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Does publication of interest rate paths provide guidance? ☆

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ABSTRACT

Does the central bank practice of publishing interest rate projections (IRPs) improve how market participants map new information into future interest rates? Using high-frequency data on forward rate agreements (FRAs) we compute *market forecast errors*; differences between expected future interest rates and ex-post realizations. We assess their change in narrow windows around monetary policy announcements and macroeconomic releases in Norway and Sweden. Overall, communication of future policy plans does not improve markets' response to information, irrespective of whether or not IRPs are in place. A decomposition of market reactions into responses to the current monetary policy action ("target") and responses to signals about the future ("path"), reveals that only policy actions lead to improvements in market forecasts.

1. Introduction

The practice of publicly communicating future policy intentions, forward guidance, is by now widespread among central banks. Communication strategies take different forms, from loosely indicating future policy options through speeches, to the more explicit form of describing the central bank's planned conditional course of action through published interest rate projections (IRPs). The latter form has now been pursued by New Zealand, Norway and Sweden for more than a decade.

As a conceptual simplification, we find it useful to distinguish between two main motives for this development.[1] First, by announcing a plan for future policy rates the central bank might directly affect long-term interest rates. Communication can then be justified as a means to control more than just short-term rates, a rationale that is particularly relevant close to the zero-lower bound. Second, statements about future plans, coupled with explanations of the considerations behind them, may serve to improve market participants' understanding of the central bank's systematic reaction pattern. Here communication is motivated as a means to sharpen the effectiveness of monetary policy's systematic component by improving market

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[1] In practice these two motives are closely connected and likely to be simultaneously at play, but for the purpose of disseminating and evaluating the rationale behind policy communication, we believe the distinction is useful. Blinder et al. (2008) articulate a similar distinction, separating between "creating news" and "reducing noise".

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participants' ability to map current information into likely monetary policy consequences. The following statement by Ben Bernanke, then Chairman of the Board of Governors of the Federal Reserve System, is illustrative of this second motivation: "I believed then, as I do today, that transparency enhances public understanding [...] and ultimately makes policy more effective by tightening the linkage between monetary policy, financial conditions, and the real economy" (Bernanke, 2013).

The trend toward more explicit policy communication by central banks has been followed by careful empirical studies to analyze its consequences. This literature has largely been oriented toward the first of the two motives above, and has documented that central bank communication actually does affect market rates. However, little is known about the extent to which communication serves its second rationale; to improve markets' understanding of the central bank's reaction pattern. In this paper, we are more oriented toward this second motivation, as we explore how the practice of publishing interest rate projections (IRPs) has influenced market participants' ability to forecast interest rates.

Our empirical strategy is to study market interest rate reactions in tight windows around monetary policy announcements and other macroeconomic releases in Norway and Sweden. These two countries are particularly well suited for our purposes since they introduced IRPs within otherwise stable monetary policy regimes of inflation targeting. Moreover, with a difference-in-differences approach, we contrast market reactions in Norway and Sweden, which began to publish IRPs in 2005 and 2007 respectively, to market reactions in New Zealand and Canada which both have targeted inflation over our sample period, but have not introduced IRPs in this time frame.[2]

Our starting point is to back out market expectations of future 3-month interest rates from forward rate agreements (FRAs). We next compute the markets' forecast errors (MFEs) at four different horizons up to one year ahead, by comparing these expectations to the actual realizations of each respective 3-month interest rate. Following earlier literature, we study if markets reacted to announcements of monetary policy and various macroeconomic releases, but we also move one step further and ask if the reactions were in the right direction: did the announcements serve to improve market participants' ability to forecast future monetary policy?

To fix ideas, we anticipate our analysis and display in Fig. 1 how MFEs have responded to a variety of announcements. The graphs show two-year rolling regressions estimates, together with two standard deviation error bands, of the impact of macroeconomic releases and monetary policy announcements, on MFE-changes occurring within thirty-minute windows around each announcement.[3] Overall, monetary policy announcements and macroeconomic releases tend to reduce MFEs and hence move market interest rate expectations toward ex-post realizations. The vertical lines in Fig. 1 mark the introduction of IRPs. Our question is if communication of future policy intentions through IRPs stimulated this tendency toward MFE reductions.

Fig. 1 suggests that there might have been improved market reactions in Sweden, but not in Norway. Further analysis provides two perspectives on this difference. First, for other releases than the monetary policy decision, such as the monthly updates on consumer price inflation, there is no sign in either country that the presence of IRPs improved market reactions. The improvements in Sweden are present only for responses to monetary policy announcements.

Second, whenever monetary policy announcements have reduced MFEs in either Norway or Sweden, this has occurred via market reactions to implemented policy actions, not via reactions to communication of future policy intentions. We reach this conclusion after using the approach of Gürkaynak et al. (2005) to distinguish market reactions to implemented policy from communication of future policy intentions. This method, by now the workhorse for empirical work on forward guidance, decomposes market reactions to monetary policy announcements into a target and a path factor. The former captures movements in the current short-term interest rate level, while the latter captures longer-term interest rate movements that are orthogonal to the short-term rate. Hence, the target factor can be interpreted as the market response to monetary policy actions, while the path factor can be interpreted as responses to communication of future intentions that cannot be inferred from implemented policy. In the Norwegian and Swedish data, one observes substantial reactions through both the path and target factors when monetary policy decisions are announced.

Strikingly though, the path-reactions do *not* generally serve to reduce forecast errors, neither before nor after IRPs were introduced in either country. Hence, communication of future policy intentions that cannot be inferred from current actions alone, have not served to reduce forecast errors. The practice of publishing IRPs has not changed this pattern.

The common finding across time and our two countries, is that when monetary policy announcements have reduced MFEs, this has occurred via the target factor only. In Norway this occurred already before interest rate projections were utilized, and the strength with which target reactions reduced forecast errors did not change after interest rate projections were introduced. In Sweden, in contrast, this effect is only present after the Riksbank began to publish interest rate projections, not before. It thus seems that it is the two central banks' *actions* that has mattered for markets' forecast errors. Regarding why the target factor began to reduce forecast errors in Sweden after they introduced IRPs, we can only speculate. A plausible explanation might be that in Sweden, the introduction of IRPs in 2007 improved the central bank's explanations of its current policy actions. In Norway, the current actions gave reduced forecast errors already before IRPs came into use, which might be why the introduction of IRPs in 2005 did not improve markets' understanding of policy actions any further. Arguably, explanation of current actions does not require the publication of future policy intentions.

[2] New Zealand has published IRPs throughout our sample period, Canada has yet not introduced IRPs. Note that we cannot focus on New Zealand alone, because we lack high-frequency data before it introduced IRPs in 1997, and because its policy regime changed after IRPs were introduced.

[3] The estimates are obtained by pooling all releases as in Swanson and Williams (2014), and each estimate is centered on the respective release, using data one year back and one year forward. Further details are provided in the appendix' Section B.

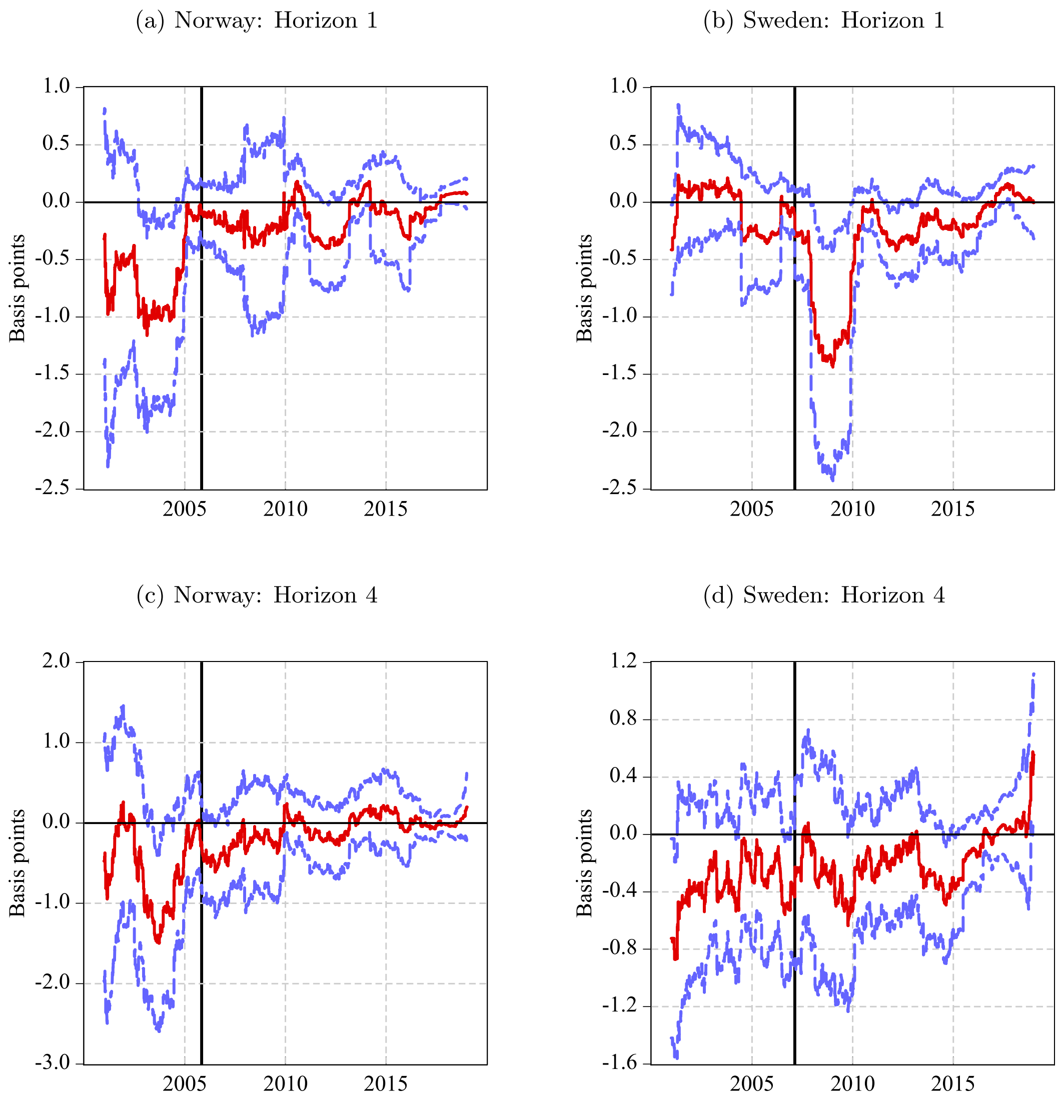

Fig. 1. Time varying response of Market Forecast Errors (MFEs) to macro releases and monetary policy announcements.
Notes: Daily centered two-year rolling-window estimates of how market forecast errors (MFEs) respond to released macroeconomic data and monetary policy announcements, pooled. MFEs computed as the gap between ex-post realized interest rates and corresponding 1- and 4-quarter forward rate agreements (FRAs) traded previously. Changes in MFEs are computed as the difference between MFEs immediately before a release and 30 min after. Negative numbers indicate reduced forecast errors. Estimation based on the method proposed by Swanson and Williams (2014). The bands cover two standard errors around each point estimate. Sample: January 2000 - March 2019.

Our use of high-frequency interest rate futures data to capture market expectations about monetary policy dates back to Guthrie and Wright (2000) and Kuttner (2001). Gürkaynak et al. (2005) followed in their footsteps when decomposing market reactions into target and path factors. They found that both actions and statements about future policy influence asset prices, and particularly that statements have greater influence on long-term Treasury yields. Campbell et al. (2012) have later utilized this same decomposition, finding similar effects of FOMC statements right up until and well into the financial crisis, concluding that statements can influence market rates even when one is close to or at the zero-lower-bound. They also argue that these reactions are driven by perceptions that the central bank has superior knowledge about the underlying state of the economy, rather than that statements commit policymakers to a future course of action.

In a related paper, Brubakk et al. (2017) have recently approached the Norwegian and Swedish data in similar spirit, asking if the path factor shifts when the two countries' central banks announce new interest rate projections. Brand et al. (2010) and Leombroni et al. (2017) distinguish communication from actions more directly, by separating market reactions to ECBs publication of current policy decisions from market reactions to ECBs press conference 45 minutes later. All these studies find considerable reactions to communication.[4]

While our paper shares the above literature's focus on high-frequent market reactions, our analysis differs by asking if policy communication guides markets to *improved* interpretation of available information, rather than just asking if communication *shifts* market rates.

Our focus on market participants' ability to predict future policy rates is shared by Kool and Thornton (2012). They use survey forecasts and evaluate if these forecast were improved after forward guidance was introduced, finding moderately improved forecastability over short horizons in Norway and Sweden. We use high-frequency traded FRAs, rather than infrequent survey data, to measure market expectations. Not only do the FRAs reliably capture market expectations because they are actually traded upon, but their high frequency allows us to credibly estimate how market expectations react to released information. Beechey and Österholm (2014) also use expectations inferred from market data. They evaluate the forecasting properties of central bank IRPs and market participants' forecasts at the same time, and find that they share similar properties of biasedness, (in-) efficiency and low forecast precision.

