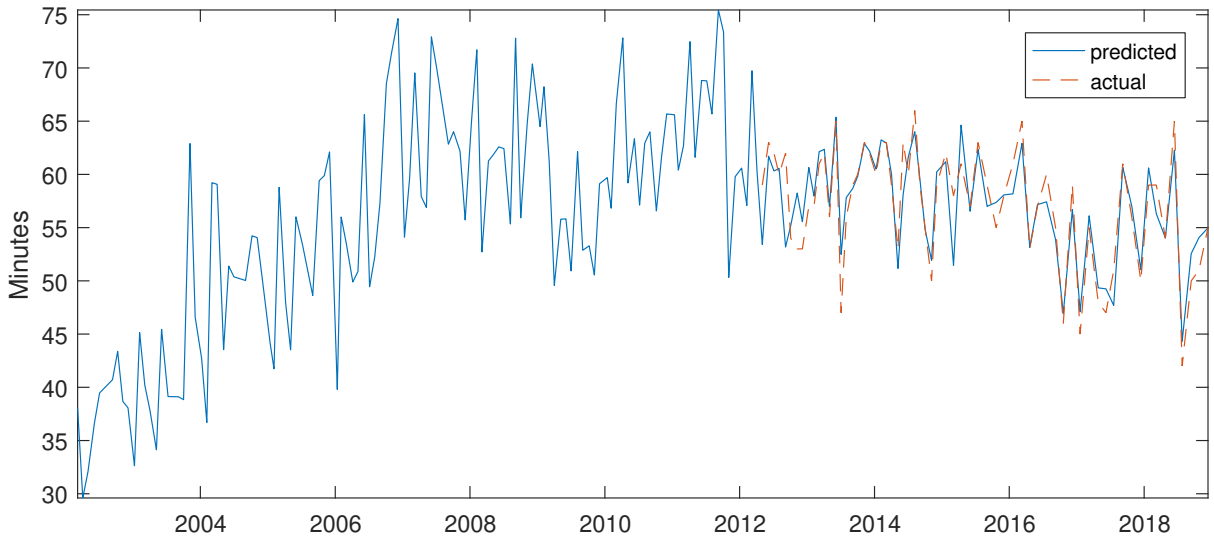
[16] Up until 2014, press releases only announced policy rate decisions. In January and December 2015, the releases contained an additional note that "*further monetary policy measures will be communicated [..] at [the] press conference [..] today*" (in the ensuing press conferences, the introduction 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:[17]

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

where $\#Words$ is the number of words in each press conference transcript. The regression yields an R^2 of 78% and, as Figure A1 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 A1: Length of ECB Press Conferences



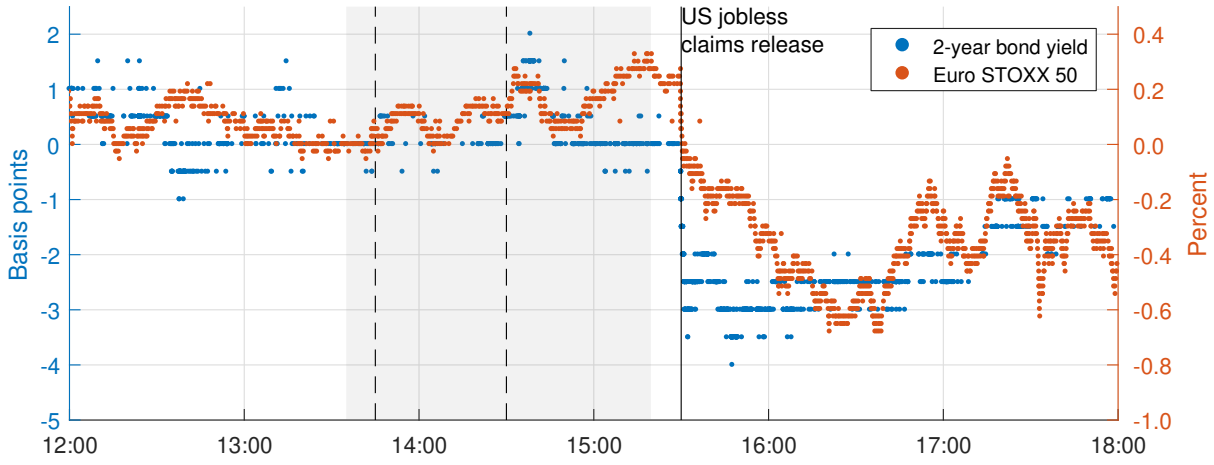
The dashed red line shows the actual length of all press conferences for which a video recording is available. The solid blue line shows the predicted press conference length based on the number of words in the respective conference transcript.

Figure A2, 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).[18] 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

[17] Video 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.

[18] In 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 A2: Intraday Futures Data on 4 April 2002

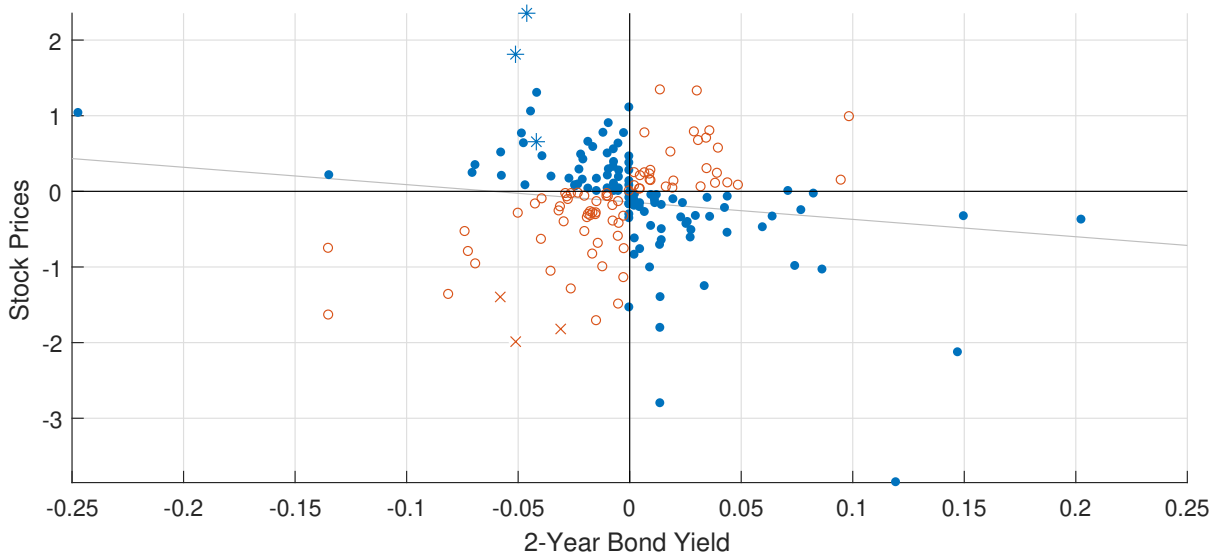


The grey area indicates the event window from 13:35 to 15:20 (CET), i.e. 10 minutes prior to the press release and 20 minutes after the end of the press conference. At 15:30, unexpectedly high US initial jobless claim numbers were released.

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 A3 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 A3: 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