The theoretical literature on forward guidance provides ample motivation for our study. Woodford (2001) discusses general advantages of having the central bank communicate its policy intentions, arguing that transparency is key to policy effectiveness. Rudebusch and Williams (2008) argue, within a New Keynesian model with incomplete information, that a central bank that publishes interest rate projections can improve welfare by informing market participants about the central bank's reaction function. The reason is that IRPs guide private agents to better map observed macroeconomic events into future interest rate consequences. On the other hand, Morris and Shin (2002) formalize the concern that central bank communication might prevent private agents from utilizing other sources of information, which brings even the theoretical benefits of IRP publication into question.[5]

Overall, our results indicate that the practice of publishing interest rate projections has not improved markets' understanding of what new macroeconomic information implies for future interest rates. However, our findings do not support the Morris and Shin hypothesis either, as market forecasts have continued to be improved by macroeconomic releases to approximately the same extent after IRPs became available, as before. Hence, we do not contend that the publication of interest rate projections has distorted markets. Rather, our evidence more neutrally establishes that so far, the observed communication of future policy intentions through IRPs has not guided markets to better anticipate how interest rates will be set in the future.

In what follows, Section 2 describes our data and the institutional settings behind them. In Section 3 we study market reactions to monetary policy announcements, while in Section 4 we consider macroeconomic releases. Section 5 concludes.

2. Interest Rates and Monetary Policy in Norway, Sweden, New Zealand, and Canada

We will study the role of central bank forecasts in Norway and Sweden, using New Zealand and Canada as controls in an extension. These countries are all (relatively) small open economies, which have been under an inflation targeting monetary policy regime over our entire sample period, spanning January 2000 throughout March 2019.

2.1. Institutional Setting

Norges Bank began to publish its own forecast for the key policy rate (the sight deposit rate) on November 2, 2005, while Sveriges Riksbank followed by publishing its own IRP for its key policy rate (the repo rate) on February 15, 2007. Forecast horizons have varied somewhat, typically between 12 and 15 quarters for Norges Bank and up to three years for the Riksbank.

In both Norway and Sweden, the policy rate forecasts are conditional on macroeconomic projections based on economic models together with judgment by the Monetary Policy Committee, and published in Monetary Policy Reports following an interest rate decision. The forecasts are for quarterly averages of the key policy rate. Over our sample period, both countries have primarily emphasized inflation and output gaps as their main target variables, but they increasingly emphasized financial stability toward the end of our sample.

A key difference between the two institutions is that the Riksbank has accompanied every policy rate announcement with an updated IRP, while Norges Bank publish their IRP somewhat less frequently. Currently, the Riksbank decides on its policy rate six times a year, but this frequency has varied up to eight per year in our sample period. Until 2013, Norges Bank published interest rate projections three times per year, usually in March, June and October. Since 2013, Norges Bank has published its IRP four times a year while it makes 6 interest rate decisions per year. Over our sample period, the frequency of Norges Bank's interest rate decisions has varied from six to ten per year. Both the Riksbank and Norges Bank publish confidence bands together with their point forecasts.[6]

[4] A full survey of the literature on how central bank communication affects interest rates is beyond the scope of this paper. For an early summary of studies in the field, tending to find that communication affects interest rates, see Blinder et al. (2008).

[5] Svensson (2006) show that this result is overturned if the central bank has somewhat precise information.

[6] For further details on monetary policy and interest rate projections in Norway and Sweden, see Holmsen et al. (2008) and Riksbank (2017) respectively.

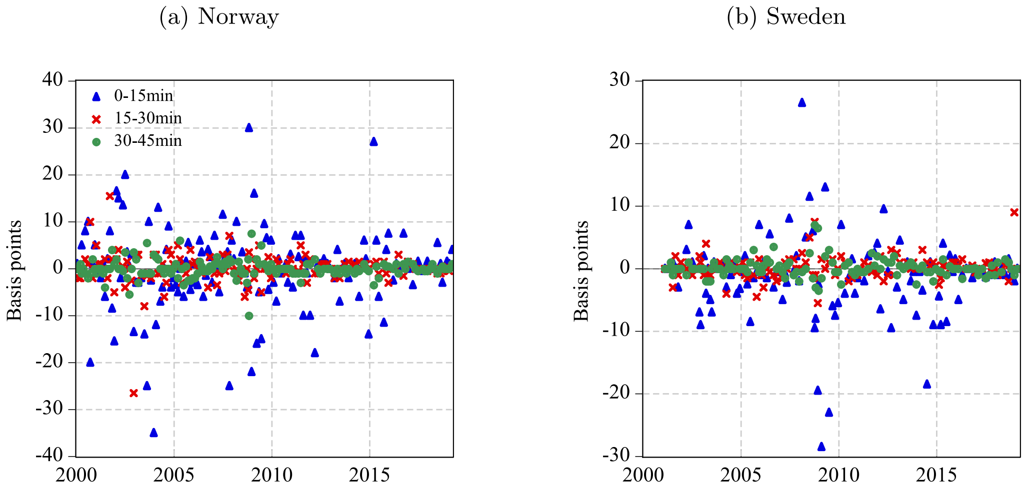

Fig. 2. Alternative window-lengths for measuring market reactions after monetary policy releases.
Notes: Movements of 1-year forward rate agreements (FRAs) after monetary policy announcements in Norway and Sweden. The responses are computed from immediately before to 15 min after, from 15 to 30 min after, and from 30 to 45 min after each monetary policy announcement. Sample: January 2000 - March 2019.

The Reserve Bank of New Zealand (RBNZ) began publishing its own IRPs in 1997. The forecast horizon is 8 quarters, and the interest rate being forecast is the quarterly average of the 90-day Bank Bill rate. RBNZ's procedure for publishing is very similar to that in Norway and Sweden, see Mirkov and Natvik (2016) or Drew and Karagedikli (2008) for further details. The Bank of Canada has not pursued a policy of publishing IRPs in our sample period, but did for a period in 2009–2010 utilize other explicit means of forward guidance, see Charbonneau and Rennison (2015).

2.2. Data

We use high-frequency data on forward rate agreements (FRAs) for Norway, Sweden, and New Zealand, provided by the Thomson Reuters Tick History database, as our measure for market expectations. Our sample period is 01.01.2000 to 03.31.2019. The FRA contracts are comparable to the US Libor future contracts traded on CME. For Canada we use such interest rate futures. For all countries the horizons are fixed at the International Money Market (IMM) dates.[7]

Let $i_{t,h}^{market}$ denote the FRA rate for the future 3-month interbank interest rate at IMM-horizon h, determined in the market at time t. We want to measure the forecast error for the ex-post realization of the 3-month rate at the same date as the horizon h, and denote this rate $i_{\tau(h)}$, where $\tau(h)$ denotes the IMM-date for horizon h. We let mfe_t^h denote the market forecast error implied by a forward rate at time t for horizon h. Hence, MFEs are defined as follows:

$$mfe_t^h = i_{\tau(h)} - i_{t,h}^{market}. \quad (1)$$

We will consider the first four IMM-dates as forecast horizons h, each approximately one quarter ahead following time t.

The interest rate $i_{t,h}^{market}$ is directly quoted by market participants at high frequency. We will utilize the change in mfe_t^h within narrow windows around announced interest rate decisions or released updates on key macroeconomic variables. For this purpose, we collect the exact timing of both macro releases and monetary policy announcements in Norway, Sweden, New Zealand, and Canada. The window we will use is from immediately before the new information is available to market participants, to 30 min after.

The benefit of a rather narrow window, is that confounding factors that affect interest rates are less problematic. The narrower the window, the more likely we are to isolate the effect of each specific information event. On the other hand, if markets need time to react, a wider window may be necessary to capture their response. Fig. 2 presents market reactions at different intervals after monetary policy announcements. We see that most of the reaction typically occurs in the first 15 min, but between 15 and 30 min after announcements there will often still be marked movements. There is a clear tendency for the forward rates to settle down thereafter, as we see the response from 30 to 45 min after announcements are negligible.[8]

[7] IMM dates are the quarterly dates which most futures contracts and option contracts use as their scheduled maturity date or termination date. The IMM dates are the third Wednesday in March, June, September and December.

[8] For brevity, Fig. 2 displays only movements in the FRA maturing four IMM dates ahead. The patterns for shorter horizons are similar. Results available upon request.

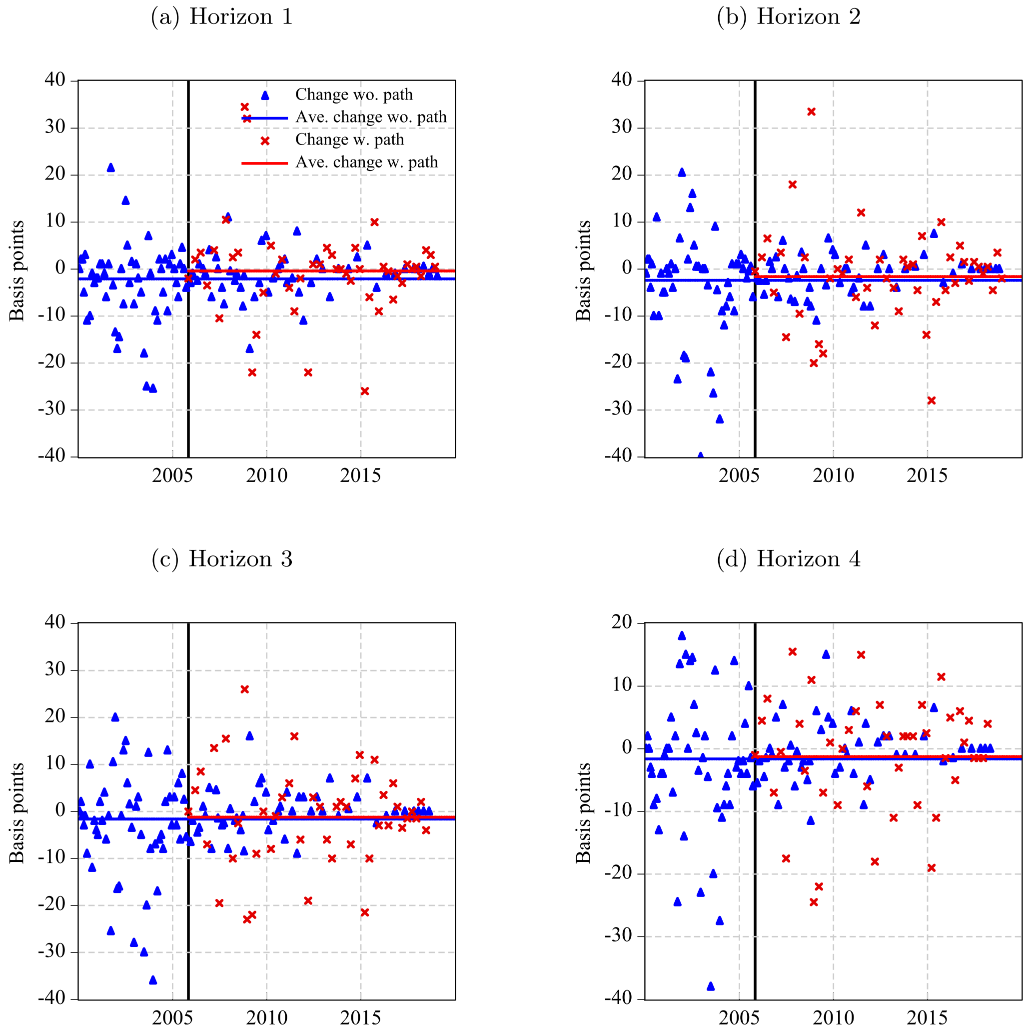

Fig. 3. Market Forecast Error (MFE) response to monetary policy announcements in Norway.
Notes: Change in Market Forecast Eerrors (MFEs) from immediately before to 30 min after monetary policy announcements. Blue triangles refer to policy meetings where no interest rate projection (IRP) was published together with the current interest rate decision, and the blue line is the average MFE change across these meetings. Red crosses refer to meetings where an interest rate projection was published together with the current interest rate decision, and the red line is the average MFE change across these meetings. Sample: January 2000 - March 2019.

We consider releases of the following macroeconomic variables: The consumer price index (monthly), industrial production (monthly), the trade balance (monthly), gross domestic product (quarterly), PMI headline (purchasing managers sentiment index, monthly), retail sales (monthly), the unemployment rate (monthly), the economic tendency indicator (Sweden only, monthly), oil investments (Norway only, quarterly), and a credit aggregate (Norway only, monthly).

The IRPs in Norway and Sweden provide the central banks' forecasts of future (short-term) *policy* rates. In contrast, FRAs capture the markets' forecasts of future (short-term) *market* rates plus an additional term premium. The realized market rates can in turn be considered as the sum of the policy rate plus a short-term premium. This raises two notable issues with our empirical approach.