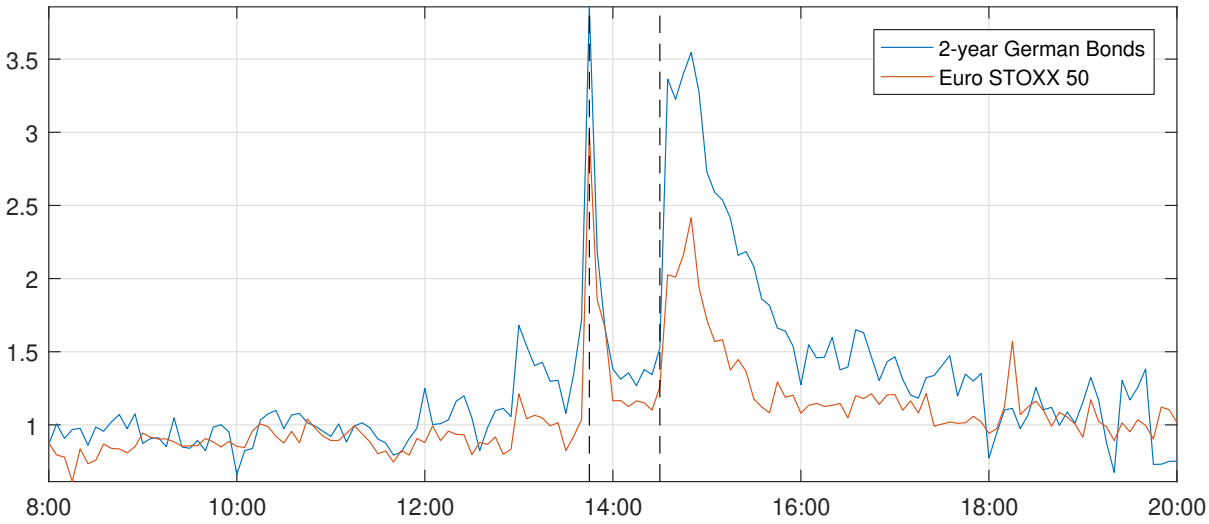
The core of my analysis is based on tick-by-tick data on two futures traded on the derivatives exchange Eurex, see Table A6.[19]

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 A4 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 A4: 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.

[19]For 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 13:45), 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

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

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

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

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.[20] 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 A2 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:

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

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.

[20] Since 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		
	$\hat{\Theta}$	*s.e.*	$\hat{\Theta}$	*s.e.*	# releases in event windows
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.

Furthermore, during all but six of the 186 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 are the release that most frequently coincide with ECB announcements.

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

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

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	
	$\hat{\Theta}$	*s.e.*	$\hat{\Theta}$	*s.e.*
Constant	0.05**	0.02	0.95	0.69
Output				
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 **??**, lastly, lists the monthly macroeconomic variables I use to extract principal components for the FAVAR estimation in Section **??**.

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.

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:

$$\underset{T\times N}{X} = \underset{T\times N}{Z} \quad \underset{N\times N}{\Pi}$$

$$\iff \text{(2y yield, stocks)} = (Z^{\text{PP}}, Z^{\text{I}}) \begin{pmatrix} \Pi^{\text{PP}}_{2y\,yield} & \Pi^{\text{PP}}_{stocks} \\ \Pi^{\text{I}}_{2y\,yield} & \Pi^{\text{I}}_{stocks} \end{pmatrix}$$

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

- $\hat{\Pi}^{\text{PP}}_{2y\,yield} > 0$ and $\hat{\Pi}^{\text{I}}_{2y\,yield} > 0$, i.e. both shocks raise the 2-year bond yield
- $\hat{\Pi}^{\text{PP}}_{stocks} < 0$, i.e. a pure policy shock lowers stock prices
- $\hat{\Pi}^{\text{I}}_{stocks} > 0$, 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.[21]

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.[22] In particular, for each bootstrap repetition, I

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

[21] Note that Cieslak and Schrimpf (2018) 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.

[22] The 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 A9: Financial Market Reactions

		Policy News		**Pure Policy**		**Information**	
		$\hat{\beta}$	*s.e.*	$\hat{\beta}$	*s.e.*	$\hat{\beta}$	*s.e.*
Nominal Bond Yields	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
Inflation-Linked Swaps	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
Stocks	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
Exchange Rates	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 A10: 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*	3.3	7.2***	2.7
Euro STOXX 50 Dividends		1.2	2.0	-3.7	2.7	8.3***	2.8
GDP Growth	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
Ind. Prod. Growth	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
Unemp. Rate	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
CPI Inflation	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
PPI Inflation	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.