First, our object of interest, mfe_t^h, regards market rates only: We will compare FRAs to realized market rates. Strictly speaking, this means that we are estimating how new information affects markets' ability to forecast future market rates, not future policy rates alone. These responses will reflect the markets' ability to forecast policy rates under the additional assumption that our observed short-window changes in FRAs reflect changes in expectations about policy rates, not changes in expected short-term premia.

Second, the fact that FRAs might reflect term premia in addition to expected future market rates means that it is simplistic to consider the level of mfe_t^h as a forecast error only. This is why our interest lies in high-frequent MFE *changes* rather than levels. We will study MFE changes in 30-min windows around releases of monetary policy decisions and other macroeco-

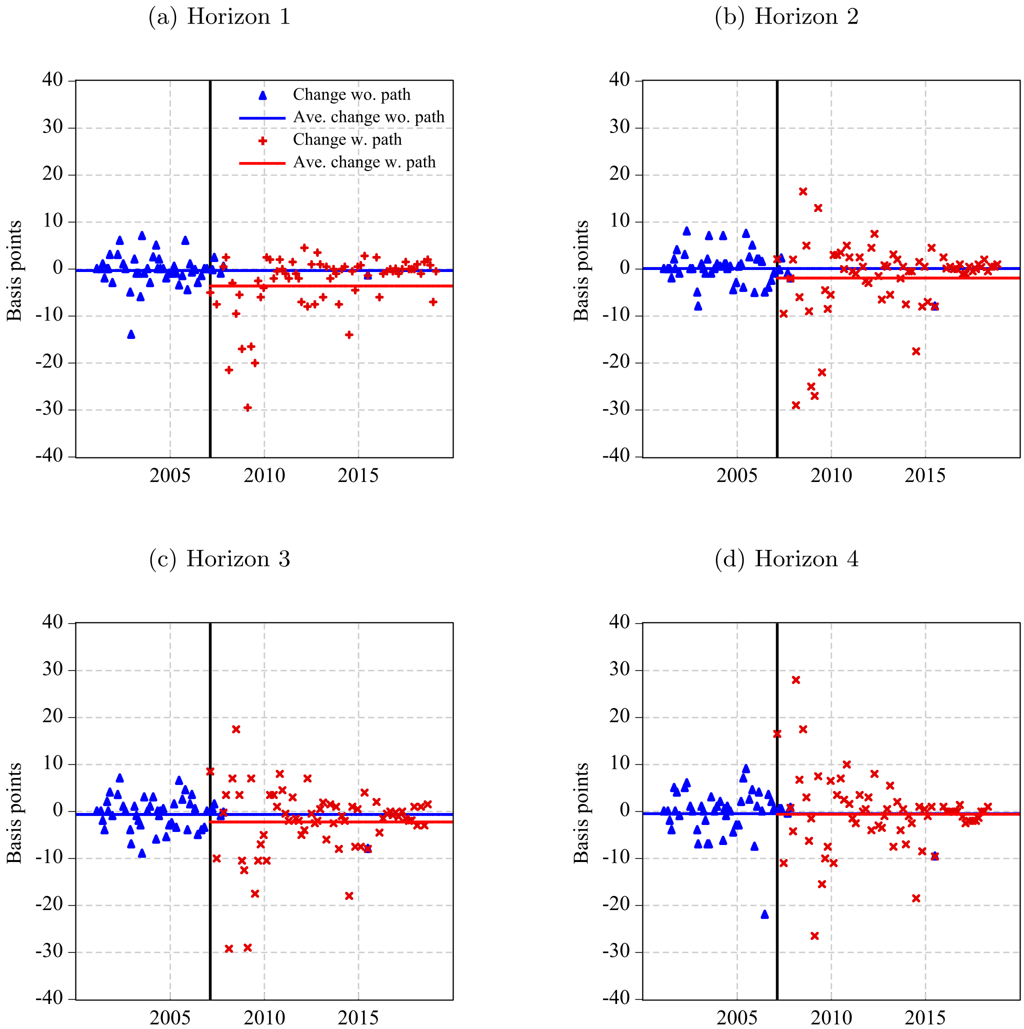

Fig. 4. Market Forecast Error (MFE) response to monetary policy announcements in Sweden.
Notes: Change in Market Forecast Eerrors (MFEs) from immediately before to 30 min after monetary policy announcements. Blue triangles refer to policy meetings where no interest rate projection (IRP) was published together with the current interest rate decision, and the blue line is the average MFE change across these meetings. Red crosses refer to meetings where an interest rate projection was published together with the current interest rate decision, and the red line is the average MFE change across these meetings. Sample: January 2000 - March 2019.

nomic news, and then interpret these responses as movements in forecast errors under the assumption that FRA premia are constant in these specific windows. This assumption is typically imposed in the empirical literature on monetary policy communication, see for instance Gürkaynak (2005) and Brand et al. (2010).

While it is common practice in the literature to assume that premia are constant around announcements and macroeconomic releases, we acknowledge that it is impossible to validate this assumption with certainty. Generally speaking, variation in term premia within the narrow windows we study would work against detecting statistical evidence that markets' forecast errors respond. We therefore anticipate our results and note that MFEs generally do fall in our announcement windows. Hence, it seems unlikely that the FRA-variation our empirical strategy utilizes is driven by premia alone. Moreover, we will find a different impact of IRP introduction on MFE responses in Norway than in Sweden. If these differences are driven by premia alone, then term premia variability must be correlated with the introduction of IRPs in one country, but not in the other. This also seems unlikely. We therefore believe the assumption of constant premia is innocuous. Moreover, in the conclusion we return to how one of our results may be re-interpreted if both premia and expectations are responding.

3. How Do Monetary Policy Announcements Affect Market Forecast Errors?

The extent to which a monetary policy announcement guides markets about the future evolution of short-term interest rates will be reflected in how mfe_t^h responds. Note that it is the absolute value of forecast errors that matters here: we need

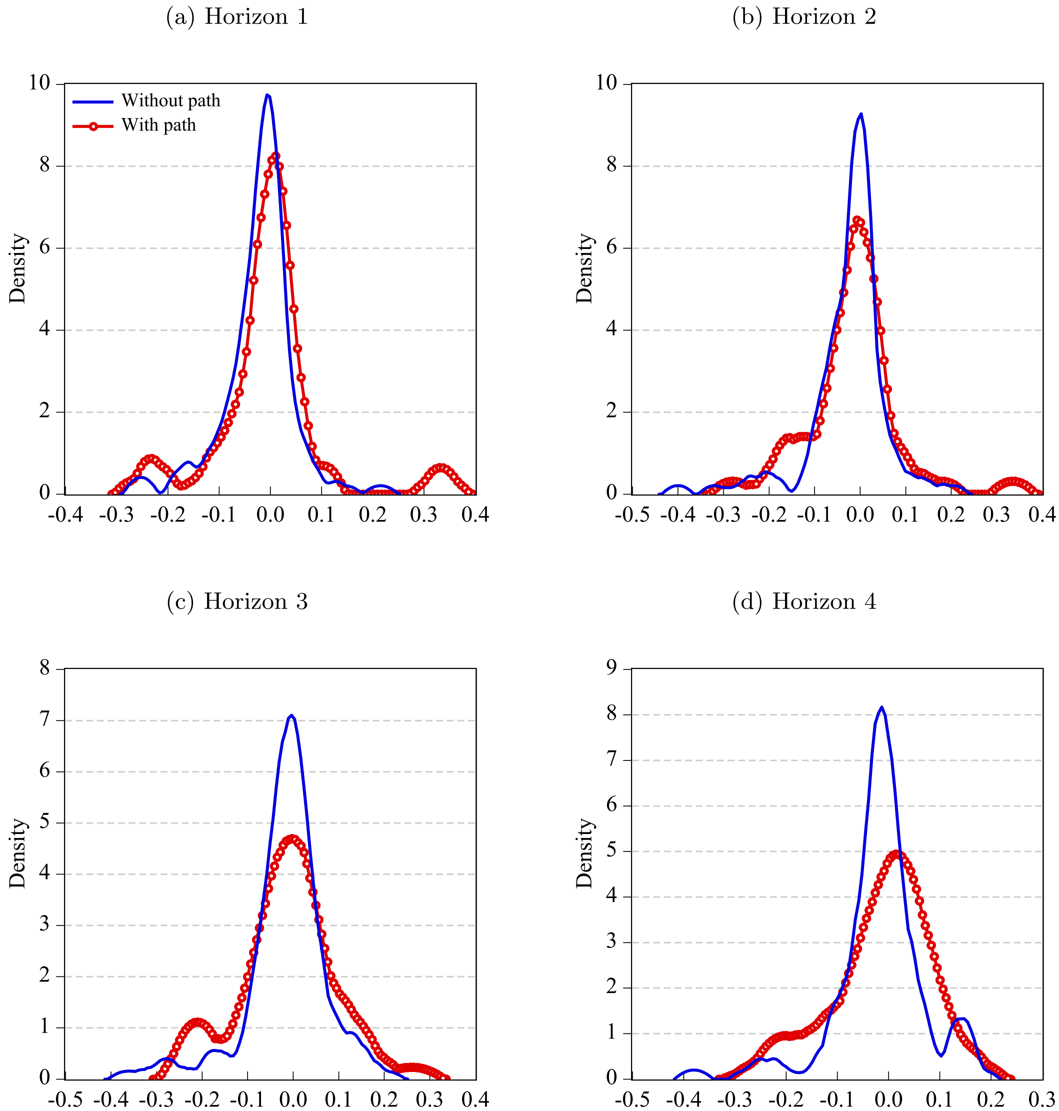

Fig. 5a. Distribution of Market Forecast Errors (MFE) movements around monetary policy announcements in Norway.
Notes: Estimated kernels for the distributions of change in Market Forecast Errors (MFEs) from immediately before to 30 min after monetary policy announcements. The kernel distribution indicated by the blue solid line is for changes in MFEs when there is not interest rate projection (IRP), while red line with circles are for distributions with IRP. Sample: January 2000 - March 2019.

not distinguish between an initially negative forecast error that moves up and an initially positive forecast error that moves down,- in both cases the forecast moves closer to the ex-post realization. Hence, we will study movements in market forecast errors from right before an announcement to 30 min after, defined as $\Delta|mfe_t^h| = |mfe_t^h|^{+30min} - |mfe_t^h|^{\div Ann}$.

First, we assess if the response of $\Delta|mfe_t^h|$ to monetary policy announcements changed after Norges Bank and the Riksbank began to publish IRPs. Second, we ask if the underlying drivers behind the patterns observed are market responses to current monetary policy actions or market responses to communicated monetary policy intentions that cannot be inferred from policy actions.

3.1. MFE Responses and Interest Rate Projections

Figs. 3 and 4 plot the change in market forecast errors, $\Delta|mfe_t^h|$, around monetary policy announcements in Norway and Sweden. Each figure contains one plot per horizon *h*. Red crosses refer to announcements which were accompanied by the central bank's IRP, blue triangles refer to announcements that were unaccompanied by an IRP. The high number of positive values reveals that a monetary policy announcement does not necessarily contribute to a reduced forecast error. Naive

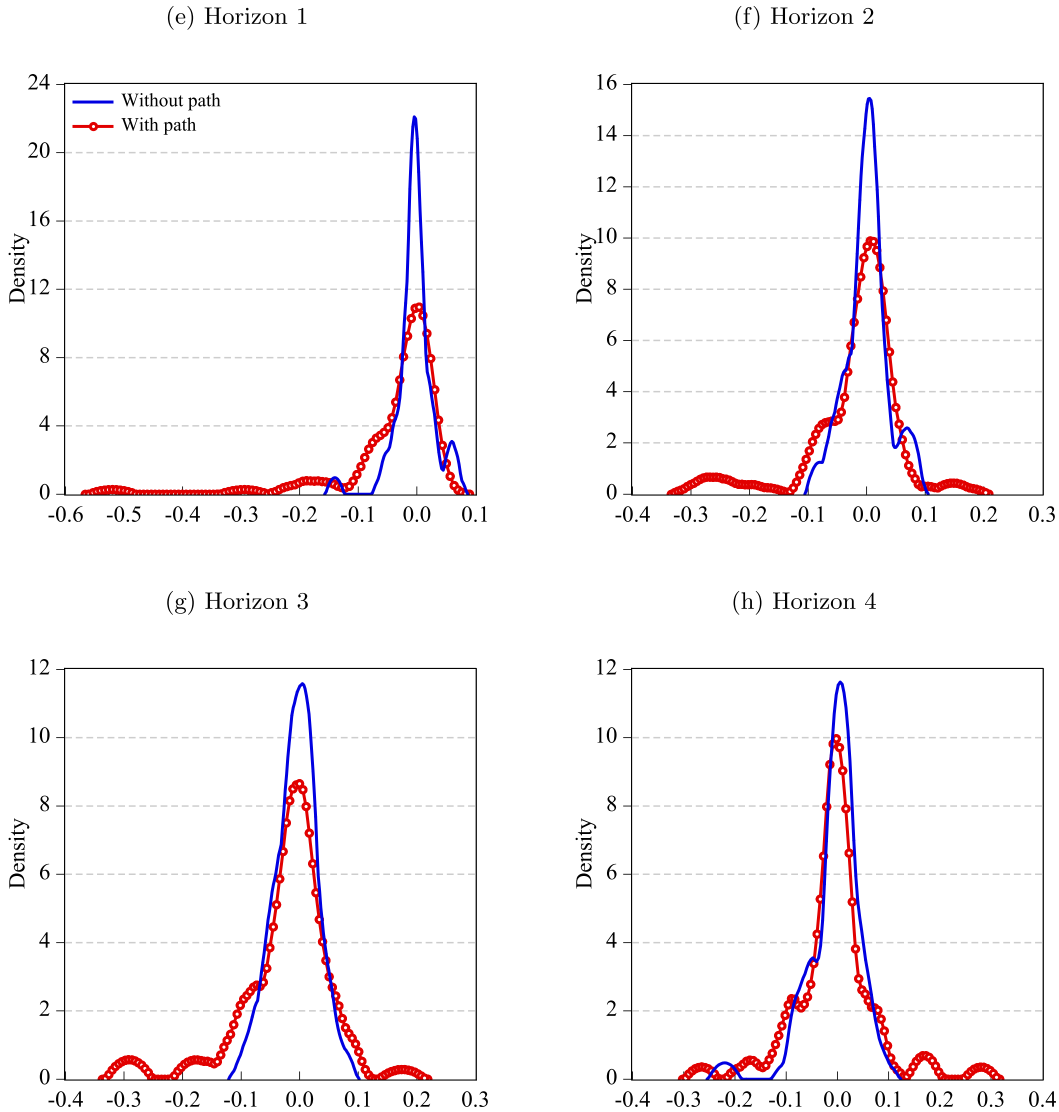

Fig. 5b. Distribution of Market Forecast Errors (MFE) movements around monetary policy announcements in Sweden.
Notes: Estimated kernels for the distributions of change in Market Forecast Errors (MFEs) from immediately before to 30 min after monetary policy announcements. The kernel distribution indicated by the blue solid line is for changes in MFEs when there is not interest rate projection (IRP), while red line with circles are for distributions with IRP. Sample: January 2000 - March 2019.

eyeballing of the movements in forecast errors leaves the impression of no particular pattern other than a mean response close to zero.

The blue solid lines in each figure display the average MFE response to announcements that are unaccompanied by IRPs. In Norway this line lies below zero, implying that interest rate announcements without IRPs on average have guided markets toward the realized future interest rate level. The red line shows the mean MFE responses to announcements accompanied by IRPs. We see that for Norway the red and blue lines lie close to each other, indicating that the publication of IRPs have not added information above the ordinary interest rate announcements. In Sweden, shown in Fig. 4, on the other hand, the red line lies below the blue line at all horizons. This indicates that monetary policy announcements have been more informative after the Riksbank began to publish its own interest rate projection.

An alternative view of the data is offered by Fig. 5, which shows kernel estimates of the $\Delta|mfe_t^h|$-distributions around monetary policy announcements. As one would expect, all the distributions are centered close to zero. The Norwegian distributions are highly similar before and after the central bank begun to publish its own interest rate projections. In contrast, in the Swedish distributions we clearly see that after the Riksbank introduced IRPs, mass moved leftwards, toward MFE-reductions, for three out of four horizons.

Table 1
Market forecast error responses to monetary policy announcements. Norway.

	A: Horizon 1				B: Horizon 2			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Before IRP (ψ)	−0.030	−0.030	−0.030	−0.030	−0.036	−0.036	−0.036	−0.036
	(−2.66)	(−2.65)	(−2.63)	(−2.63)	(−2.35)	(−2.34)	(−2.32)	(−2.32)
Change after IRP (β)	0.022				0.022			
	(1.59)				(1.29)			
Change after IRP, with IRP (β_1)		0.026				0.020		
		(1.38)				(0.94)		
Change after IRP, no IRP (β_2)		0.018				0.024		
		(1.41)				(1.48)		
Change after IRP, with IRP, no crisis (β_1^{nc})			0.017	0.023			0.024	0.024
			(1.10)	(1.40)			(1.23)	(1.12)
Change after IRP, no IRP, no crisis (β_2^{nc})			0.023	0.026			0.026	0.029
			(1.74)	(1.91)			(1.59)	(1.70)
Change after IRP, with IRP, crisis (β_1^{c})			0.075	0.032			−0.006	0.012
			(0.97)	(0.80)			(−0.09)	(0.34)
Change after IRP, no IRP, crisis (β_2^{c})			0.002	0.010			0.017	0.019
			(0.11)	(0.63)			(0.76)	(1.07)
Adjusted R^2	0.01	0.01	0.02	0.00	0.01	0.00	−0.01	−0.01
Observations	151	151	151	151	150	150	150	150
Average FE	0.168				0.339			
	C: Horizon 3				**D: Horizon 4**			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Before IRP (ψ)	−0.030	−0.030	−0.030	−0.030	−0.027	−0.027	−0.027	−0.027
	(−1.93)	(−1.93)	(−1.91)	(−1.91)	(−1.80)	(−1.79)	(−1.78)	(−1.78)
Change after IRP (β)	0.024				0.019			
	(1.36)				(1.13)			
Change after IRP, with IRP (β_1)		0.018				0.015		
		(0.83)				(0.71)		
Change after IRP, no IRP (β_2)		0.029				0.023		
		(1.72)				(1.39)		
Change after IRP, with IRP, no crisis (β_1^{nc})			0.027	0.027			0.023	0.022
			(1.25)	(1.21)			(1.14)	(1.03)
Change after IRP, no IRP, no crisis (β_2^{nc})			0.024	0.024			0.020	0.019
			(1.42)	(1.36)			(1.18)	(1.14)
Change after IRP, with IRP, crisis (β_1^{c})			−0.027	0.002			−0.031	0.002
			(−0.45)	(0.05)			(−0.63)	(0.06)
Change after IRP, no IRP, crisis (β_2^{c})			0.047	0.035			0.036	0.027
			(1.90)	(1.84)			(1.40)	(1.42)
Adjusted R^2	0.01	0.00	0.01	0.00	0.00	0.00	0.00	−0.01
Observations	147	147	147	147	145	145	145	145
Average FE	0.548				0.710			

Notes: Regression results based on Eqs. (2) to (4), with coefficient in question in parenthesis on each row. 'Before IRP' means the period before interest rate projections were introduced. 'Change after IRP' is the change in coefficient estimate after interest rate projections were introduced. In column marked (2) the post-IRP period is divided into monetary policy announcements that were accompanied by an IRP or not. The two columns marked (3) and (4) separates crisis from non-crisis periods, using two alternative crisis definitions. In column (3), a crisis dummy equals 1 only in the global financial crisis from 2008 to 2009, while column (4) extends the crisis dummy to the European sovereign debt crisis as well (2008–2012). Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Average FE means the average forecast error over the sample period, January 2000- March 2019. t-values in parenthesis (Newey-West corrected standard errors).

To scrutinize the significance of the differences in Figs. 3 and 4, we run simple regressions comparing $\Delta|mfe_t^h|$ before and after IRPs were introduced. We study each horizon in Norway and Sweden separately, starting from the specification

$$\Delta|mfe_t^h| = \psi + \beta I_t + \varepsilon_t, \tag{2}$$

where $I_t = 0$ before IRPs were being published, and $I_t = 1$ thereafter. The estimate of ψ will capture the average MFE-response in the years before IRPs were used, while β captures how the average MFE-response has changed thereafter. If the presence of IRPs has provided substantial guidance, β should be negative.

For Norway, we extend this specification to distinguish between policy announcements that were accompanied by a forecast ($D_t = 1$) and meetings that were unaccompanied by a forecast ($D_t = 0$) in the period after IRPs were introduced:

$$\Delta|mfe_t^h| = \psi + \beta_1 I_t D_t + \beta_2 I_t (1 - D_t) + \varepsilon_t. \tag{3}$$

For both countries, we also isolate the international financial crises to ensure that results are not driven by anomalies in these particular periods. We provide two alternatives, one for the Global Financial Crisis (GFC) of 2008 and 2009, and another

Table 2
Market forecast error responses to monetary policy announcements. Sweden.

	A: Horizon 1				B: Horizon 2			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Before IRP (ψ)	−0.004	−0.004	−0.004	−0.004	0.003	0.003	0.003	0.003
	(−0.70)	(−0.70)	(−0.70)	(−0.70)	(0.57)	(0.56)	(0.56)	(0.56)
Change after IRP (β)	−0.030				−0.022			
	(−2.76)				(−2.15)			
Change after IRP, no crisis (β^{nc})		−0.008	−0.009			−0.008	−0.015	
		(−1.13)	(−1.28)			(−1.13)	(−1.78)	
Change after IRP, crisis (β^{c})		−0.129	−0.058			−0.080	−0.031	
		(−3.36)	(−2.75)			(−2.16)	(−1.62)	
Change after IRP, no leaning (β^{nl})				−0.041				−0.03
				(−2.65)				(−2.18)
Change after IRP, leaning (β^{l})				−0.012				−0.008
				(−1.34)				(−0.80)
Adjusted R^2	0.03	0.31	0.10	0.05	0.02	0.13	0.02	0.03
Observations	121	121	121	121	119	119	119	119
Average FE	0.218				0.277			
	C: Horizon 3				D: Horizon 4			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Before IRP (ψ)	−0.006	−0.006	−0.006	−0.006	−0.004	−0.004	−0.004	−0.004
	(−1.07)	(−1.06)	(−1.06)	(−1.06)	(−0.47)	(−0.47)	(−0.47)	(−0.47)
Change after IRP (β)	−0.015				−0.001			
	(−1.52)				(−0.06)			
Change after IRP, no crisis (β^{nc})		−0.006	−0.011			−0.003	−0.010	
		(−0.73)	(−1.22)			(−0.32)	(−0.87)	
Change after IRP, crisis (β^{c})		−0.056	−0.021			0.010	0.011	
		(−1.57)	(−1.16)			(0.28)	(0.58)	
Change after IRP, no leaning (β^{nl})				−0.021				0.002
				(−1.49)				(0.16)
Change after IRP, leaning (β^{l})				−0.007				−0.005
				(−0.67)				(−0.39)
Adjusted R^2	0.01	0.06	0.00	0.00	−0.01	−0.01	0.00	−0.02
Observations	118	118	118	118	116	116	116	116
Average FE	0.596				0.938			

Notes: Regression results based on Eqs. (2) and (4), with coefficient in question in parenthesis on each row (the D_t-dummy in Eq. (4) not relevant for Sweden). 'Before IRP' means the period before interest rate projections were introduced. 'Change after IRP' is the change in coefficient estimate after interest rate projections were introduced. The two columns marked (2) and (3) separates crisis from non-crisis periods, using two alternative crisis definitions. In column (2), a crisis dummy equals 1 only in the global financial crisis from 2008 to 2009, while in column (3) the crisis dummy extends into the European sovereign debt crisis as well (2008–2012). Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Average FE means the average forecast error over the sample period, January 2000- March 2019. t-values in parenthesis (Newey-West corrected standard errors).

which also includes the Euro-crisis (the dummy runs from 2008 to 2012). In addition, for Sweden we isolate the period 2010–2014 where the Riksbank is claimed to have been "leaning against the wind" by taking house prices into account, without precisely communicating it (Svensson, 2015).[9] For Norway, where we keep the dummy D_t, this implies estimating:

$$\Delta|mfe_t^h| = \psi + \beta_1^{nc} I_t^{nc} D_t + \beta_2^{nc} I_t^{nc}(1 - D_t) + \beta_1^{c} I_t^{c} D_t + \beta_2^{c} I_t^{c}(1 - D_t) + \varepsilon_t, \tag{4}$$

where $I_t^c = 1$ in crisis periods (2008–2009 or 2008–2012), while $I_t^{nc} = 1$ in non-crisis periods after IRPs were introduced. For Sweden, $D_t = 0$ always since almost all meetings have been accompanied by a projection ever since IRPs were first introduced. In addition, for Sweden we have one specification where $I_t^c = 1$ for the leaning period 2010–2014 and $I_t^{nc} = 1$ for the other periods after IRPs were introduced.

Results are provided in Tables 1 and 2 for Norway and Sweden, respectively. For each horizon, the first column refers to the specification in Eq. (2). For Norway, the second column refers to the specification in (3). The final two columns refer to specification (4) isolating the two alternative definitions of the financial crisis period, 2008–2009 and 2008–2012 respectively.

The regressions confirm the visual impression from Figs. 3 and 4. Before Norges Bank introduced its projections in 2005, the market forecast errors were on average reduced by monetary policy announcements. The second row shows that the incremental response of $\Delta|mfe_t^h|$ after Norges Bank introduced IRPs in 2005, β from Eq. (2), is positive at all horizons and statistically insignificant. This holds both for meetings that were accompanied and for meetings that were unaccompanied by an interest rate projection, and is approximately unchanged when we control for crisis periods.