References

Altavilla, C., L. Brugnolini, R. Gürkaynak, G. Ragusa, and R. Motto (2018). Measuring euro area monetary policy. *ECB Working Paper forthcoming*.

Andrade, P. and F. Ferroni (2018, July). Delphic and Odyssean Monetary Policy Shocks: Evidence from the Euro Area. Working Paper Series WP-2018-12, Federal Reserve Bank of Chicago.

Bernanke, B. S. and K. N. Kuttner (2005, 06). What Explains the Stock Market's Reaction to Federal Reserve Policy? *Journal of Finance 60*(3), 1221–1257.

Bohl, M. T., P. L. Siklos, and D. Sondermann (2008). European Stock Markets and the ECB's Monetary Policy Surprises. *International Finance 11*(2), 117–130.

Brand, C., D. Buncic, and J. Turunen (2010). The impact of ECB monetary policy decisions and communication on the yield curve. *Journal of the European Economic Association 8*(6), 1266–1298.

Campbell, J. R., C. L. Evans, J. D. Fisher, and A. Justiniano (2012). Macroeconomic effects of federal reserve forward guidance. *Brookings Papers on Economic Activity 2012*(1), 1–80.

Campbell, J. R., J. D. Fisher, A. Justiniano, and L. Melosi (2017). Forward guidance and macroeconomic outcomes since the financial crisis. *NBER Macroeconomics Annual 31*(1), 283–357.

Cieslak, A. and A. Schrimpf (2018). Non-Monetary News in Central Bank Communication. *NBER Working Paper 25032*.

Cochrane, J. H. and M. Piazzesi (2002, May). The Fed and Interest Rates - A High-Frequency Identification. *American Economic Review 92*(2), 90–95.

Ehrmann, M. and M. Fratzscher (2009). Explaining monetary policy in press conferences. *International Journal of Central Banking*.

Fry, R. and A. Pagan (2011). Sign restrictions in structural vector autoregressions: A critical review. *Journal of Economic Literature 49*(4), 938–60.

Gilchrist, S., D. Lopez-Salido, and E. Zakrajsek (2015, January). Monetary policy and real borrowing costs at the zero lower bound. *American Economic Journal: Macroeconomics 7*(1), 77–109.

Gürkaynak, R., B. Sack, and E. Swanson (2005). Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking 1*(1), 55–93.

Hanson, S. G. and J. C. Stein (2015). Monetary policy and long-term real rates. *Journal of Financial Economics 115*(3), 429–448.

Jarocinski, M. and P. Karadi (2018, March). Deconstructing Monetary Policy Surprises - The Role of Information Shocks. CEPR Discussion Papers 12765, C.E.P.R. Discussion Papers.

Kane, A., J. Rogers, and B. Sun (2017). Communications Breakdown: The Transmission of Different Types of ECB Policy Announcements. Technical report.

Kuttner, K. N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of Monetary Economics 47*(3), 523 – 544.

Leombroni, M., A. Vedolin, G. Venter, and P. Whelan (2016). Central bank communication and the yield curve. Technical report.

Miranda-Agrippino, S. (2016). Unsurprising Shocks: Information, Premia, and the Monetary Transmission. Discussion Papers 1613, Centre for Macroeconomics (CFM).

Nakamura, E. and J. Steinsson (2018). High frequency identification of monetary non-neutrality: The information effect. *The Quarterly Journal of Economics*.

Rogers, J. H., C. Scotti, and J. H. Wright (2014). Evaluating asset-market effects of unconventional monetary policy: a multi-country review. *Economic Policy 29*(80), 749–799.

Romer, C. D. and D. H. Romer (2000, June). Federal reserve information and the behavior of interest rates. *American Economic Review 90*(3), 429–457.

Swanson, E. T. (2017). Measuring the Effects of Federal Reserve Forward Guidance and Asset Purchases on Financial Markets. Technical report.