[9] In this specification we do not add any of the crisis dummies. We thank an anonymous referee for suggesting that we isolate this specific period.

Table 3
Difference in differences - Norway and Sweden.

	Horizon: 1	2	3	4	Horizon: 1	2	3	4
	I: RBNZ Ia: Norges Bank vs RBNZ				Ib: Riksbank vs RBNZ			
Constant (ψ)	−0.047	−0.016	0.005	0.013	−0.042	−0.020	−0.005	0.002
	(−2.97)	(−0.77)	(0.52)	(0.90)	(−2.89)	(−1.06)	(−0.36)	(0.09)
Country (γ_1)	0.016	−0.020	−0.037	−0.042	0.038	0.023	0.000	−0.005
	(1.25)	(−1.21)	(−2.06)	(−1.61)	(2.43)	(1.14)	(−0.04)	(−0.25)
IRP-period (γ_2)	0.036	0.017	0.000	0.003	0.031	0.024	0.015	0.022
	(1.62)	(0.68)	(−0.01)	(0.15)	(1.39)	(1.04)	(0.76)	(1.05)
IRP-period × country (β)	**−0.015**	**0.005**	**0.027**	**0.020**	**−0.056**	**−0.044**	**−0.031**	**−0.024**
	(−0.93)	**(0.26)**	**(1.13)**	**(0.68)**	**(−1.97)**	**(−1.66)**	**(−1.38)**	**(−0.98)**
Adjusted R^2	0.03	0.03	0.03	0.11	0.00	−0.01	0.03	0.04
Observations (years ×2)	40	38	38	38	39	37	37	37
	II: Bank of Canada IIa: Norges Bank vs BoC				IIb: Riksbank vs BoC			
Constant (ψ)	−0.032	−0.031	−0.004	−0.014	−0.032	−0.030	−0.005	−0.009
	(−2.52)	(−1.96)	(−0.59)	(−1.56)	(−3.09)	(−2.21)	(−0.93)	(−0.96)
Country (γ_1)	0.000	−0.005	−0.028	−0.015	0.028	0.032	0.000	0.006
	(0.03)	(−0.21)	(−1.68)	(−0.72)	(2.51)	(2.42)	(−0.04)	(0.51)
IRP-period (γ_2)	0.016	0.024	−0.004	0.011	0.018	0.024	−0.002	0.003
	(1.17)	(1.43)	(−0.50)	(0.93)	(1.57)	(1.61)	(−0.32)	(0.29)
IRP-period × country (β)	**0.005**	**−0.002**	**0.031**	**0.012**	**−0.043**	**−0.043**	**−0.013**	**−0.006**
	(0.28)	**(−0.06)**	**(1.67)**	**(0.57)**	**(−2.56)**	**(−2.50)**	**(−1.15)**	**(−0.42)**
Adjusted R^2	0.03	0.12	0.11	0.04	0.03	0.06	0.02	−0.09
Observations (years ×2)	39	37	37	37	38	36	36	36

Notes: Regression results from the difference in difference specification in Eq. (5), comparing Norway and Sweden to New Zealand and Canada. Coefficient-symbol in parenthesis on each row. IRP is short for interest rate projection. Market forecast errors (MFE) are aggregated to a yearly sum for each country. In panel Ia, the yearly sum of changes in forecast errors around monetary policy announcements in Norway are compared to those in New Zealand before and after Norges Bank introduced IRPs. Panel Ib reports results from the same exercise, but now for Sweden and New Zealand. In panels IIa and b, the control country is Canada instead of New Zealand. The difference-in-difference coefficient of interest is 'IRP-period × country'. Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Sample period: January 2000 - March 2019. t-values in parenthesis (Newey-West corrected standard errors).

In Sweden, the results go in the opposite direction. MFE-responses were insignificant before the Riksbank introduced its IRPs, and then significantly negative thereafter. When we look at the crisis dummies, it seems that most of the improvements in MFE responses occurred in the crisis periods. However, the sub-period that most clearly stands out is the leaning-against-the-wind period from 2010–2014. In these years the MFE responses are back to their pre-IRP levels. This is consistent with the view that the Riksbank pursued an ill-communicated policy of responding to house prices in this specific period. It seems that the improvements in MFE responses that occurred in Sweden, materialized in the years when the Riksbank was not alleged to pursue an opaquely formulated policy.

The results above indicate that in Sweden, the introduction of IRPs served to guide markets' to interpret policy announcements more precisely, whereas in Norway it did not. However, this interpretation is questionable as the periods before and after IRPs might differ along other important dimensions than the introduction of projections alone. For this reason, we consider a difference-in-differences approach where we compare Norway and Sweden to New Zealand and Canada. In New Zealand, IRPs have been published throughout our sample period. In Canada, the practice of regularly publishing IRPs has not been introduced. Hence, by differencing out the coinciding movements in market forecast errors in New Zealand and Canada, we factor out those sources of time variation that are common across our two countries of interest (Norway and Sweden) and our two control countries (New Zealand and Canada), and unrelated to the introduction of IRPs. Fig. A.2 in the appendix shows that the policy interest rates in Norway and Sweden co-move with the policy rates in New Zealand and Canada, supporting the relevance of this exercise.

Because central banks do not hold interest rate meetings on the same days, we need to time-aggregate our data in order to have observations from both countries at the same frequency. Unfortunately for our purposes, there are quarters where some of the central banks in question do not hold policy meetings. We therefore aggregate to the yearly frequency.[10] The aggregated MFE change then is the sum of all MFE changes, as defined earlier over 30-min windows around monetary policy meetings, during a year. More precisely, the aggregated MFE change for country i in year T is

$$\Delta\left|MFE^h_{i,T}\right| \equiv \sum_{t=1}^{J_{i,T}} \Delta\left|mfe^h_{i,t}\right|,$$

where $J_{i,T}$ is the number of monetary policy announcements in country i in year T.

[10] In the appendix, we extend this analysis to a quarterly aggregation. As those results show, the quarterly aggregated data yields similar results as the yearly aggregation.

We estimate the following specification for Norway and Sweden separately, comparing them to New Zealand and Canada in separate regressions:

$$\Delta\left|MFE_{i,T}^{h}\right| = \psi + \gamma_1 I_i + \gamma_2 I_T + \beta I_i I_T + \varepsilon_t. \quad (5)$$

where $I_i = 0$ if i is the comparison country (New Zealand or Canada), $I_i = 1$ if i is Norway or Sweden, and $I_T = 1$ after Norges Bank or Riksbank began to publish IRPs. Hence, in the regression comparing Norway to New Zealand, $\psi + \gamma_1$ captures the average change in forecast errors around policy announcements in the period before Norges Bank began publishing IRPs, while γ_2 captures any source of change in forecast error responsiveness that coincided with Norway's introduction of IRPs and was common across New Zealand and Norway. Our main parameter of interest is β, as it captures the change in responsiveness that occurred after IRPs were introduced and that was not shared with New Zealand.

Table 3 presents the results for each country differenced against New Zealand and Canada in separate regressions. Because we now have aggregated the data to a yearly frequency, there are fewer observations (number of years multiplied by two, the number of countries being compared) and lower t-values. Still, we see that the previously emphasized results regarding IRPs remain qualitatively unchanged. The estimates of β are close to zero and insignificant in Norway, while they are negative and significant at the shorter horizons in Sweden. Hence, our previously found effects of publishing IRPs were not driven by omitted time-varying factors that Norway or Sweden shared with New Zealand or Canada.

Finally, one might be concerned that spreads in the object being forecast in an FRA, i.e. premia in the interbank offered rates, have risen and become more volatile in the period after Norway and Sweden introduced IRPs, in particular after the widespread turbulence from Fall 2007. This pattern is documented across a variety of economies, see for instance Taylor and Williams (2009). The concern would be that interbank rates have become less predictable because their premia have become less predictable, and that this might weaken the negative response of MFEs to monetary policy announcements in the later part of our sample. At this point, note first that the increase in premia is a wide international phenomenon, and therefore should have been picked up by our differencing against New Zealand and Canada above. In addition, when we look directly at estimated interbank rate premia after 2007, we find that to the extent they are correlated with our observed MFE changes, this comovement is *negative*. That is, if we let $prem_t$ denote the actual interbank premium at time t, the correlation between $\Delta|mfe_t^h|$ and $\Delta|prem_{t+h} - prem_t|$ is negative at all horizons h.[11] Hence, to the extent that premia affect our results, the effect is to *strengthen* the negative response of MFEs to monetary policy announcements after IRPs were introduced.

3.2. Target vs. Path Responses

Publication of IRPs is primarily considered a tool to communicate future policy intentions. However, our analysis above does not distinguish how markets react to communication of intentions from how markets react to monetary policy actions (the actual decision on the current short-term policy rate).

To distinguish actions from intentions, we rely on the method proposed by Gürkaynak et al. (2005). They use principal component analysis to decompose market interest rate reactions up to 4 quarters ahead into a "current federal funds rate target" factor and a "future path of policy" factor. These factors summarize uncorrelated sources of variation in the surprise movements in market rates. The former captures implemented policy actions, whereas the latter captures surprise changes in future short term rates. As the two are orthogonal by construction, the path factor represents reactions to communication about future policy that cannot be inferred from implemented decisions. Section C in the appendix explains this method in more detail. Notably, the two factors together explain 98 percent of the total variation in interest rate reactions in Norway, and 96 percent in Sweden. Moreover, as documented in Appendix C, the path factor explains a substantial and increasing share of the interest rate reactions as the horizon increases. At the two-, three- and four-quarter horizons in Norway, the R-squared of the path factor is 0.36, 0.54 and 0.62, respectively. The corresponding numbers in Sweden are 0.34, 0.47, and 0.64.

Note that for the shortest horizon in this decomposition, we use the one-month-ahead interest rate implied by foreign exchange forward contracts.[12] Occasionally, the one-month rate matures after the next monetary policy meeting, and hence the change in this rate might in principle be contaminated by changes in expectations about future interest rate decisions. However, this occurred for only 9 out of 121 policy meetings in Sweden, and 11 out of 152 meetings in Norway. For 17 of these 20 episodes the overlap was less than three days. It therefore constitutes a negligible problem for our purposes. Note that we choose the one-month rate rather than a shorter one because the one-month rate is less likely to be influenced by other factors than the information from the central bank within the window, especially banks' short term liquidity management.[13]

[11] The correlations in Norway are −0.07, −0.02, −0.04, and −0.22, at the three, six, nine and twelve month horizons, respectively. In Sweden, these correlations are −0.53, −0.24, −0.30, and −0.35. The premia we use in these exercises are the spread between the interbank rates and the Overnight Indexed Swap (OIS). For Norway we use the Norges Bank estimated OIS due to the lack of a market based alternative, see Lund et al. (2016).

[12] This rate is the interest rate differential between USD and NOK in the FX swap market. In both Norway and Sweden, the FX swap market is one of the most liquid segments of the fixed-income market. We convert the difference between the FX forward rate and the spot rate to basis points. Then we use the high-frequency change in the 1-month interest rate differential around the monetary policy announcement as a measure of the market's immediate response to new information.

[13] Ideally, we would use standard proxies for short-term expectations like one-week Overnight Indexed Swap (OIS) rates, but these do not exist over our full sample period. However, in Sweden there are OIS rates available from 2007. This market is illiquid, but should still proxy for the expected policy rate over the next week. For the period where OIS rates have existed in Sweden (after 2007), one-week OIS rates and the one-month rate we utilize in our main analysis have a correlation of 0.7. In contrast, the correlation between one-week OIS rates and the short-term rate that is available over our full sample, one-week foreign exchange contracts, is only 0.5.

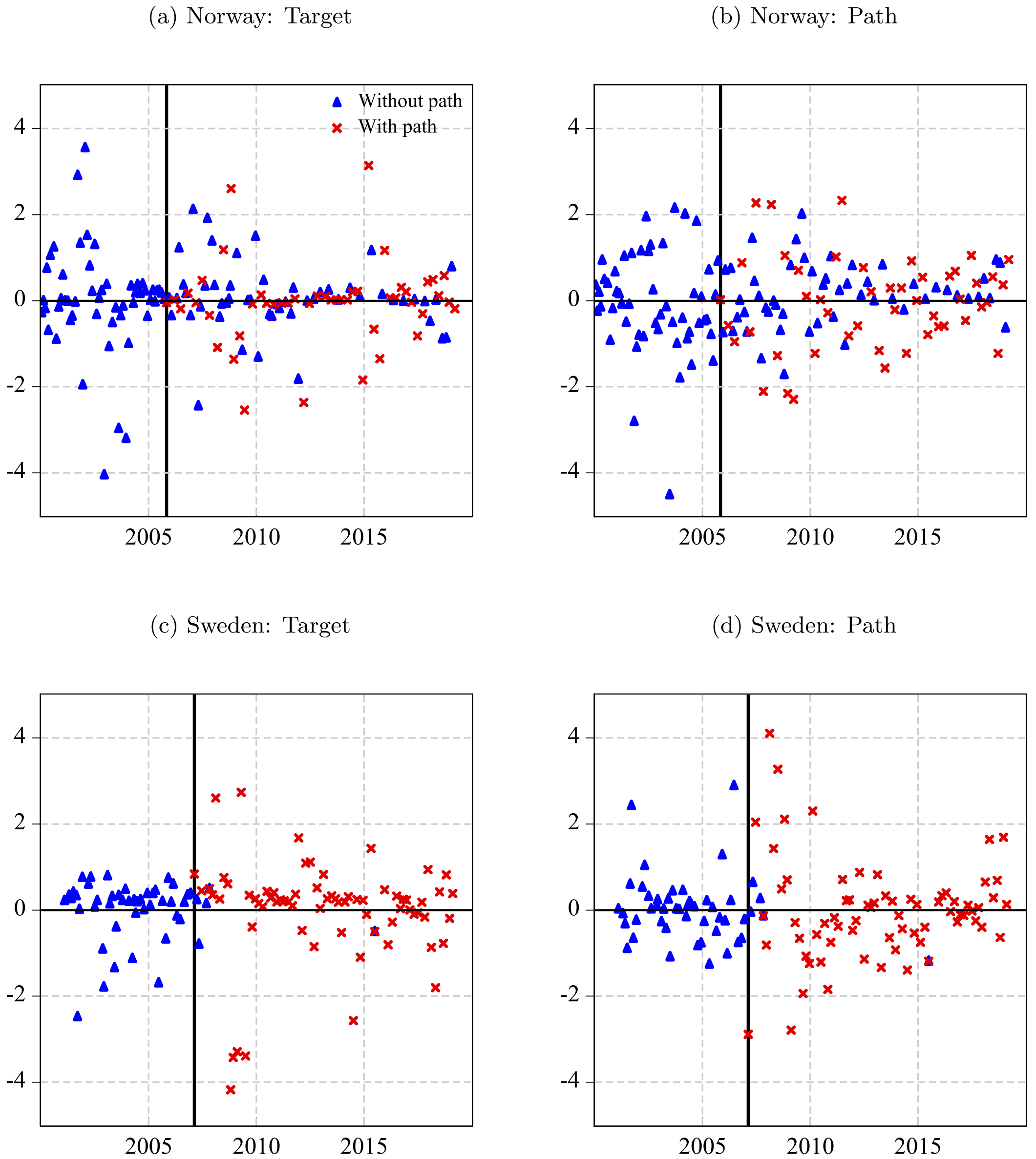

Fig. 6. Target and path responses to monetary policy announcements.
Notes: Movements in the path and target factors of forward rate agreements (FRAs) from immediately before to 30 min after monetary policy announcements. Sample: January 2000 - March 2019.

Fig. 6 displays the target and path factors computed in 30-min windows around policy announcements in Norway and Sweden. As before, red circles refer to policy announcements accompanied by an interest rate projection. We see that while both factors typically deviate from zero after policy announcements, the market reactions captured by the target factor are often negligible. This reflects that in several of the announcements, the policy action was to keep the short-term rate unchanged and in accordance with market expectations. Similar to what Gürkaynak et al. (2005) found for the US, Fig. 6 also shows that the path factor tends to deviate substantially from zero around policy announcements in both Sweden and Norway.

To disentangle how the two types of market reactions contribute to forecast errors, we estimate the following specification for each horizon and country separately:

$$\Delta|mfe_t^h| = \psi + \gamma_1 Z_t^{tar} + \gamma_2 Z_t^{path} + \beta I_t + \alpha_1 I_t Z_t^{tar} + \alpha_2 I_t Z_t^{path} + \varepsilon_t, \qquad (6)$$

where Z_t^{tar} and Z_t^{path} are the absolute values of the 30-min target and path factors displayed in Fig. 6. Table 4 provides the results from this regression.

Table 4
Path vs. target factor.

	Horizon: 1	2	3	4
	A: Norway			
Constant (ψ)	0.010	0.024	0.023	0.014
	(0.93)	(1.53)	(1.14)	(0.55)
Target Factor (γ_1)	−0.030	−0.067	−0.057	−0.043
	(−1.59)	(−4.01)	(−3.59)	(−2.73)
Path Factor (γ_2)	−0.021	−0.013	−0.014	−0.011
	(−1.58)	(−0.53)	(−0.43)	(−0.26)
Change after IRP (β)	−0.018	−0.019	−0.008	−0.004
	(−1.09)	(−1.05)	(−0.35)	(−0.14)
Target $\times$ IRP (α_1)	0.018	0.046	0.046	0.023
	(0.58)	(1.59)	(1.74)	(1.04)
Path $\times$ IRP (α_2)	0.030	0.002	−0.009	0.000
	(1.20)	(0.06)	(−0.22)	(0.01)
Adjusted R^2	0.06	0.21	0.14	0.09
Observations	151	150	147	145
	B: Sweden			
Constant (ψ)	0.006	0.006	0.001	0.012
	(0.96)	(1.39)	(0.11)	(1.28)
Target Factor (γ_1)	−0.024	0.009	0.002	0.006
	(−1.41)	(0.53)	(0.11)	(0.28)
Path Factor (γ_2)	0.005	−0.014	−0.014	−0.036
	(0.43)	(−1.63)	(−1.61)	(−1.39)
Change after IRP (β)	0.018	0.014	0.015	−0.018
	(2.07)	(1.33)	(1.26)	(−1.05)
Target $\times$ IRP (α_1)	−0.046	−0.052	−0.039	−0.029
	(−1.84)	(−2.27)	(−1.95)	(−1.09)
Path $\times$ IRP (α_2)	−0.014	0.005	0.001	0.060
	(−0.98)	(0.21)	(0.05)	(1.75)
Adjusted R^2	0.58	0.29	0.23	0.07
Observations	121	119	118	116

Notes: Regression results based on Eq. (6), where change in forecast error is regressed on the absolute value of target and path factors. Our computation of target and path factors is outlined in Appendix C and follows the procedure of Gürkaynak et al. (2005). 'IRP' is short for interest rate projection. Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Sample period: January 2000- March 2019. t-values in parenthesis (Newey-West corrected standard errors).

Focusing first on the estimated γ_1 and γ_2 in rows two and three of Table 4, we see that for Norway it was the target factor response that contributed to reduce forecast errors before IRPs were introduced. This holds at all horizons. For Sweden, our previously presented evidence showed that forecast errors were not systematically reduced by monetary policy announcements in the period before IRPs were introduced. Table 4 shows that this pattern applies in both the target and path dimensions, although the latter seem to have reduced forecast errors somewhat at longer horizons.

The bottom two rows of Table 4 provide estimates of how the target and path contributions to $\Delta|mfe_t^h|$ changed after IRPs were introduced (α_1 and α_2). In Norway, none of these estimates are significant, again suggesting that the introduction of IRPs did not improve market participants' forecasts of monetary policy. In Sweden, our estimates imply that the improvement of MFE-reactions after IRPs were introduced predominantly came from the target factor, not from the path factor. The estimates of α_1 are negative at all horizons, though insignificantly so at the longest horizon. The estimates of α_2 indicate a slight negative contribution only at the shortest horizon, and at this horizon the estimate is not statistically significant.[14]

Together with the MFE movements revealed previously, Table 4 leaves us with a notable pattern. Publication of IRPs is generally considered as a means to more effectively communicate future policy intentions. The path factor by construction captures exactly this dimension of how markets interpret policy announcements. Yet, the introductions of IRPs have not increased the extent to which path factor reactions reduce forecast errors. Even in Sweden, where we have seen that MFEs began to fall upon policy announcements after IRPs were introduced, it is primarily the policy action, as captured by the target factor, that has guided markets on future monetary policy.

One might well question why the target factor reduces MFEs, and why this has only happened in Sweden. Here we can only speculate. One interpretation is that central banks may help market participants to better understand the rationale behind current policy *actions*. Thereby, markets might better infer what these actions imply for future policy. Moreover, it is plausible that there are diminishing returns here: If market participants initially struggle to interpret what current actions imply for future policy, better explanations by the central bank may have a sizeable effect. If market participants initially have a fairly clear understanding of what current actions imply for future policy decisions, there is less scope for improvement.[15] We find this

[14] None of these results change when we isolate the crisis period from 2007 to 2009. Details available upon request.

[15] At the extreme, the returns to communication must have decreasing returns: if markets already understand policy actions perfectly, then any increased effort to communicate will necessarily have zero effect on markets' mapping from actions to future policy.

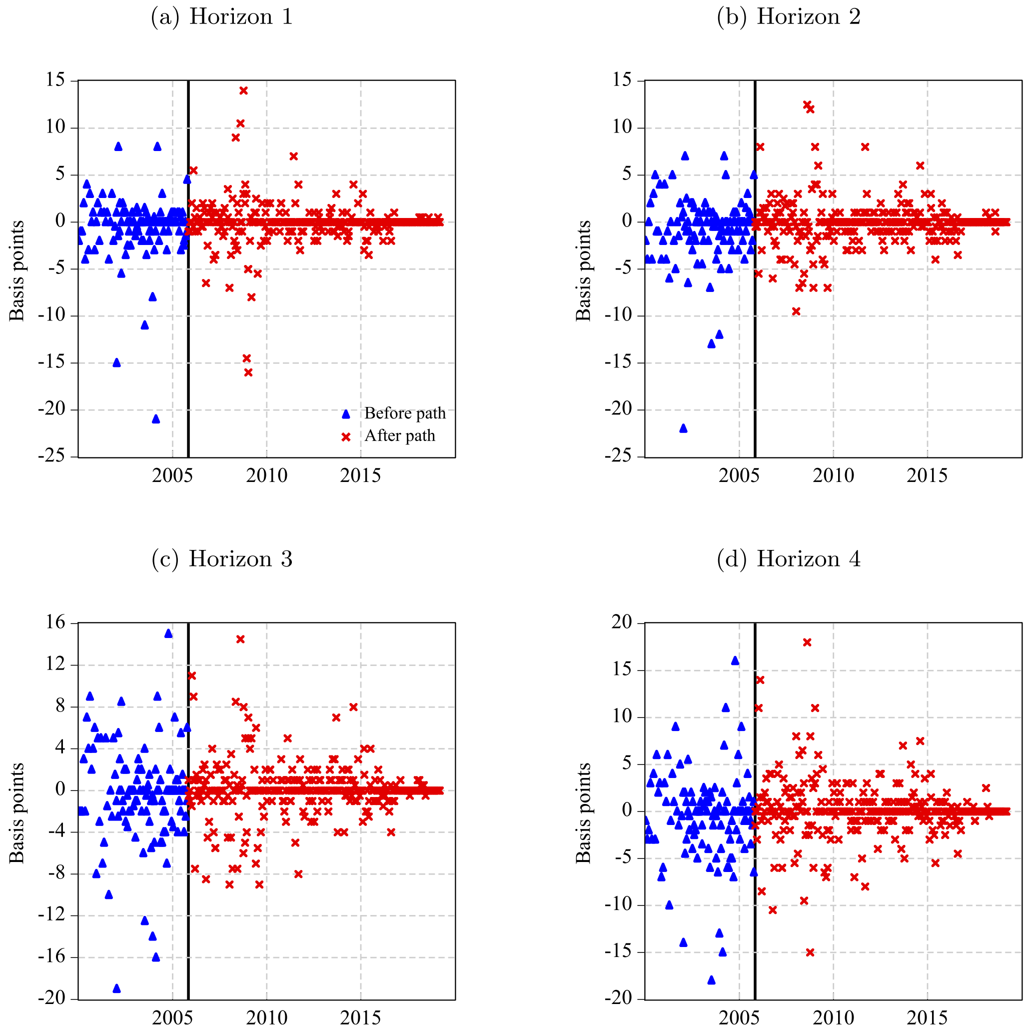

Fig. 7a. Market Forecast Error (MFE) responses to macro releases in Norway.
Notes: Change in Market Forecast Errors (MFEs) from immediately before to 30 min after the monthly release of the consumer price index (CPI) and industrial production (IP) in Norway. Sample: January 2000 - March 2019.

interpretation plausible since the improved reactions through the target factor occurred only in Sweden. Here the target factor initially was not contributing to reduced forecast errors. In contrast, in Norway the target factor contributed to reduced forecast errors before IRPs were utilized, and this did not improve further after IRPs were introduced.

4. Movements in Market Forecast Errors around Macroeconomic Data Releases

If IRPs serve to illuminate how the central bank systematically responds to changes in the economic environment, its "reaction function", then their presence should improve how market forecasts react to new macroeconomic information in general. We therefore extend our analysis to explore how MFEs have responded to the macroeconomic releases described in Section 2.2.

As an illustration, Fig. 7 plots MFE-movements in 30-min windows around the consumer price index (CPI) and industrial production releases. We see that market reactions are moderate for most of the releases, but there are several episodes of substantial responses. In Table 5 we examine a set of the arguably most important macro releases systematically. The first row in Table 5 shows that on average the MFE-movements have been negative, as one would expect. However, these average responses are small, reflecting the many releases with little new information in Fig. 7.

For each country, the second and third lines of Table 5 show estimates from the specification in Eq. (2), where the units of observation are the MFE-changes around macro releases. The estimate of ψ reflects the average response of MFEs before IRPs were introduced, while β captures the change after IRPs were introduced. The β-estimates are small, non-negative, and insignificantly different from zero. There is nothing that indicates improved MFE-responses in the post-IRP period.

Next, we zoom in on the monthly releases of the consumer price index (CPI), as this arguably will be the most important release for interest rates under inflation targeting. The results are displayed in Table 6. These give the same overall pattern as

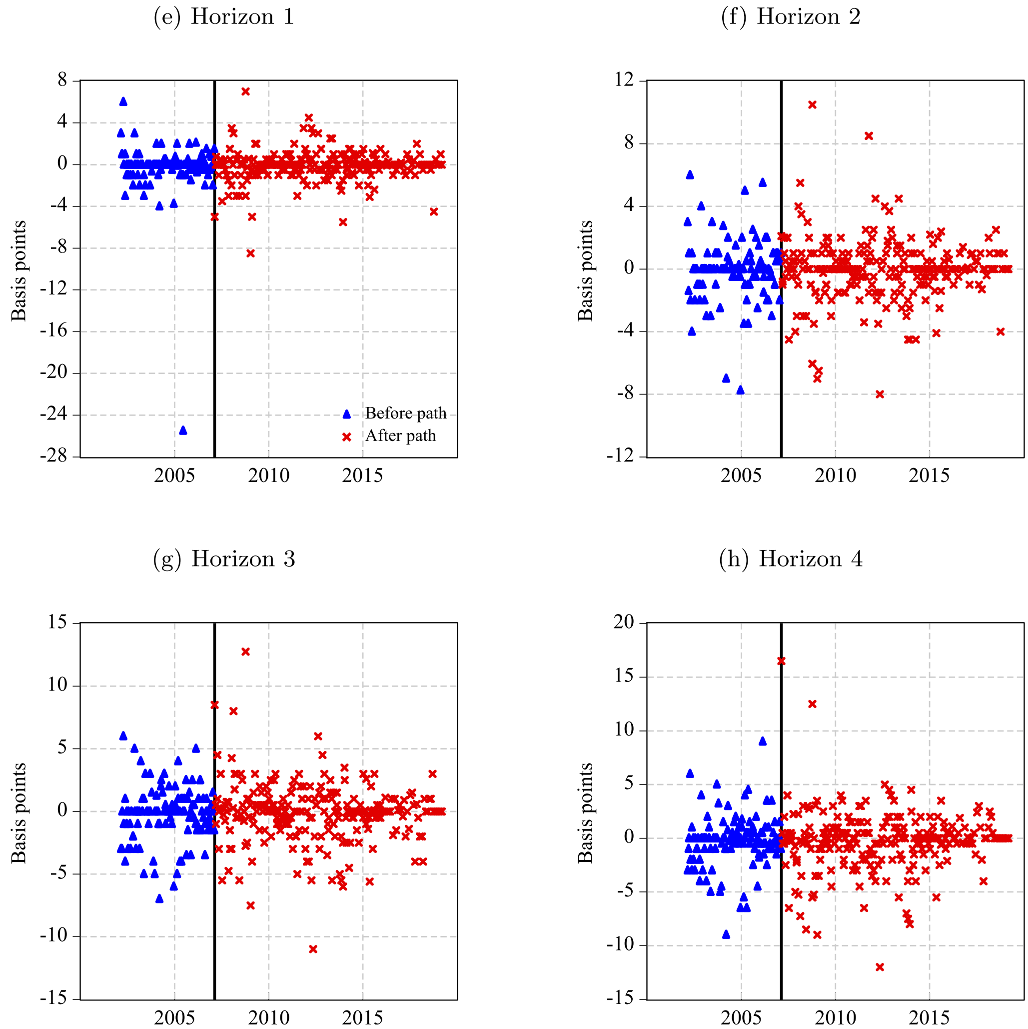

Fig. 7b. Market Forecast Error (MFE) responses to macro releases in Sweden.
Notes: Change in Market Forecast Errors (MFEs) from immediately before to 30 min after the monthly release of the consumer price index (CPI) and industrial production (IP) in Sweden. Sample: January 2000 - March 2019.

we saw in Table 5. In short, it does not seem that IRPs have guided markets to better interpret what macroeconomic news implies for future monetary policy.[16]

5. Conclusion

To a considerable extent, the ultimate benefits from explicit monetary policy communication depend on how strongly it guides markets to better interpret what available information implies for future interest rate decisions. We provide novel evidence on this exact issue. Consistent with the rich existing evidence from a variety of countries and periods, we do find that interest rates in forward contracts respond a great deal to central bank communication. However, the introduction of central bank interest rate projections (IRPs) has done little to improve these responses in the sense of bringing them closer to realized interest rates. Overall, central bank communication about future policy through IRPs has played only a limited role in guiding markets, at most.

We base our conclusion on two main findings. First, upon monetary policy announcements, the path factor of market reactions, which is to be interpreted as markets' response to central bank communication about the future, does not systematically move market forecasts closer to realized outcomes when central bank projections are present. It does seem that market reactions to announced policy decisions were generally improved in Sweden after the Riksbank introduced its

[16] Isolating the crisis periods of 2007–2009 or 2008–2012 does not change these results in any substantial manner. In an earlier version of this paper we used data on market expectations to scale each release by the extent to which it surprised market participants. The results were essentially the same as in Table 5 here as well. Details available on request

Table 5
Change in market forecast errors around macro releases.

	Horizon: 1		2		3		4	
	A: Norway							
Average	−0.001		−0.001		0.000		−0.001	
	(−1.49)		(−2.48)		(−0.46)		(−1.04)	
Before IRP (ψ)		−0.002		−0.003		−0.001		−0.003
		(−1.39)		(−1.58)		(−0.37)		(−1.45)
Change after IRP (β)		0.002		0.002		0.001		0.003
		(1.01)		(0.89)		(0.28)		(1.35)
Adjusted R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1255	1255	1227	1227	1267	1267	1188	1188
	B: Sweden							
Average	−0.001		0.000		−0.001		−0.002	
	(−1.76)		(−0.02)		(−1.78)		(−2.97)	
Before IRP (ψ)		−0.001		0.000		−0.003		−0.003
		(−0.88)		(−0.19)		(−2.42)		(−2.73)
Change after IRP (β)		0.000		0.000		0.002		0.002
		(0.32)		(0.21)		(1.75)		(1.35)
Adjusted R^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Observations	1008	1008	987	987	1015	1015	959	959

Notes: The change in market forecast errors around releases of macro economic data in Norway and Sweden, at 4 different horizons. Coefficients from the specification in Eq. (7) in parenthesis on each row. The releases are: domestic consumer price index (CPI), domestic industrial production, trade balance, purchasing managers sentiment index (PMI), unemployment rate, gross domestic product (GDP), retail sales, economic tendency indicator (Sweden only), oil investments (Norway only), aggregate credit (K2, Norway only). 'IRP' is short for interest rate projection. Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Sample period: January 2000- March 2019. t-values in parenthesis (Newey-West corrected standard errors).

Table 6
Change in market forecast errors around CPI releases.

	Horizon: 1	2	3	4
	A: Norway			
Before IRP (ψ)	−0.008	−0.012	−0.007	−0.010
	(−1.68)	(−2.15)	(−0.92)	(−1.47)
Change after IRP (β)	0.007	0.011	0.007	0.013
	(1.30)	(1.80)	(0.96)	(1.64)
Adjusted R^2	0.01	0.01	0.00	0.01
Observations	231	228	225	222
	B: Sweden			
Before IRP (ψ)	−0.006	−0.001	−0.005	−0.004
	(−1.31)	(−0.41)	(−1.33)	(−0.86)
Change after IRP (β)	0.005	0.002	0.005	0.000
	(0.99)	(0.43)	(1.07)	(0.07)
Adjusted R^2	0.00	0.00	0.00	−0.01
Observations	206	203	200	197

Notes: The change in market forecast errors around releases of the consumer price index in Norway and Sweden, at 4 different horizons. Coefficients from specification in Eq. (7) in parenthesis on each row 'IRP' is short for interest rate projection. Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Sample period: January 2000- March 2019. t-values in parenthesis (Newey-West corrected standard errors).

own IRPs, but these improvements arose only for the target factor, which captures the monetary policy action rather than communication of future policy intentions. In both countries, the path factor reactions are sizeable, but unlike target reactions they do not systematically bring market expectations closer to ex-post realizations.

Second, upon macroeconomic releases, there is no sign that the presence of IRPs makes market rates respond more in the direction of ex-post realized interest rates. Hence, it does not seem that IRPs have guided markets toward a better understanding of what macroeconomic information implies for future monetary policy.

As discussed toward the end of Section 2.2, by interpreting our results in terms of market forecast errors, we are implicitly assuming that premia in FRAs are constant within the 30-min windows we consider. While this assumption is widely imposed in the literature on central bank communication, it is worthwhile to reflect upon how our results might be reinterpreted if the assumption is violated. It could be that our observed movements in target factors reflect changes in market forecasts, whereas the path factor movements primarily reflect responses of forward premia to monetary policy announcements. This would explain the apparent paradox that after monetary policy announcements, path factor responses typically are large, but fail to reduce forecast errors systematically. Importantly though, even under this alternative interpretation of our results, the main insight from our analysis withstands: It does not seem that the practice of publishing interest rate projections has guided markets to better understand how the central banks will set interest rates in the future.

The practice of having central banks publish their own interest rate projections may be advocated on various grounds, and improving markets' understanding of future interest rates and central banks' reaction patterns are only two of them. Hence, we do not claim that publishing IRPs is without merit. However, we do believe our findings contrast with part of the motivation for publishing IRPs, as expressed by both policymakers and the academic literature. Moreover, our results motivate caution in interpreting the widespread evidence that markets respond to central bank communication. That pattern does not necessarily imply that the practice of publishing IRPs provides guidance on future policy.

Appendix A. Additional figures and tables

See Figs. A1–A3 and Table A.1.

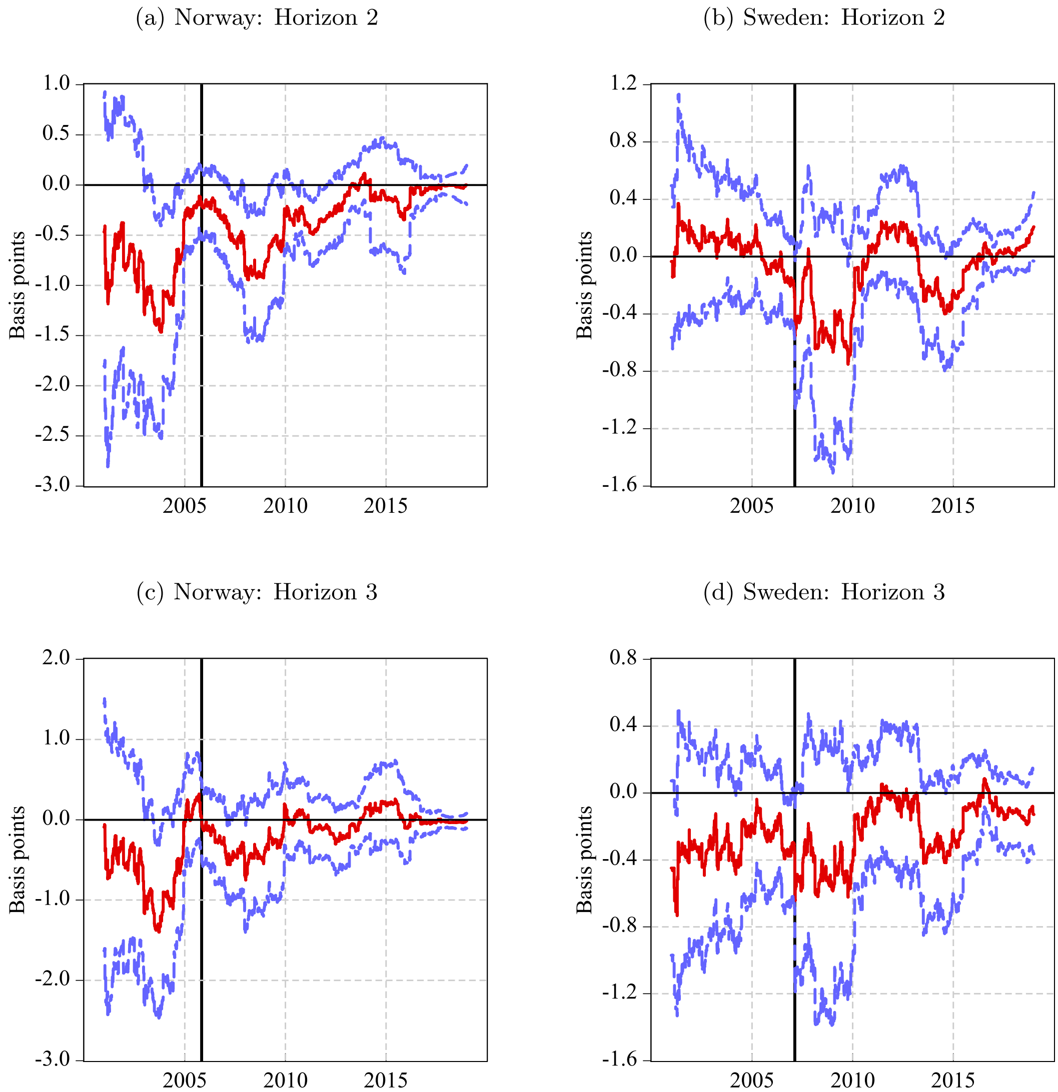

Fig. A.1. Time varying MFE responses to macro releases and monetary policy announcements.
Notes: Daily centered two-year rolling-window estimates of how market forecast errors (MFEs) respond to released macroeconomic data and monetary policy announcements, pooled. MFEs computed as the gap between ex post realized interest rates and corresponding 2- and 3-quarter forward interest rate agreements traded previously. Changes in MFEs are computed as the difference between MFEs immediately before a release and 30 min after. Negative numbers indicate reduced forecast errors. Estimation based on the method proposed by Swanson and Williams (2014). The bands cover two standard errors around each point estimate.

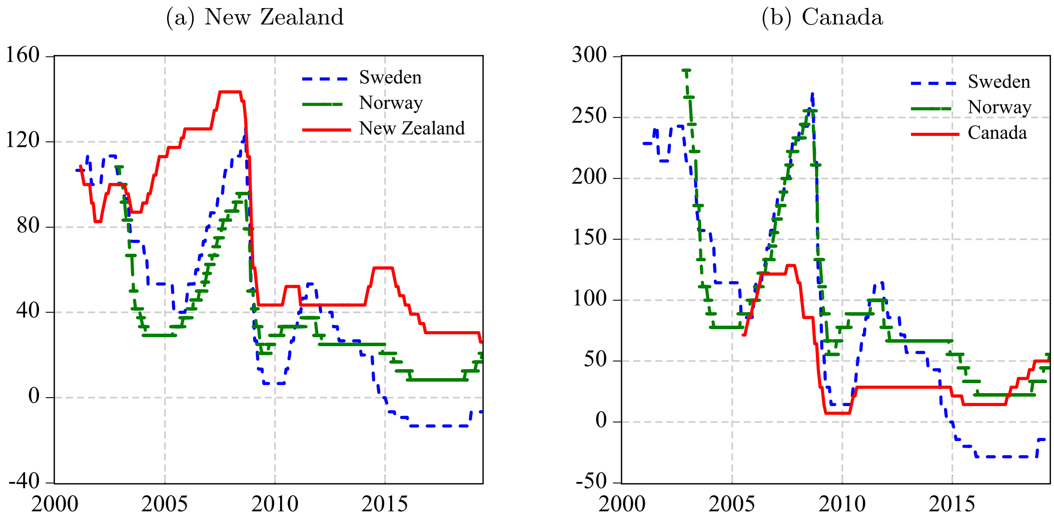

Fig. A.2. Comparing key policy rates in Sweden and Norway with New Zealand and Canada.
Notes: Figure compares the Swedish and Norwegian key policy rates to those of New Zealand (panel a) and Canada (panel b). All rates indexed to 100 in January 2003 in panel a, and to 100 in January 2006 in panel b.

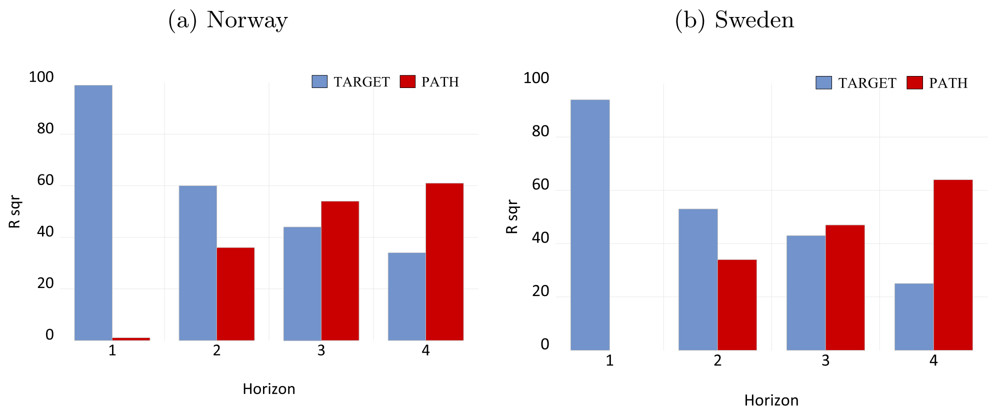

Fig. A.3. Explanatory Power of Path and Target Factors for Interest Rates.
Notes: The individual contributions of the two orthogonal factors "target" and "path" in explaining the responses of the 1-month rate, the second, third and fourth IMM FRA (respectively horizon 1 to 4) in 30-min windows around monetary policy announcements. Each factor's individual contribution is measured by the R-squared from standard univariate OLS regressions with the respective interest-rate change as dependent variable and the respective factor as explanatory variable.

Appendix B. Rolling window regressions

We here summarize how we estimate the rolling-window regressions in Fig. 1 and A.1. Our approach to pooling different releases follows Swanson and Williams (2014), who study interest rate reactions to macroeconomic news.

For each horizon h, we first estimate the non-linear least specification

$$\Delta|mfe_t^h| = \delta^T \boldsymbol{\beta} \mathbf{I_t} + \varepsilon_t, \tag{B.1}$$

where $\mathbf{I_t}$ is a vector of dummies that each equals 1 whenever one specific macro release or a monetary policy announcement takes place. Next, $\boldsymbol{\beta}$ is a vector of coefficients on these dummies. In contrast, δ^T consists of a year-specific scalars that may take on different values in each calendar year T. Hence, the $\boldsymbol{\beta}$-vector scales how much each release typically affects market forecast errors, across all years in our sample. The coefficient δ^T captures how the influence of all releases combined varies over time.

Next, to move from calendar years to windows centered around each release, we estimate rolling regressions of

$$\Delta|mfe_t^h| = \delta^\tau \widehat{\mathbf{I}}_\mathbf{t} + \varepsilon_t, \tag{B.2}$$

Table A.1
Difference in differences - Norway and Sweden (Quarterly data).

	Horizon: 1	2	3	4	Horizon: 1	2	3	4
I: RBNZ								
Ia: Norges Bank vs RBNZ					Ib: Riksbank vs RBNZ			
Constant (ψ)	−0.055	−0.022	0.003	0.021	−0.047	−0.024	−0.008	0.002
	(−4.04)	(−1.28)	(0.24)	(1.40)	(−4.08)	(−1.76)	(−0.68)	(0.11)
Country (γ_1)	0.021	−0.019	−0.039	−0.054	0.045	0.028	0.006	−0.001
	(1.34)	(−0.81)	(−1.50)	(−2.03)	(3.82)	(1.93)	(0.52)	(−0.04)
IRP-period (γ_2)	0.043	0.022	0.003	−0.008	0.036	0.029	0.019	0.021
	(2.18)	(1.13)	(0.16)	(−0.42)	(1.84)	(1.62)	(1.10)	(1.06)
IRP-period × country	−0.022	0.004	0.026	0.034	−0.065	−0.048	−0.040	−0.025
(β)	(−1.14)	(0.14)	(0.89)	(1.12)	(−3.05)	(−2.33)	(−1.81)	(−1.09)
Adjusted R^2	0.01	0.02	0.02	0.04	0.02	0.01	0.01	0.00
Obs. (quarters ×2)	151	149	147	145	147	145	143	141
II: Bank of Canada								
IIa: Norges Bank vs BoC					IIb: Riksbank vs BoC			
Constant (ψ)	−0.028	−0.028	−0.005	−0.013	−0.029	−0.024	−0.004	−0.005
	(−2.62)	(−1.86)	(−0.39)	(−1.00)	(−3.15)	(−1.87)	(−0.39)	(−0.49)
Country (γ_1)	−0.005	−0.013	−0.031	−0.020	0.027	0.028	0.002	0.006
	(−0.40)	(−0.49)	(−1.49)	(−1.00)	(2.50)	(2.08)	(0.24)	(0.54)
IRP-period (γ_2)	0.012	0.021	−0.002	0.009	0.014	0.018	−0.003	−0.001
	(1.05)	(1.36)	(−0.14)	(0.62)	(1.41)	(1.31)	(−0.25)	(−0.11)
IRP-period × country	0.008	0.004	0.031	0.017	−0.043	−0.038	−0.018	−0.003
(β)	(0.52)	(0.16)	(1.38)	(0.78)	(−2.95)	(−2.06)	(−1.13)	(−0.19)
Adjusted R^2	0.00	0.02	0.02	0.01	0.03	0.01	0.00	−0.02
Obs. (quarters ×2)	148	146	144	142	144	142	140	138

Notes: Regression results from the difference in difference specification in Eq. (5), comparing Norway and Sweden to New Zealand and Canada. Coefficient-symbol in parenthesis on each row. IRP is short for interest rate projection. Market forecast errors (MFE) are aggregated to a yearly sum for each country. In panel Ia, the yearly sum of changes in forecast errors around monetary policy announcements in Norway are compared to those in New Zealand before and after Norges Bank introduced IRPs. Panel Ib reports results from the same exercise, but now for Sweden and New Zealand. In panels IIa and b, the control country is Canada instead of New Zealand. The difference-in-difference coefficient of interest is 'IRP-period × country'. Horizon 1 to 4 represent the next four IMM-maturity dates, approximately 3-month, 6-month, 9-month and 1-year ahead horizons respectively. Sample period: 01.01.2000–03.31.2019. t-values in parenthesis (Newey-West corrected standard errors).

where $\widehat{\mathbf{I}_t} = \hat{\boldsymbol{\beta}}\mathbf{I}_t$ uses the estimated value of $\hat{\boldsymbol{\beta}}$ from (B.1). Our rolling estimation of (B.2) uses two years of data centered at each day of release, τ. Hence, the resultant estimates of δ^{τ} reflect how a "generic release" affects MFEs at time τ. To account for two-stage sampling uncertainty, the standard errors estimated in (B.2) are scaled up by a factor based on the standard errors estimated in (B.1) and interpolation between them.

Appendix C. Target vs. path decomposition

We here summarize how we decompose market reactions into a target and a path factor, the method of Gürkaynak et al. (2005).

The starting point is the equation:

$$X = F\Lambda + \eta \tag{C.1}$$

where X is a matrix in which each row corresponds to a monetary policy announcements at specific point in time, and each column contains the 30-min change of a specific asset price around each announcement. The prices we consider are the FRAs described in Section 2.2. Importantly though, to obtain a shorter-horizon interest rate than the 3-month FRA, we use the one-month interest rate implied by foreign exchange forward contracts. F is a matrix of unobserved factors, Λ is a matrix of factor loadings and η is white noise.

The key finding of the now vast empirical literature following Gürkaynak et al. (2005), is that two factors (two appropriately composed columns of F) suffice to explain the data in X. The same has been found to apply to Norway, see for instance Brubakk et al. (2017). In total, the two first factors together explain 98 and 96 percent of our data's interest rate reactions in Norway and Sweden, respectively. Denote these two factors F_1 and F_2. To obtain a structural interpretation of them, they are rotated to yield two new orthogonal factors Z_1 and Z_2 which explain the data in X to exactly the same extent as F_1 and F_2 did, but with the additional restriction that Z_2 has no effect on one-month fx-forward implied interest rates (our measure of the instant effect of monetary policy action not connected to signals about future policy). The rotation is simply $Z = FU$, where $F = [F_1, F_2], Z = [Z_1, Z_2]$, and U is a 2×2 matrix constructed such that Z_2 on average is associated with no change in the closest FRA. Hence, Z_1 is associated with variation in the current policy target rate, whereas Z_2 captures any other information than the current policy rate that affects the expected path of the monetary policy rate over the next year. The names follow: "target" and "path" factors.

Fig. A.3 shows how much each the target and path factor contribute to explaining interest rate reactions at different horizons in Norway and Sweden. The figure simply displays the R-squared from the regression

$$\Delta i_t^h = \gamma Z_t^j + \varepsilon_t, \tag{C.2}$$

where Δi_t^h is the response of the h-horizon interest rate to a monetary policy announcement at time t and Z_t^j is factor j at time t, where j is either target or path. Recall that because the two factors are orthogonal by construction, the sum of R-squared from regressing interest rates on each factor separately equals the total R-squared from regressing interest rates on both factors at once. As we see from Fig. A.3, the target factor explains more at the lower horizons, while the path factor explains more at the longer horizons. At the shortest horizon, the target factor explains everything by construction.

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